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Governed by the Cycle: Direct and Inverted Interest-Rate Sensitivity of Emerging Market Corporate Debt

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Abstract

An innovative approach to quantify interest rate sensitivities of emerging market corporates is proposed. Our focus is centered at price sensitivity of modeled investment grade and high yield portfolios to changes in the present value of modeled portfolios composed of safe-haven assets, which define risk-free interest rates. Our methodology is based on blended yield indexes. Modeled investment horizons are always kept above one year thus allowing to derive empirical implications for practical strategies of interest rate risk management in the banking book. As our study spans over the period 2002 – 2015, it covers interest rate sensitivity of assets under the pre-crisis, crisis, and post-crisis phases of the economic cycles. We demonstrate that the emerging market corporate bonds both, investment grade and high yield types, depending on the phase of a business cycle exhibit diverse regimes of sensitivity to interest rate changes. We observe switching from a direct positive sensitivity under the normal pre-crisis market conditions to an inverted negative sensitivity during distressed turmoil of the recent financial crisis, and than back to direct positive but weaker sensitivity under new normal post-crisis conjuncture. Our unusual blended yield-based approach allows us to present theoretical explanations of such phenomena from economics point of view and helps us to solve an old controversy regarding positive or negative responses of credit spreads to interest rates. We present numerical quantification of sensitivities, which corroborate with our conclusion that hedging of interest rate risk ought to be a dynamic process linked to the phases of business cycles as we evidence a binary-like behavior of interest rate sensitivities along the economic time. Our findings allow banks and financial institutions for approaching downside risk management and optimizing economic capital under Basel III regulatory capital rules.

JEL Code: E43; G11; G12; G15; G20

Keywords: Fixed Income, Portfolio Performance Evaluation, Downside Risk Management, Emerging Markets, Corporate Debt, Interest Rate Sensitivity.

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1. Introduction

The likelihood that the U.S. Federal Reserve starts gradually raising interest rates exercises unprecedented pressure on the whole global financial system. As interest rates are about to recover from historically low levels they place significant strain on bank profitability and capital adequacy levels. A volume of recent scientific research addressing effects of interest rate changes on bank performance and solvency keeps growing. See, for example Berends et al (2013), Landier et al (2013), Bessis (2015), Fuerst et al (2015), Haddad (2015), Neal et al (2015), Dupoyet et al (2016), Gubareva and Borges (2016), and references therein.

The regulatory bodies also try to create the widespread awareness of possible negative impacts of interest rate changes on bank balance sheets and profitability. For instance, the Basel Committee on Banking Supervision in April of this year issued “Standards for Interest Rate Risk in the Banking Book” (2016). On the other hand about a year before the European Banking Authority (EBA) published “Guidelines on the management of interest rate risk arising from non-trading activities” (2015). The guidance provided in these updated guidelines applies to the interest rate risk arising from non-trading activities (IRRBB). This detailed guidance focuses thematically on five areas of interest risk assessment and control: scenarios and stress testing, measurement assumptions, methods for measuring interest rate risk, governance and identification of interest rate risk, and calculation and allocation of capital to interest rate risk.

The above mentioned documents by the Basel Committee on Banking Supervision and by the EBA comprehensively outline the possible effects of interest rate increases, including changes to net interest margins, balance sheet structure, and values of interest-sensitive assets and liabilities. At this point it becomes especially important to correctly assess an interest rate sensitivity of assets, which is a measure of how much the price of a fixed-income asset will fluctuate as a result of changes in the interest rate environment. The more the price fluctuates, the more sensitive to interest rate is the asset.

But what is really important for managing IRRBB is how the prices of assets react on medium term downward or upward trends in interest rate dynamics. Nevertheless, the interest rate sensitivity of corporate debt is traditionally analyzed in terms of yield sensitivity of corporate bonds to changes in the yield curve of risk-free assets, see Manzoni (2002), Landschoot (2008), Boulkeroua and Stark (2010 and 2013), and references therein. In this context, impacts in asset prices are obfuscated as researchers main interests are centered on interest rate – credit spread relationship, and not on final impacts in present value of risky securities.

Another important aspect of our research is that we assess the price response from the perspective of medium term investment in the banking book. Thus we are interested in interrelations between changes in present value of risky and risk-free assets over a considerably long periods; 1-, 2- and 3-year long. This explains the novelty of our approach as opposed to the studies of daily changes in interest rates and credit spreads, which employ averaging of daily statistics over extended time intervals in order to come out with a kind of average sensitivities. We show that our results contrast with many quantitative and qualitative findings of previous research, see Boulkeroua and Stark (2010 and 2013), Neal et al (2015), and Dupoyet et al (2016, among others.

As to theoretical interpretations of interest rate – credit spread relationship, among the cornerstone studies in this field we mention the Merton (1974) structural model, which implies a negative response of credit spreads to interest rates, i.e. it means that the probability of default is affected by changes in the interest rate. We also cite the other side of the theoretical divide that advocates a positive relationship between changes in yield spreads and changes in the risk-free rate, see Kamin and Kleist (1999). This Merton (1974) versus Kamin and Kliest (1999) controversy had attracted our attention both from the theoretical and empirical points of view as there were lots of empirical observations fitting each of the models. Thus, studying interest rate sensitivities we decided to undertake further research seeking to solve the above controversy.

Hence, our attempts to advance a theoretical interpretation of interest rate – credit spread relationship is quite timely, as most of recent research in this field is focused on empirical side of the problem. We emphasize the works of Kamin and Kliest (1999), Davies (2008), Boulkeroua and Stark (2010 and 2013), Neal et al (2015), and Dupoyet et al (2016). It is also worth noting that research in this area has been mostly focusing at the U.S. domestic bond market. The fact that U.S. domestic financial market for government and corporate bonds is the biggest in the world explains its attraction for researchers involved in empirical investigations of the relationship between the yield spread on corporate bonds and changes in the yield of U.S. government bonds, see Piazzesi and Schneider (2010), Bauer and Hamilton (2015), Begenau et al (2015), etc.

Differently to the cited above works our research addresses the EM corporate debt. Note that the importance of non-U.S. financial markets keeps growing; see Mishkin and Eakins (2015). For example, the level of corporate debt in EM had quadrupled between 2004 and 2014. In respect to the non-U.S. markets, we would like to mention the already cited study of the evolution and determinants of emerging market credit spreads performed Kamin and Kleist (1999) and the previously cited research of Manzoni (2002) who studied the behavior of yield spreads on an ISMA Sterling Eurobond Index composed by bonds from different markets including Latin America, etc. As such studies are rather rare, additional research into non-U.S. corporate is highly desirable.

Having a slightly different perspective and focusing on sensitivity of EM asset prices to risk-free interest rates, here we go beyond the interest rate and credit spreads dynamics. In our work, we analyze the interest rate sensitivity as a price sensitivity of a chosen portfolio composed by EM corporate bonds to changes in the prices of U.S. Treasury bonds, which determine changes in the risk-free interest rates. We consider two different cases when the

EM bond portfolio is either hedged by short positions in U.S. Treasury bonds or not. This work also contributes to the research on interdependence between the credit risk, interest rate risk, and liquidity risks, being related to downside risk management and financial stability improvement; see Gubareva (2014), Gubareva and Borges (2014), and Gubareva and Borges (2016).

And last but not least, this paper aims to contribute by providing answers to the following chief question: does it make an economic sense to hedge interest risk of U.S. dollar denominated EM corporate debt by short positions in U.S. Treasury bonds or by pay-fixed receive-float interest rate swaps? We try to respond this question separately for EM investment grade (IG) and EM high yield (HY) corporates. The answers to these questions are of particular importance for interest rate risk management and for dimensioning economic capital to allocate for mitigating this type of risk. Hence our research is potentially important not only for academia community, but also to financial industry players and regulatory bodies.

This paper is structured as follows. Section 2 describes the data and details the scope of our studies. Section 3 introduces the methodology and assumptions developed for analyses of asset prices´ volatility. Section 4 presents empirical results. Section 5 provides discussions and illustrations of the implications of the obtained results, and Section 6 offers concluding remarks.

2. Empirical Data and Scope

Being rather interested in aggregate interest rate hedge techniques at a portfolio level and not focusing on a cherry-picking performance of certain selected assets, we opt to study an IR sensitivity of the EM portfolios prices. Our approach is based on yield indices describing EM corporate debt performance. After careful studies of existing indices our choice was to use two J.P. Morgan Corporate Emerging Market Bond Indices: the Broad High Grade Blended Yield (Bloomberg ticker JBBYIGIG) and the Broad High Yield Blended Yield (Bloomberg ticker JBBYNOIG). As one could infer from the tickers´ abbreviations, the former presents a blended yield for Investment Grade bonds while the latter offers a blended yield for Non-Investment Grade instruments.

The blended high yield emerging market corporate bond index (JBBYNOIG) is a rule based index engineered to measure speculative grade corporate bond performance of USD denominated fixed-rate corporate bonds of issuers in emerging markets as defined by J.P. Morgan. This index is calculated using quite a widespread universe of emerging market corporate debt. Over four hundred corporate bonds issued by over two hundred issuers from over forty emerging market countries contribute to the blended yield index calculations. Similarly, the blended high grade emerging market corporate bond index (JBBYIGIG) is also a rule-based index engineered to measure investment grade corporate bond performance of

USD denominated fixed-rate corporate bonds of issuers in emerging markets. Its issue, issuer and geography coverage is similar to the one described above.

These two indexes JBBYIGIG and JBBYNOIG provide more than 14-year long historical yield series, starting at December 31, 2001, which represent a considerable time interval for studying EM debt performance in the twenty first century. In our research the final date of analyzed data is put to be December 31, 2015. Of course for analyzing a dynamics of asset values and portfolios prices, the price index perhaps would be a better choice, but to the best of our knowledge no price indexes with similar issuer, geography and historic coverage are available in the market. Thus, instead of researching an individual bond price histories and/or developing a range of bond price indexes from a selected universe of individual bond data we opt for using the two above mentioned yield indexes to measure high grade and high yield EM corporate debt performance.

As the main focus of our research is to analyze asset price changes we rule out total return indexes as well, as the reinvestment of the net interest income proceeds does not enter the scope of the present research.

Being interested in a dynamics of changes in present value of modeled portfolios hedged against interest rate risk, we model the basic interest rate risk hedge as a holding of short positions in US Treasuries with the five year maturity similar to the maturity of the above mentioned blended yield indexes. To describe the price dynamics of the interest rate risk hedge we employ the US Global Generic rate index available through the Bloomberg terminal under the USGG5YR ticker whose maturity is equivalent to the maturity of the two bond indices being analyzed.

The next section describes the methodology allowing for comprehensive analysis of EM corporate bond portfolios based on the time series of the broad blended yield indexes, along with our approach to tackle interest rate risk hedge based on shorting US Treasury bonds, relied on the US Global Generic rate historical series.

3. Methodology

The basis element of our yield-based framework is a conversion of the available index value of the blended yield into the average price of the modeled portfolios, namely EM IG portfolio and EM HY portfolio, in accordance with the employed index, JBBYIGIG and JBBYNOIG, respectively. We start our explanation with an example of just one bond.

A cash flow received in n-years should be discounted at the n-year interest rate. Combining cash flows in different years leads us to a general formula for the present value of a cash flow stream:

$$P = \sum_{n=1}^{N} \frac{CF_n}{(1 + y_n)^n} \tag{1}$$

Then, this formula could be simplified for a 5-year bond with annual coupon *c* and face value p. The price P of this bond could be written as

$$P = \frac{c}{1+y} + \frac{c}{(1+y)^2} + \frac{c}{(1+y)^3} + \frac{c}{(1+y)^4} + \frac{c+p}{(1+y)^5} \tag{2}$$

where y is a market interest rate for the level of riskiness associated with the bond under analyses. Here, for simplicity reasons we assume a term structure of bond yield to be flat. When the bond coupon *c* is equal to the yield *y* the bond is issued at par.

However a blended yield index provides us only with time series of yield value *y*. So we do not have any actionable information on the subjacent bonds coupon values. So, at this point one needs an assumption which would permit to overcome this lack of information in order to find an average price of a modeled portfolio. Thus we assume a continuous rebalancing of the portfolio. This assumption if frequently used to study risk minimization strategies for portfolio immunization, see for instance Fong and Vasicek (2015).

In our case the assumption which is even more important than the assumption of the continuous portfolio rebalancing is the assumption of a "cruising speed" rebalancing or constant rate rebalancing of the portfolio. This assumption means that a bond entering the model portfolio stays in the portfolio for a certain holding period, say *n* years, and by the end of this period the bond is sold out. We assume that all bonds in the modeled portfolio represent equal weights. Fig. 1 schematically represents the rebalancing of the modeled portfolio consisting at any moment in time of four bonds with the identic face value. In our schematic example the "continuous" rebalancing is represented by quarterly rebalancing. A lifetimes of the consecutively issues bond are presented as horizontal lanes.

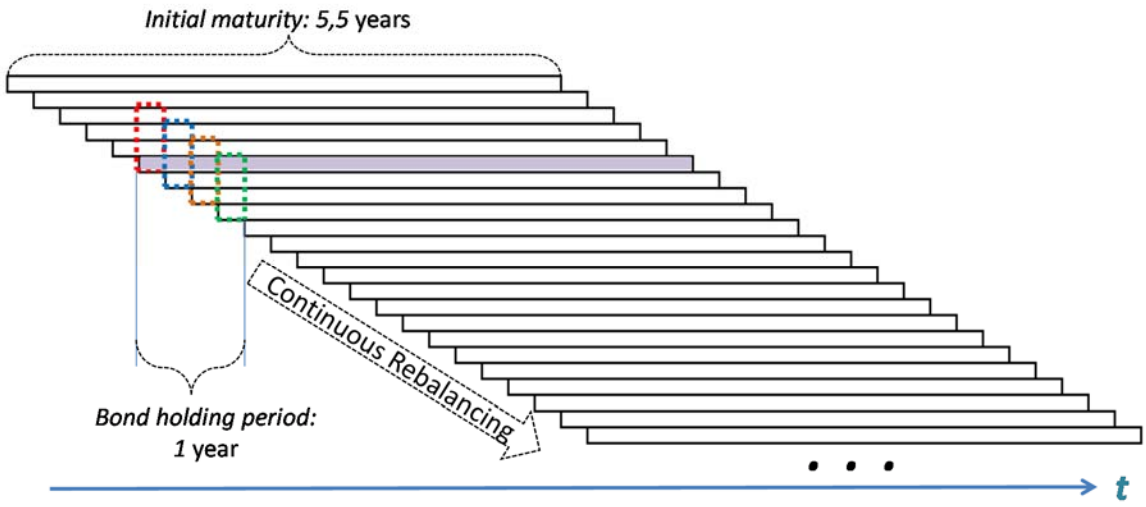

Figure 1. Continuous rebalancing of the hypothetical four-bond portfolio with a complete renewal of assets during one year interval

As could be seen from Figure 1, we assume that the bonds are regularly issued once a quarter. While issued a new on-the-run security has initial maturity of five years and a half. The newly issued bond become a part of the portfolio, and spends in portfolio a period of time, which we call bond holding period. In our example such bond holding period equals one year. A bond which spent one year in the portfolio, so-called off-the-run security with residual maturity of 4,5 years, is substituted by a newly issued on-the-run bond. In this example the average residual maturity of the portfolio is always equal to five years, the point of term structure which we are interested in in our research.

The example above could be easily generalized for a situation when a bond holding period may equal *n* years, or 260**n* banking days. As the vast majority of bonds are issued at par, this gives us a key to finding an average coupon of the modeled portfolio at the date *d* as an average of the index yield daily values observed over the *n* years prior to this date *d*.

$$c = \frac{1}{n * 260} \sum_{i=1}^{n*260} y_i \tag{3}$$

Here we consider that the year consists of 260 working days for which index data are available. During this study we employed three different holding periods *n* of 1, 2, and 3 years. The choice of this time intervals will be discussed in more detail further in the text.

Our research performs modeling of the two portfolios namely, EM IG and EM HY portfolios, as described by the JBBYIGIG and JBBYNOIG indexes, respectively. So now we are able to price each of these two model portfolios at any date covered by the employed JBBYIGIG and JBBYNOIG historical series. The more precisely is to say that for 1 year holding period the time window of reconstructed portfolio prices is 2003-2015, for 2 year holding period – 2004-2013, and for 3 year holding period – 2005-2015. The time intervals differ as in order to calculate the average coupon for a chosen portfolio the appropriate rebalancing speed must be chosen. In other words, the time extension of the yield averaging window is set equal to the length of the respective bond holding period.

The possibility to have historical price series for the two, IG and HY EM model portfolios enables us to quantify asset value appreciation/depreciation occurred in the respective modeled portfolios over any chosen period of time as the difference between portfolio prices subjacent to the two chosen dates:

$$\Delta_{P\_EM}(t, H) = P_{EM}(t + H) - P_{EM}(t) \tag{4}$$

where H stands for a time horizon over which the impact in price is analyzed.

The same approach is also applied for analyzing price changes of the short positions in US Treasuries performing the role of hedge instruments while the performance of the EM portfolios hedged against interest-rate risk is studied. So, for the long positions in US treasuries we have straight away:

$$\Delta_{P\_UST\_LONG}(t, H) = P_{UST\_LONG}(t + H) - P_{UST\_LONG}(t) \tag{5}$$

while dealing with the short positions we just invert the signs in the right hand side of the equation (5):

$$\Delta_{P\_UST\_SHORT}(t, H) = P_{UST_{LONG}}(t) - P_{UST\_LONG}(t + H) \tag{6}$$

It is worth noticing that we are interested in price changes over rather extended time intervals. Herein we analyze a variety of the rebalancing rates, i.e., bond holding periods, being combined with the several lengths of time horizons over which the changes in value of the modeled portfolios are analyzed. Table 1 below presents our selection:

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes
1Y	*1Y*	*2003-2015*	*2004-2015*
2Y	*1Y*	*2004-2015*	*2005-2015*
2Y	*2Y*	*2004-2015*	*2006-2015*
3Y	*1Y*	*2005-2015*	*2006-2015*
3Y	*2Y*	*2005-2015*	*2007-2015*
3Y	*3Y*	*2005-2015*	*2008-2015*

Table 1. Available windows of price changes for diverse bond holding periods and portfolio impact horizons.

For the presented above available windows of price changes we analyze performance of the pure asset sides of the EM IG and HY portfolios, interest rate sensitivity of assets, the efficiency of hedge, downside risk exposures of hedged and unhedged portfolios as well as the respective upsides.

The downside risk of the portfolio we define as the most negative move in the price of the portfolio, being it hedged or unhedged

$$Downside = \min_t \Delta_P(t, H), \tag{6}$$

while the upside we define, just in the opposite manner, as a maximum gain over an analyzed period:

$$Upside = \max_t \Delta_P(t, H), \tag{7}$$

The meaning of all these metrics we will discuss in more detail in the next sections dedicated to the empiric results obtained by our approach and the discussion of their implications.

As we are interested in price-wise interest rate sensitivity, we try to simplify our model and eliminate less important details. For instance, continuous rebalancing involves continuous buying and selling assets. Nonetheless we exclude transaction expenses and gains as in fact they respectively represent the out-of-pocket and into-the-pocket money, which do not affect present value of future cash flows of assets composing our modeled portfolios.

4. Empiric results

4.1. Visual and Correlation analyses of the two EM corporate bond indices.

Figures 2 and 3 present the historical series of the yields in bps as per JBBYIGIG and JBBYNOIG indexes, respectively. For the sake of visual comparison and spread visualization these series are plotted along with the US Global Generic rate as per USGG5YR index.

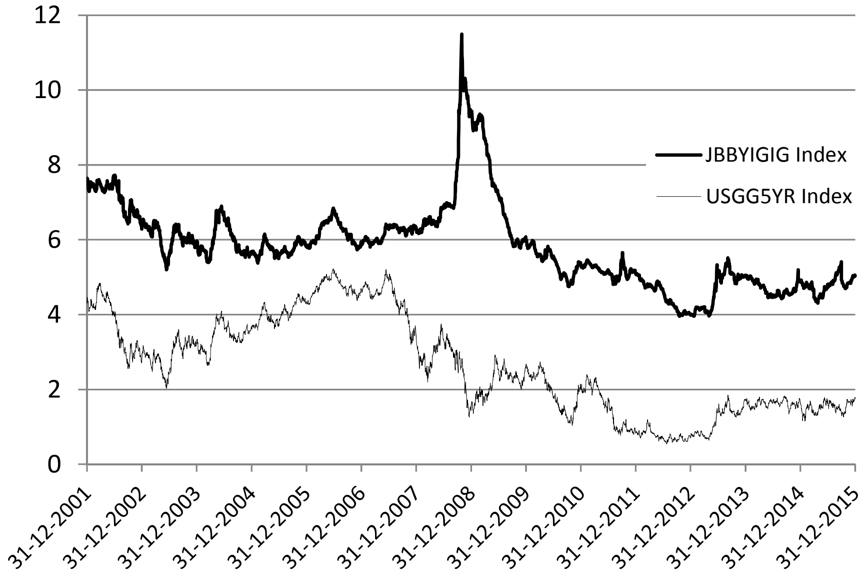

Figure 2. Blended bond yield of EM IG corporates vs. US Global Generic rate.
Source: Bloomberg

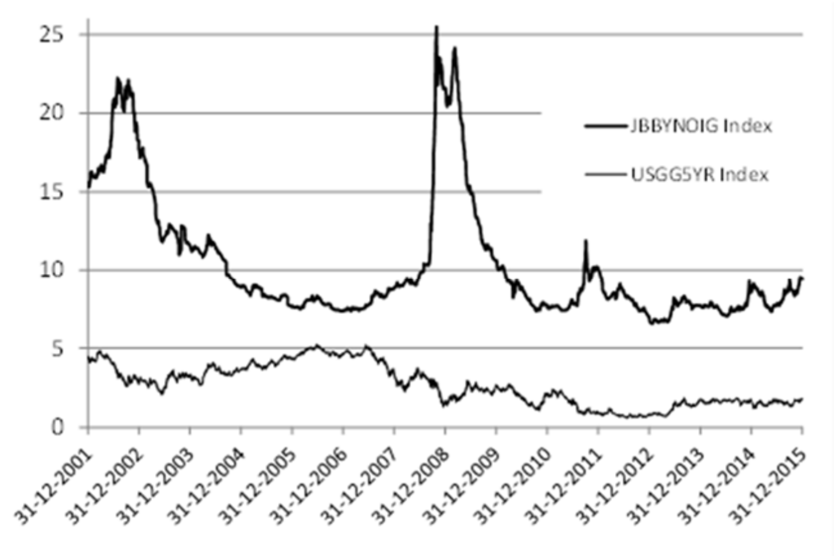

Figure 3. Blended bond yield of EM HY corporates vs. US Global Generic rate.
Source: Bloomberg

Both charts depict a substantial widening of IG and HY bond spreads over risk-free rates in 2008 and 2009 corresponding to the gigantic flight-to-quality effect coinciding with the apogee of the global financial crisis. After the crisis the yields of risky and risk-free assets visually appear to move on parallel courses, creating a visual impression that during the six recent years the short position in UST would be a good hedge for EM portfolios. As we show later on, the problem here is that even under such circumstances the hedge efficiency could be rather questionable, as what counts at the end is the difference between the price changes of the portfolios composed, on one hand, of risky assets and, on the other hand, of risk-free securities while these changes are verified over the time horizon chosen to analyze asset value appreciation/depreciation.

But prior to the analysis of price changes, we present a correlation study. Fig.4 and Fig.5 depict a behavior of Pearson coefficient for 120 days long arrays of movements in the yields of risky and risk-free assets.

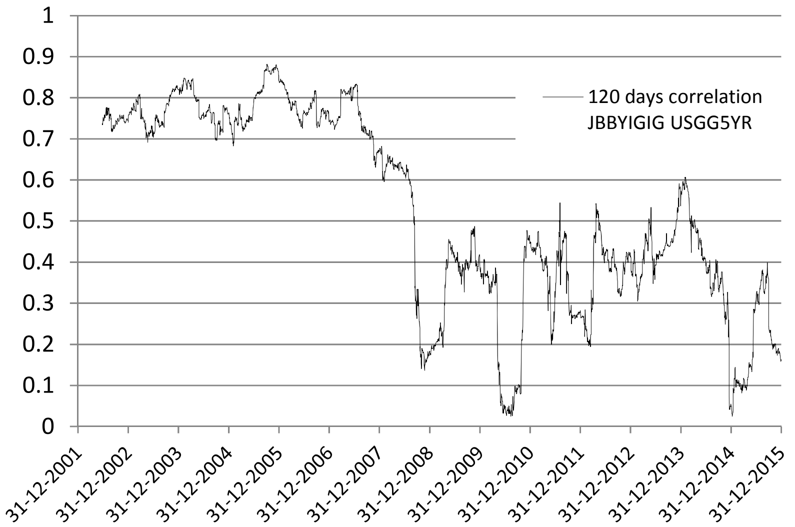

Figure 4. Correlation between yields of EM IG bonds and US Global Generic rates.

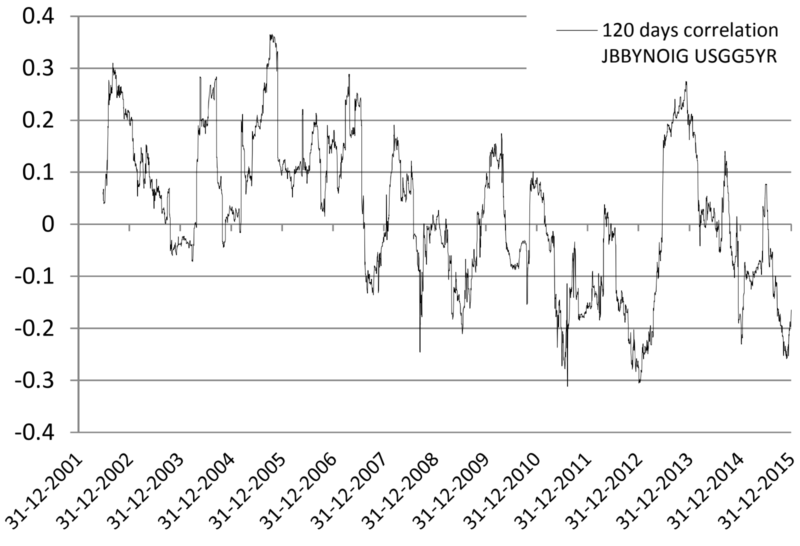

Figure 5. Correlation between yields of EM HY bonds and US Global Generic rates.

A visual comparative analysis of this two charts permits to conclude that moves in the yields of EM IG bonds are significantly more correlated to the moves in the rates of the risk-free assets than the yields of EM HY bonds. At least, the correlation coefficient for EM IG bonds never exhibits negative values, while the correlation coefficient for EM HY bonds almost half of the time stays in the negative territory, the evidencing contrarian behavior of the yields of speculative grade securities in respect to the UST yields. Mean values of 0,526 and 0,021 for the IG and HY bonds, respectively, averaged over the available data history also corroborate with stated above. The average value of the correlation coefficient for EM HY bonds very closed to zero certifies, in a long run, a practically full absence of correlation between the yields of HY EM corporates and the UST over long enough time intervals.

Nevertheless this simplistic correlation approach and the presented figures do not really tell as the whole story, as more detailed analysis in terms of asset price changes presented further sections reveals the more complex nature of the interest rate sensitivity. We undertake the more advanced studies by quantifying the impacts of the yield dynamics on the present values of modeled portfolios occurred over diverse time horizons under several assumptions regarding the cruising speed, i.e., the rate of rebalancing or renewal of the portfolio. For that reason, we use the yield data to recalculate price histories for the selected portfolios composed of IG and HY EM corporate securities.

4.2. Modeled portfolio prices

In this subsection we present our calculations of the historic prices for the model portfolios under the selected assumptions regarding the time interval along which the modeled portfolio is completely renewed, namely of 1, 2, and 3 years. We consider the face value of the portfolio to be equal to 1000 million USD. Fig. 6 represents the price dynamics of the 3 EM IG bond portfolios with the respective bond holding periods equal to the discussed above time intervals.

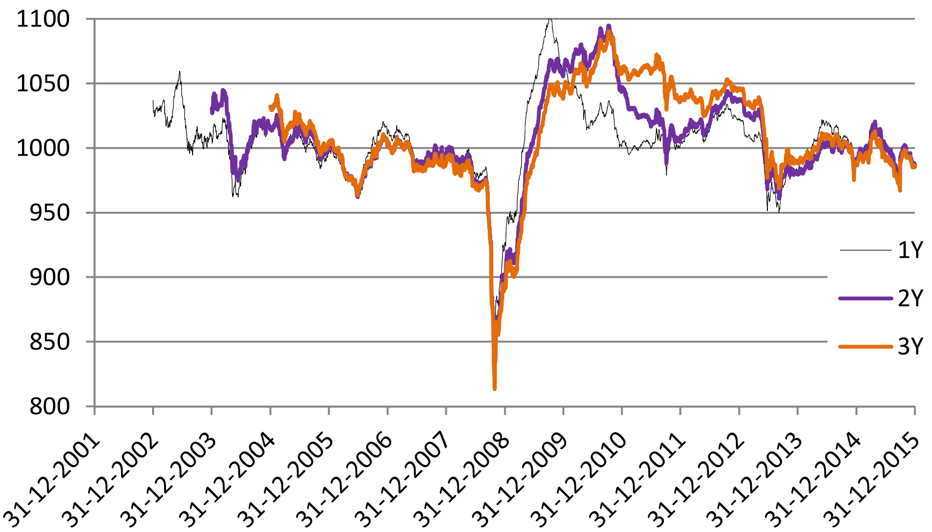

Figure 6. Prices of the EM IG bond portfolios with different bond holding periods.

As it appears from the comparative analysis of the price plots the price behaviors appears to be quite similar prior to the apogee of the global financial crisis at the end of 2008 and during the last three years. Still during the recovery phase one could observe major differences in the price behaviors. For the portfolio undergoing a complete renewal along 1 year rebalancing period the price bottom is not so deep as for the other portfolios while the major upside in prices occurs within 1Y after the bottom is reached. For the portfolios with the bond holding periods of 2 and 3 years the recovery spikes are not so sharp occurring over the respective 2 to 3 year long periods.

Fig. 7 represents the price dynamics of the 3 EM HY bond portfolios with the bond holding periods equal to 1, 2, and 3 years.

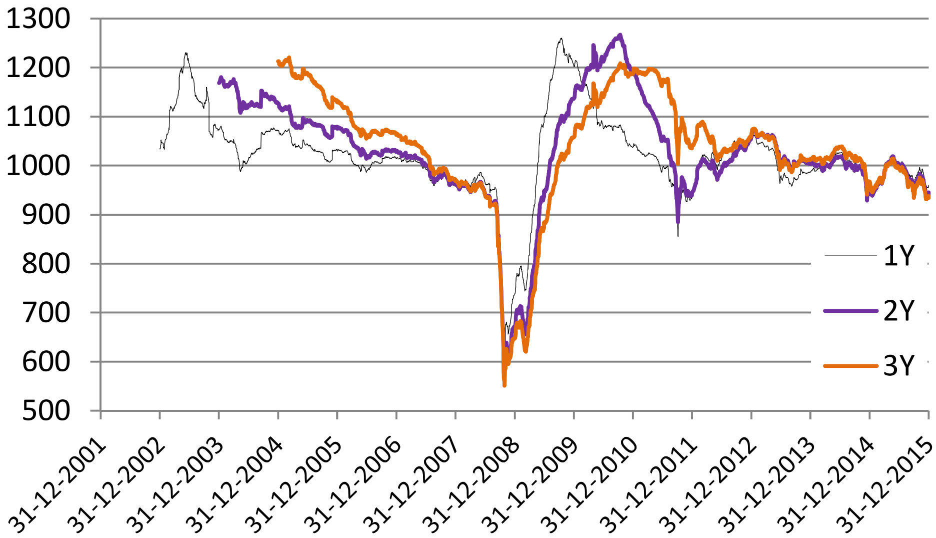

Figure 7. Prices of the EM HY bond portfolios with different bond holding periods.

These plots of the HY bond portfolio prices corroborate with our conclusions regarding the price recovery dynamics as a function of the bond holding period, which we obtained from the analysis of the Fig. 6 depicting prices of IG bond portfolios over the same period. It is worth noting that as expected we observe that the financial crisis influence on the price behavior of the modeled HY portfolio is stronger than on the price behavior of the modeled IG portfolios.

Fig. 8 represents the price dynamics of the 3 UST long portfolios with the securities holding periods equal to 1, 2, and 3 years.

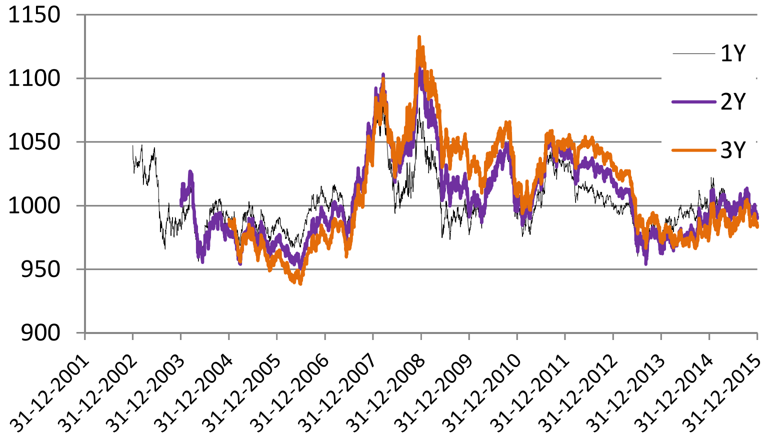

Figure 8. Prices of the UST long portfolios with different bond holding periods.

Comparing the price behavior of the risk-free UST portfolios and the risky EM portfolios one could conclude that the global financial crises represented a huge flight-to-quality event when the prices of safe assets increased and the EM bonds decreased. On the other hand the range of UST price changes (roughly -5%/+15%, see Fig.8) is narrower than the range of price changes both, for the IG EM corporate bonds (roughly -20%/+10%, see Fig.6) and HY EM corporate bonds (roughly -40%/+20%, see Fig.7).

4.3. Modeled historic price series

In this section we study dynamics of the historic series of the annual, biannual, and triennial changes is value of assets composing the EM and UST bond portfolios. The calculations are performed on a daily basis. We also construct the historic price series for the EM portfolios hedged by the short positions in the US Treasuries. The time spans of the series are limited due to the availability of data and depend on the rebalancing speed selected for the portfolio modeling as well as on the time horizon of the studied impacts.

4.3.1. EM IG corporate bond portfolios

Figure 9 represents the time behavior of the 1-year changes in value of the model EM IG corporate bond portfolio and in the risk-free UST bond portfolio, with the rebalancing rate of the portfolios equal to 1 year.

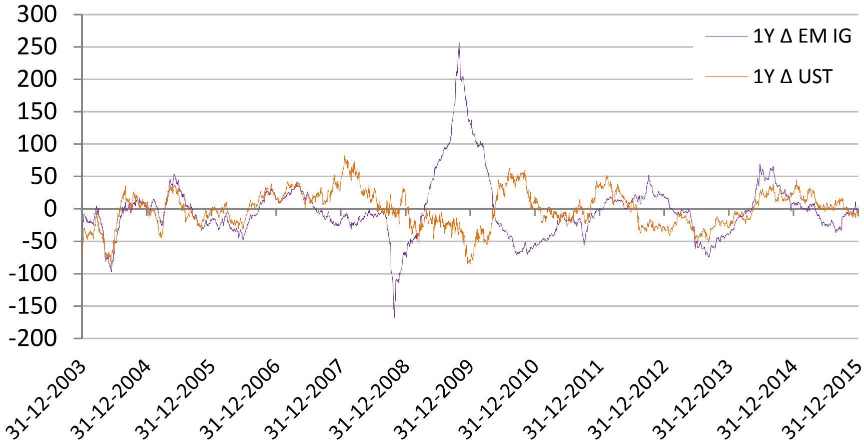

Figure 9. 1-year price changes for the EM IG and UST portfolios with 1-year bond holding period.

How to read this chart? The points plotted for December 31, 2003, represent changes in the values of the portfolios occurred over the 1 year started December 31, 2002. One clearly observes that during the period prior and after the apogee of the global financial crises, in this case along 2007 – 2012, the changes in the portfolio values are in an opposite mode.

Hence, under the above mentioned assumptions regarding the portfolio strategy, i.e., 1-year long horizon to measure portfolio results and 1-year stay of the bonds in the portfolio, – the hedging of the EM IG portfolio with the short UST positions do not compensate the negative impacts, during the periods when such setoff is the most needed. Fig 10 shows the time behavior of the 1-year changes in value of the model EM IG corporate bond portfolio hedged by the short positions in UST bonds, under the assumption of the complete portfolio rebalancing over 1-year time interval.

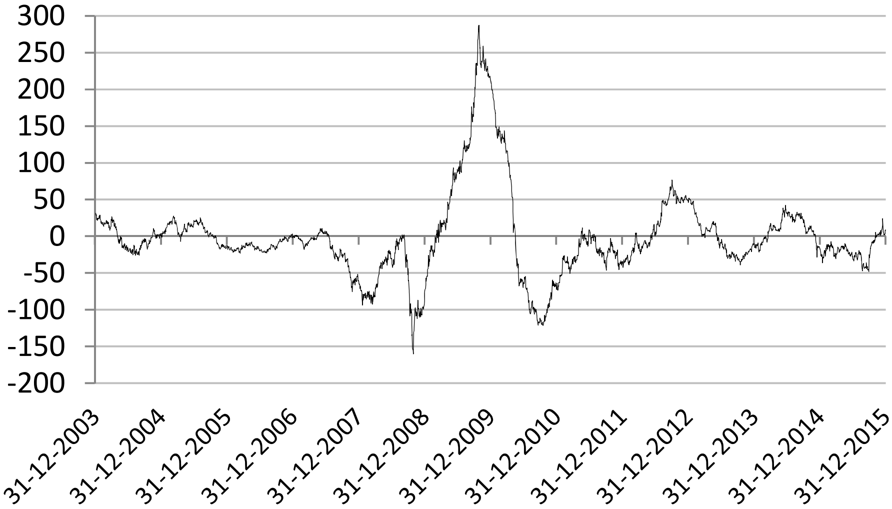

Figure 10. 1-year price changes for the EM IG long + UST short portfolio rebalancing over 1 year

As we could see by comparing Figures 9 and 10, the volatility, i.e., the width of the range, of 1-year price changes of the EM IG bond portfolio hedged by short positions in the US Treasuries is superior to the volatility of price changes for the non-hedged portfolio.

Figure 11 represents the time behavior of the 2-year changes in value of the model EM IG corporate bond portfolio and in the risk-free UST bond portfolio, with the rebalancing rate of the portfolios equal to 2 years.

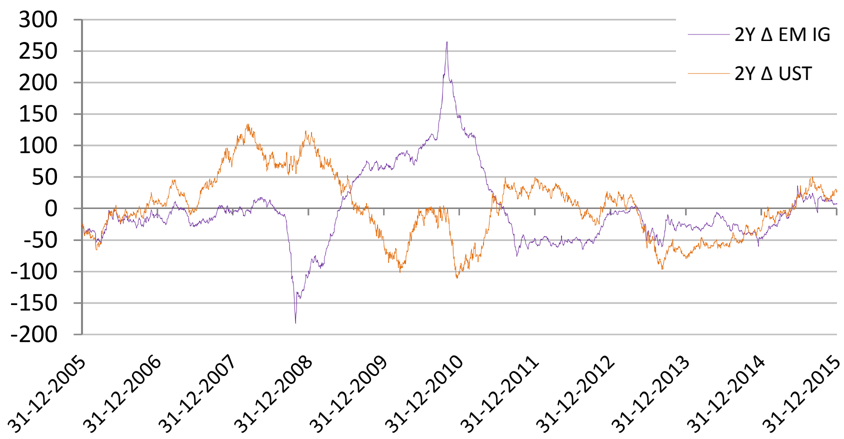

Figure 11. 2-year price changes for the EM IG and UST portfolios with 2 year bond holding period.

The chart above starts with the points plotted for December 31, 2005, which represent changes in the values of the portfolios occurred over the 2 years started December 31, 2003. One clearly observes that during the period prior and after the apogee of the global financial crises, in this case along 2006 – 2012, the changes in the portfolio values are in an opposite mode.

Hence, under the above mentioned assumptions regarding the portfolio strategy, i.e., 2-year long horizon to measure portfolio results and 2-year stay of the bonds in the portfolio, – the hedging of the EM IG portfolio with the short UST positions do not compensate the negative impacts, during the periods when such setoff is the most needed. Fig 12 shows the time behavior of the 2-year changes in value of the model EM IG corporate bond portfolio hedged by the short positions in UST bonds under the assumption of the complete portfolio rebalancing over 2-year time interval.

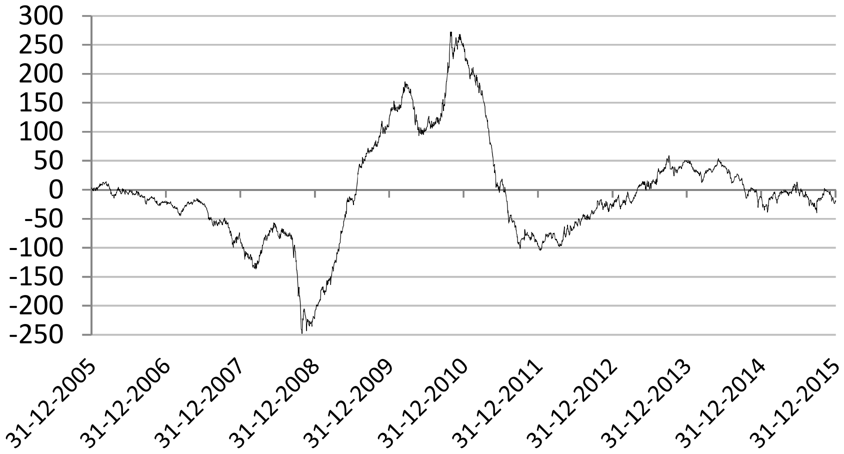

Figure 12. 2-year price changes for the EM IG long + UST short portfolio rebalancing over 2 years

As we could see by comparing Figures 11 and 12, the volatility, i.e., the width of the range, of 2-year price changes of the EM IG bond portfolio hedged by short positions in the US Treasuries is superior to the volatility of price changes for the non-hedged portfolio.

Figure 13 represents the time behavior of the 3-year changes in value of the model EM IG corporate bond portfolio and in the risk-free UST bond portfolio, with the rebalancing rate of the portfolios equal to 3 years.

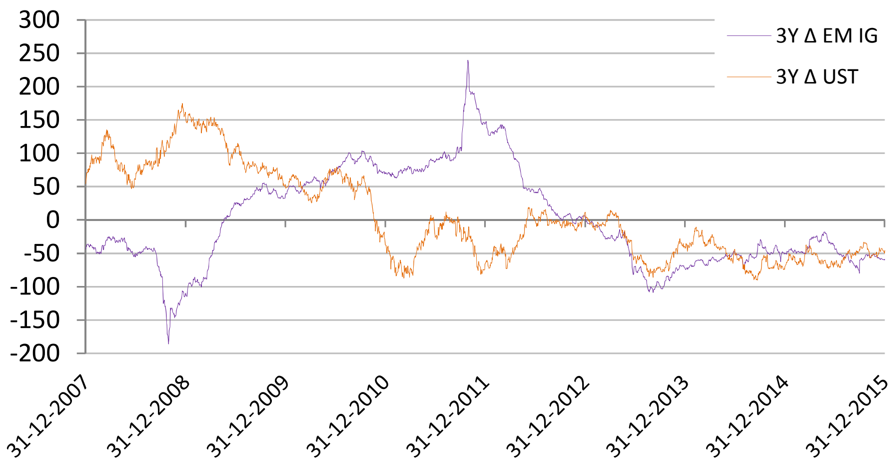

Figure 13. 3-year price changes for the EM IG and UST portfolios with 3 year bond holding period.

The chart above starts with the points plotted for December 31, 2007, which represent changes in the values of the portfolios occurred over the 3 years started December 31, 2004. One clearly observes that during the period prior and after the apogee of the global financial crises, in this case along 2007 – 2012, the changes in the portfolio values are in an opposite mode.

Hence, under the above mentioned assumptions regarding the portfolio strategy, i.e., 3-year long horizon to measure portfolio results and 3-year stay of the bonds in the portfolio, – the hedging of the EM IG portfolio with the short UST positions do not compensate the negative impacts, during the periods when such setoff is the most needed. Fig 14 shows the time behavior of the 3-year changes in value of the model EM IG corporate bond portfolio hedged by the short positions in UST bonds under the assumption of the complete portfolio rebalancing over 3-year time interval.

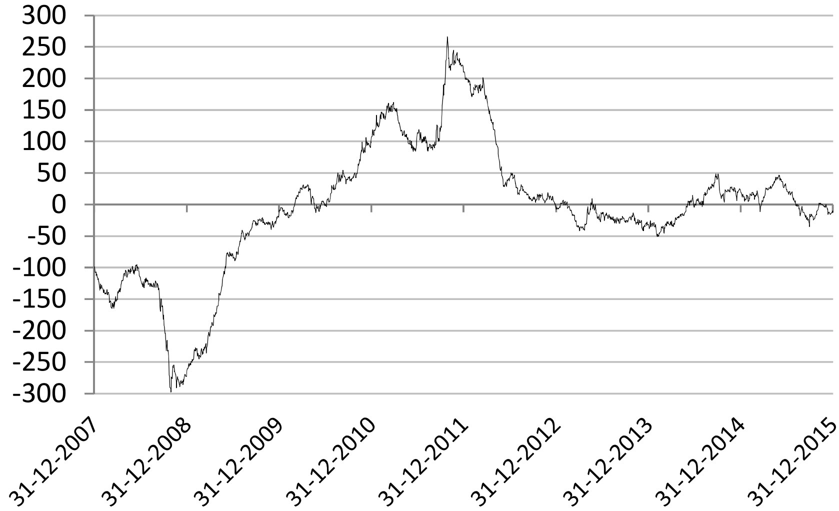

Figure 14. 3-year price changes for the EM IG long + UST short portfolio rebalancing over 3 years

As we could see by comparing Figures 13 and 14, the volatility, i.e., the width of the range, of 3-year price changes of the EM IG bond portfolio hedged by short positions in the US Treasuries is superior to the volatility of price changes for the non-hedged portfolio.

Table 2 provides the comparative analysis of upside and downside risk in the modeled EM IG portfolios of 1000 million USD, observed over the available present value gauging window as a function of the complete portfolio rebalancing period, i.e. the time each bond spends in the portfolio or the bond holding period, and of the time horizon used to calculate impacts in present values of the respective portfolios.

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes	EM IG max downside	UST short + EM IG max downside	EM IG max upside	UST short + EM IG max upside
1Y	*1Y*	*2003-2015*	*2004-2015*	-167.85	-160.46	256.24	287.26
2Y	*1Y*	*2004-2015*	*2005-2015*	-184.47	-209.07	245.20	283.22
2Y	*2Y*	*2004-2015*	*2006-2015*	-182.52	-248.31	264.64	272.48
3Y	*1Y*	*2005-2015*	*2006-2015*	-180.79	-230.29	228.31	254.94
3Y	*2Y*	*2005-2015*	*2007-2015*	-188.31	-278.39	267.66	288.34
3Y	*3Y*	*2005-2015*	*2008-2015*	-185.93	-297.64	239.38	266.04

Table 2. EM IG portfolios upsides and downsides for diverse bond holding periods and portfolio impact horizons

As could be seen from Table 2 the difference between the lowest losses and the highest gains in value of the portfolios hedged with short UST positions is always superior to that difference calculated for the unhedged portfolios. It means that, over the considered time windows, such hedge in fact does not hedge against the most extreme changes in IRR of the EM IG portfolios but rather leverage their IRR exposure. In more details the implications of these results will be addressed in the section dedicated to Discussions and Implications.

Table 3 provides the comparative analysis of the average returns originated from asset value changes. These returns were averaged over the respective available windows of price changes. We present our results for the long EM IG portfolio, long UST portfolio, and the long EM IG portfolio hedged with the portfolio of short positions in the UST. The comparison is made for several combinations of portfolio rebalancing rates and portfolio impact horizon intervals.

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes	Average EM IG return, (%)	Average UST return, (%)	Average EM IG + short UST return, (%)
1Y	*1Y*	*2003-2015*	*2004-2015*	-0.21%	-0.06%	-0.15%
2Y	*1Y*	*2004-2015*	*2005-2015*	-0.13%	0.10%	-0.23%
2Y	*2Y*	*2004-2015*	*2006-2015*	-0.26%	0.15%	-0.41%
3Y	*1Y*	*2005-2015*	*2006-2015*	-0.23%	0.20%	-0.43%
3Y	*2Y*	*2005-2015*	*2007-2015*	-0.14%	0.42%	-0.55%
3Y	*3Y*	*2005-2015*	*2008-2015*	0.03%	0.57%	-0.54%

Table 3. Average asset value driven returns for the long EM IG, long UST, and hedged long EM IG short UST portfolios for diverse bond holding periods and impact horizons.

As could be seen from Table 3 for the average asset value driven returns of EM IG portfolios, they are slightly negative for the return gauging windows starting in the pre-crisis years. For the last window 2008-2015 the average return becomes slightly positive as this window predominantly covers the post-crisis recovery. The average returns of the UST portfolios are predominantly positive, reflecting the fact that the variations in interest rates are largely downward since 2005 as could be seen in Figures 1 and 2. In its turn this also explains an inefficiency of IRR hedging by short positions in US Treasuries from the point the point of view of improving IG EM corporate portfolio performance and/or mitigating downside risks.

4.3.2. EM HY corporate bond portfolios

Figure 15 represents the time behavior of the 1-year changes in value of the model EM HY corporate bond portfolio and in the risk-free UST bond portfolio, with the rebalancing rate of the portfolios equal to 1 year.

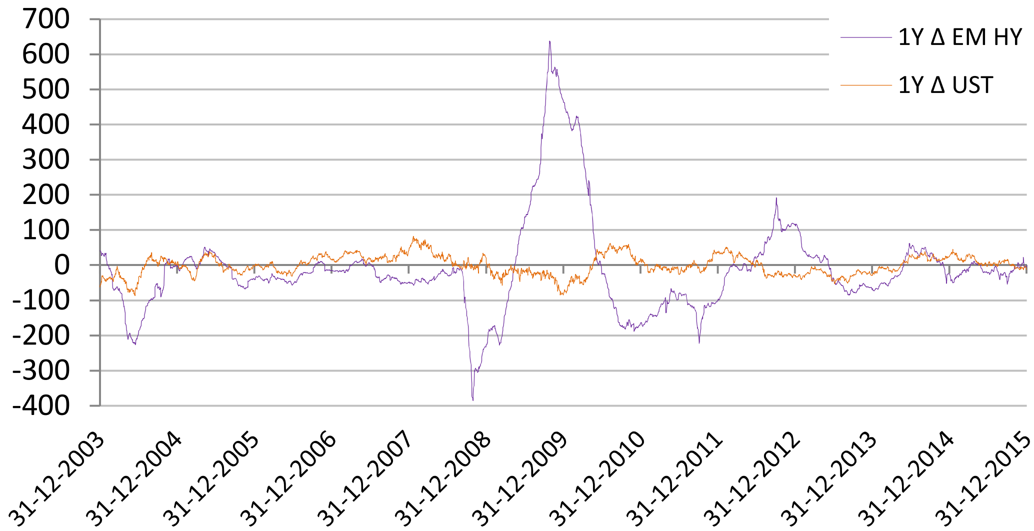

Figure 15. 1-year price changes for the EM HY and UST portfolios with 1 year bond holding period.

How to read this chart? The points plotted for December 31, 2003, represent changes in the values of the portfolios occurred over the 1 year started December 31, 2002. One clearly observes that during the period prior and after the apogee of the global financial crises, in this case along 2007 – 2012, the changes in the portfolio values are in an opposite mode. Note that the range of changes in EM HY portfolio price is several times wider than the range of changes in the value of risk-free UST portfolio.

Hence, under the above mentioned assumptions regarding the portfolio strategy, i.e., 1-year long horizon to measure portfolio results and 1-year stay of the bonds in the portfolio, – the hedging of the EM HY portfolio with the short UST positions do not compensate the negative impacts, during the periods when such setoff is the most needed. Fig 16 shows the time behavior of the 1-year changes in value of the model EM HY corporate bond portfolio hedged by the short positions in UST bonds, under the assumption of the complete portfolio rebalancing over 1-year time interval.

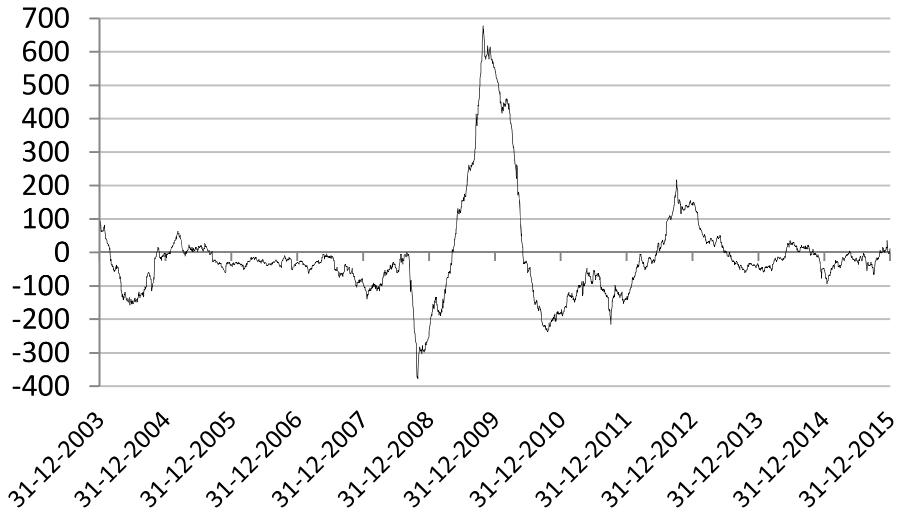

Figure 16. 1-year price changes for the EM HY long + UST short portfolio rebalancing over 1 year

As we could see by comparing Figures 15 and 16, the volatility, i.e., the width of the range, of 1-year price changes of the EM HY bond portfolio hedged by short positions in the US Treasuries is superior to the volatility of price changes for the non-hedged portfolio.

Figure 17 represents the time behavior of the 2-year changes in value of the model EM HY corporate bond portfolio and in the risk-free UST bond portfolio, with the rebalancing rate of the portfolios equal to 2 years.

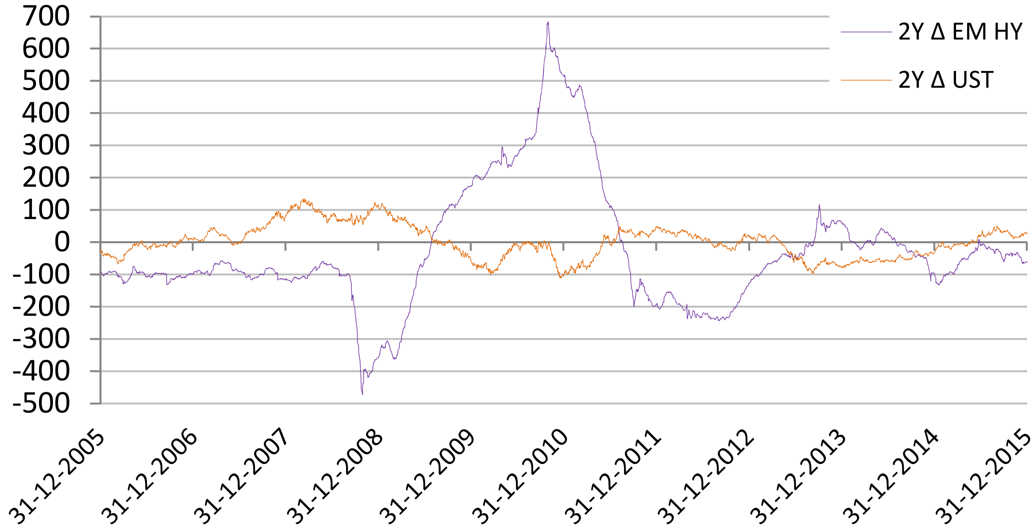

Figure 17. 2-year price changes for the EM HY and UST portfolios with 2 year bond holding period.

The chart above starts with the points plotted for December 31, 2005, which represent changes in the values of the portfolios occurred over the 2 years started December 31, 2003. One clearly observes that during the period prior and after the apogee of the global financial crises, in this case along 2006 – 2013, the changes in the portfolio values are in an opposite mode.

Hence, under the above mentioned assumptions regarding the portfolio strategy, i.e., 2-year long horizon to measure portfolio results and 2-year stay of the bonds in the portfolio, – the hedging of the EM HY portfolio with the short UST positions do not compensate the negative impacts, during the periods when such setoff is the most needed. Fig 18 shows the time behavior of the 2-year changes in value of the model EM HY corporate bond portfolio hedged by the short positions in UST bonds under the assumption of the complete portfolio rebalancing over 2-year time interval.

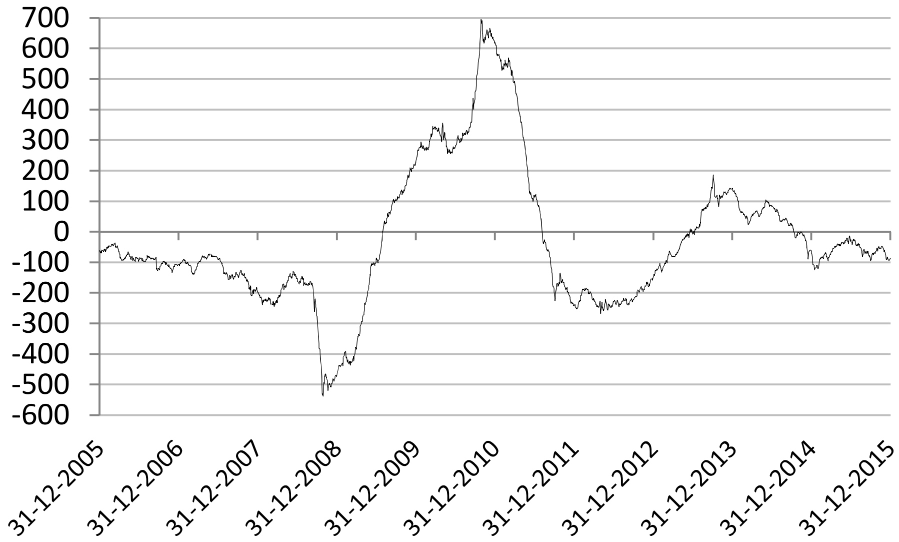

Figure 18. 2-year price changes for the EM HY long + UST short portfolio rebalancing over 2 years

As we could see by comparing Figures 17 and 18, the volatility, i.e., the width of the range, of 2-year price changes of the EM HY bond portfolio hedged by short positions in the US Treasuries is superior to the volatility of price changes for the non-hedged portfolio.

Figure 19 represents the time behavior of the 3-year changes in value of the model EM HY corporate bond portfolio and in the risk-free UST bond portfolio, with the rebalancing rate of the portfolios equal to 3 years.

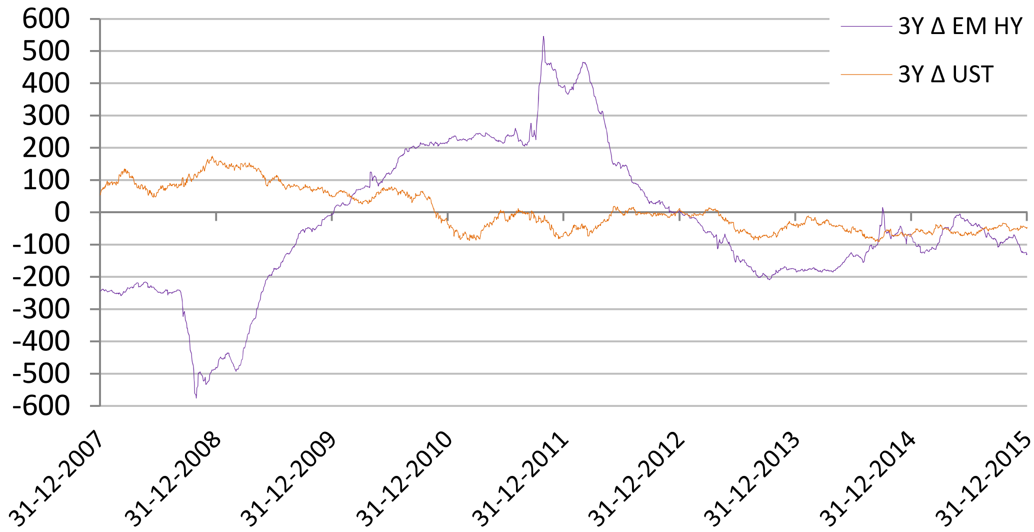

Figure 19. 3-year price changes for the EM HY and UST portfolios with 3 year bond holding period.

The chart above starts with the points plotted for December 31, 2007, which represent changes in the values of the portfolios occurred over the 3 years started December 31, 2004. One clearly observes that during the period prior and after the apogee of the global financial crises, in this case along 2007 – 2013, the changes in the portfolio values are in an opposite mode.

Hence, under the above mentioned assumptions regarding the portfolio strategy, i.e., 3-year long horizon to measure portfolio results and 3-year stay of the bonds in the portfolio, – the hedging of the EM HY portfolio with the short UST positions do not compensate the negative impacts, during the periods when such setoff is the most needed. Fig 20 shows the time behavior of the 3-year changes in value of the model EM HY corporate bond portfolio hedged by the short positions in UST bonds under the assumption of the complete portfolio rebalancing over 3-year time interval.

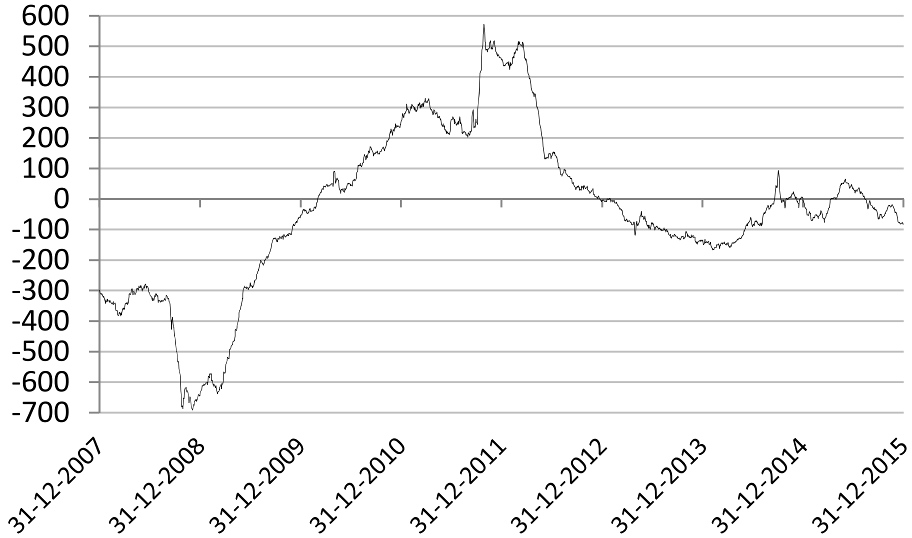

Figure 20. 3-year price changes for the EM HY long + UST short portfolio rebalancing over 3 years

As we could see by comparing Figures 19 and 20, the volatility, i.e., the width of the range, of 3-year price changes of the EM HY bond portfolio hedged by short positions in the US Treasuries is superior to the volatility of price changes for the non-hedged portfolio.

Table 4 provides the comparative analysis of upside and downside risk in the modeled EM HY portfolios of 1000 million USD, observed over the available present value gauging window as a function of the complete portfolio rebalancing period, i.e. the time each bond spends in the portfolio or the bond holding period, and of the time horizon used to calculate impacts in present values of the respective portfolios.

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes	EM HY max downside	UST short + EM HY max downside	EM HY max upside	UST short + EM HY max upside
1Y	*1Y*	*2003-2015*	*2004-2015*	-385.27	-377.88	637.58	677.71
2Y	*1Y*	*2004-2015*	*2005-2015*	-421.11	-445.59	529.87	602.50
2Y	*2Y*	*2004-2015*	*2006-2015*	-472.27	-538.06	683.39	695.76
3Y	*1Y*	*2005-2015*	*2006-2015*	-441.70	-491.20	485.97	559.59
3Y	*2Y*	*2005-2015*	*2007-2015*	-520.06	-610.99	648.14	664.14
3Y	*3Y*	*2005-2015*	*2008-2015*	-576.26	-691.85	546.30	572.96

Table 4. EM HY portfolios upsides and downsides for diverse bond holding periods and portfolio impact horizons

As could be seen from Table 4 the difference between the lowest losses and the highest gains in value of the portfolios hedged with short UST positions is always superior to that difference calculated for the unhedged portfolios. It means that, over the considered time windows, such hedge in fact does not hedge against the most extreme changes in IRR of the EM HY portfolios but rather leverage their IRR exposure. In more details the implications of these results will be addressed in the section dedicated to Discussions and Implications.

Table 5 provides the comparative analysis of the average returns originated from asset value changes. These returns were averaged over the respective available windows of price changes. We present our results for the long EM HY portfolio, long UST portfolio, and the long EM HY portfolio hedged with the portfolio of short positions in the UST. The comparison is made for several combinations of portfolio rebalancing rates and portfolio impact horizon intervals.

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes	Average EM HY return, (%)	Average UST return, (%)	Average EM HY + short UST return, (%)
1Y	*1Y*	*2003-2015*	*2004-2015*	-1.18%	-0.06%	-1.12%
2Y	*1Y*	*2004-2015*	*2005-2015*	-1.49%	0.10%	-1.59%
2Y	*2Y*	*2004-2015*	*2006-2015*	-2.53%	0.15%	-2.69%
3Y	*1Y*	*2005-2015*	*2006-2015*	-1.99%	0.20%	-2.19%
3Y	*2Y*	*2005-2015*	*2007-2015*	-2.95%	0.42%	-3.37%
3Y	*3Y*	*2005-2015*	*2008-2015*	-3.19%	0.57%	-3.76%

Table 5. Average asset value driven returns for the long EM HY, long UST, and hedged long EM HY short UST portfolios for diverse bond holding periods and impact horizons.

As could be seen from Table 5 for the average asset value driven returns of EM HY portfolios, they are considerably negative for all the presented here results gauging windows, reflecting the fact that EM HY corporates bonds were affected more strongly by the global financial crisis than the EM IG corporates securities. As it was mentioned while analyzing Table 3, the average returns of the UST portfolios are predominantly positive, reflecting the fact that the variations in interest rates are largely downward after since 2005, see Figures 1 and 2. In its turn this also explains an inefficiency of IRR hedging by short positions in US Treasuries from the point the point of view of improving HY EM corporate portfolio performance and/or mitigating downside risks.

4.3.3. Comparing performance of EM IG and HY corporate bond portfolios

It is worth performing comparative analysis of the EM IG and EM HY portfolios. Table 6 presents ranges of asset price volatility, calculated as the highest upside minus the lowest downside in the present value of the portfolio observed along the available window of price changes, for both, hedged by UST and unhedged EM IG and HY portfolios.

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes	Unhedged EM IG P&L volatility range	Hedged EM IG P&L volatility range	Unhedged EM HY P&L volatility range	Hedged EM HY P&L volatility range
1Y	*1Y*	*2003-2015*	*2004-2015*	424.09	447.72	1022.85	1055.59
2Y	*1Y*	*2004-2015*	*2005-2015*	429.67	492.29	950.99	1048.09
2Y	*2Y*	*2004-2015*	*2006-2015*	447.16	520.78	1155.66	1233.81
3Y	*1Y*	*2005-2015*	*2006-2015*	409.10	485.23	927.67	1050.79
3Y	*2Y*	*2005-2015*	*2007-2015*	455.97	566.73	1168.19	1275.14
3Y	*3Y*	*2005-2015*	*2008-2015*	425.31	563.68	1122.55	1264.80

Table 6. Price volatility ranges for EM IG and EM HY portfolios for diverse bond holding periods and portfolio impact horizons.

We clearly observe that the ranges of price changes for EM IG portfolios are more than two times narrower than those for EM HY portfolios. Thus, for the case of EM, our results explicitly attest that the present values of HY portfolios are much more volatile than the present values of IG portfolios.

Table 7 below summarizes statistics for the average returns of the unhedged EM IG, EM HY, and UST portfolios for diverse bond holding periods and portfolio impact horizons. The last two columns on the right hand side of the table present the average returns of EM IG and EM HY portfolios, respectively, being both hedged by short positions in US treasuries.

Bond Holding Period	Portfolio Impact Horizon	Available price history window	Available window of price changes	Average EM IG return, (%)	Average EM HY return, (%)	Average UST return, (%)	Average EM IG + short UST return, (%)	Average EM HY + short UST return, (%)
1Y	*1Y*	*2003-2015*	*2004-2015*	-0.21%	-1.18%	-0.06%	-0.15%	-1.12%
2Y	*1Y*	*2004-2015*	*2005-2015*	-0.13%	-1.49%	0.10%	-0.23%	-1.59%
2Y	*2Y*	*2004-2015*	*2006-2015*	-0.26%	-2.53%	0.15%	-0.41%	-2.69%
3Y	*1Y*	*2005-2015*	*2006-2015*	-0.23%	-1.99%	0.20%	-0.43%	-2.19%
3Y	*2Y*	*2005-2015*	*2007-2015*	-0.14%	-2.95%	0.42%	-0.55%	-3.37%
3Y	*3Y*	*2005-2015*	*2008-2015*	0.03%	-3.19%	0.57%	-0.54%	-3.76%

Table 7. Average asset value driven returns of EM IG, EM HY, and UST portfolios for diverse bond holding periods and portfolio impact horizons.

For the EM HY portfolios the average returns for the observed windows of price changes are considerably lower than the average returns for EM IG portfolios. It is somewhat expected result as the EM HY corporate bonds were supposed to be much more affected by the global financial crisis than the IM IG corporates. Still it is important to note, that the presented in Table 7 returns do not incorporate a part of net interest income (NII) pocketed along the available windows of price changes. As could be seen from Figures 2 and 3 the yields of EM IG and EM HY portfolios are always above 4% and 7%, respectively. Hence, the overall average results of holding EM portfolios during the analyzed periods are positive. This is consistent with conclusions from the trends of diverse total return indexes through the time intervals under considerations; see for example J.P. Morgan EMBI Global Composite (Bloomberg ticker JPEGCOMP). Nevertheless, as we are focused at interest rate sensitivity of assets in a sense of interest rate induced impacts in the present value of assets, we opt to leave NII considerations and total return considerations out of the scope of our analysis.

4.4. Assessing price-wise interest rate sensitivity of EM bond portfolios

In this section we perform a quantitative assessment of the price sensitivity of a chosen EM portfolio to changes in prices of the corresponding portfolio of US Treasuries. Instead of trying to come up with average sensitivity figures for all the available data history, we apply the methodology developed in Gubareva M. & Borges M. (2016). So, we identify the local extrema of the presented in the previous section 4.3 modeled historical series of annual changes in present values of the UST and EM bonds portfolios. In this way, we have identified 61 big moves, i.e. ups and downs, which we distributed among 3 period: 20 price moves in the “old normal” pre-crisis period (01.01.2004 – 13.07.2007), 31 moves during the ignition of and healing from the crisis (13.07.2007 – 04.04.2013), and 20 moves during the “new normal” post-crisis period (03.04.2013 – 30.06.2016). The sensitivity figures are calculated separately for each gains/losses move for both, IG and HY EM bond portfolios.

It is worth noting that being focused at price changes over rather long periods of one, two, and three years, we are not so much interested in daily responses of EM portfolios to daily moves in the yield of US government securities, even though all the historical series of price changes are calculated on a daily basis. We approach the problem of interest rate sensitivity from the portfolio management and risk management perspective, and hence we try to understand how EM portfolio prices respond to the inducing moves of UST prices. At this stage we also restrict the scope of our sensitivity studies to portfolios which are completely rebalanced during 1 year and analyze the impacts in asset prices over the 1 year horizon, see Figure 9 for the case of EM IG portfolio and Figure 15 for the case of EM HY portfolio. Comparative analyses of HY versus IG debt sensitivities are also provided.

4.4.1. Price-wise interest rate sensitivity during the pre-crisis period

4.4.1.1. Pre-crisis price-wise interest rate sensitivity of EM IG portfolio

Table 8 represents 20 major moves in the over-1-year price changes during the "old normal" pre-crisis period (01.01.2004 – 13.07.2007). For each of these 20 time windows we calculate the corresponding 1-year price change deltas for both, the UST and EM IG modeled portfolios. We also present the respective sensitivity coefficient calculated as the ratio of the value change delta observed in the EM IG portfolio to the "inducing" value change delta observed in the UST portfolio. For informative purposes we present our calculations of arithmetic average, endurance window weighted average, amplitude weighted average and endurance-times-amplitude weighted average of sensitivity coefficients. These values are averaged over three different aggregated arrays of the windows; the aggregate array of the UST positive deltas, the aggregate array of the UST negative deltas, and for the entire span of the "old normal" pre-crisis interval.

Date	Endurance window (days) (A)	Δ in UST 1Y price change (B)	Δ in EM IG 1Y price change (C)	Sensitivity D = C / B	Endurance weighted sensitivity E = A x D	Amplitude weighted sensitivity F = |B| x D	Endurance and Amplitude weighted sensitivity G = A x |B| x D
01-01-2004							
13-01-2004	13	32,69	21,39	0,65	8,5	21,4	278
03-03-2004	50	-17,31	-17,74	1,03	51,3	17,7	887
22-03-2004	19	43,08	30,05	0,70	13,3	30,0	571
14-06-2004	84	-83,17	-102,16	1,23	103,2	102,2	8582
31-08-2004	78	122,43	107,74	0,88	68,6	107,7	8404
30-09-2004	30	-38,80	-16,28	0,42	12,6	16,3	488
29-10-2004	29	25,07	17,77	0,71	20,5	17,8	515
11-01-2005	74	-33,74	-17,21	0,51	37,7	17,2	1273
08-02-2005	28	11,50	21,18	1,84	51,6	21,2	593
16-03-2005	36	-39,45	-36,30	0,92	33,1	36,3	1307
24-05-2005	69	71,71	58,67	0,82	56,4	58,7	4048
03-11-2005	163	-60,44	-71,07	1,18	191,7	71,1	11584
24-03-2006	141	39,13	27,10	0,69	97,6	27,1	3821
26-06-2006	94	-42,31	-41,96	0,99	93,2	42,0	3945
04-12-2006	161	70,08	79,27	1,13	182,1	79,3	12762
10-01-2007	37	-20,35	-15,01	0,74	27,3	15,0	555
25-04-2007	105	23,27	20,91	0,90	94,3	20,9	2195
04-06-2007	40	-25,41	-13,53	0,53	21,3	13,5	541
27-06-2007	23	5,70	2,31	0,41	9,3	2,3	53
13-07-2007	16	-12,89	-14,13	1,10	17,5	14,1	226
Total (Average): UST gain windows	666	444,66	386,37	0,87	0,90	0,87	**0,92**
Total (Average): UST loss windows	624	-373,86	-345,40	0,86	0,94	0,92	**1,02**
Sensitivity Averaged over the whole period				0,87	0,92	0,89	**0,96**

Table 8. Price-wise IR sensitivity of EM IG bonds along the pre-crisis period.

Although the four sensitivity column of Table 8 present the four different kinds of sensitivity mentioned above, we argue that from the portfolio management and/or risk management perspective the most comprehensive figures are the three sensitivity coefficients at the bottom of the right-most column, that is, endurance-times-amplitude weighted average of sensitivity coefficients. In this way, while calculating the averaged figures we ascribe bigger weights to stronger and more lasting moves of the risk-free interest rates, as exactly these types of moves are expected to and in fact provide the most important impacts on EM IG portfolios from an asset value perspective.

The sensitivity averaged over the entire "old normal" pre-crisis period (01.01.2004 – 13.07.2007), i.e. 0.96, is very closed to 1, meaning that price changes relative to EM IG portfolio closely mirror price changes of UST portfolio. In other words, a move in the risk-free interest rate is almost entirely passed through to the yield of EM IG bonds.

While comparing EM IG sensitivity averaged over the windows of the positive UST price deltas (risk free-rates downtrend intervals), i.e. 0.92, with EM IG sensitivity averaged over the windows of the negative UST price deltas (risk free-rates uptrend intervals), i.e. 1.02 we could infer that decreases of risk-free interest rates affect EM IG bonds in a weaker manner than the increases of risk-free interest rates. In other words, the EM IG portfolio suffers from risk-free rate increases more than benefits from risk-free rate decreases.

Figure 21 below represents historic behavior of endurance-times-amplitude weighted sensitivity; see the right most column of Table 8. The value of the sensitivity is depicted constant for the entire interval along which it was calculated.

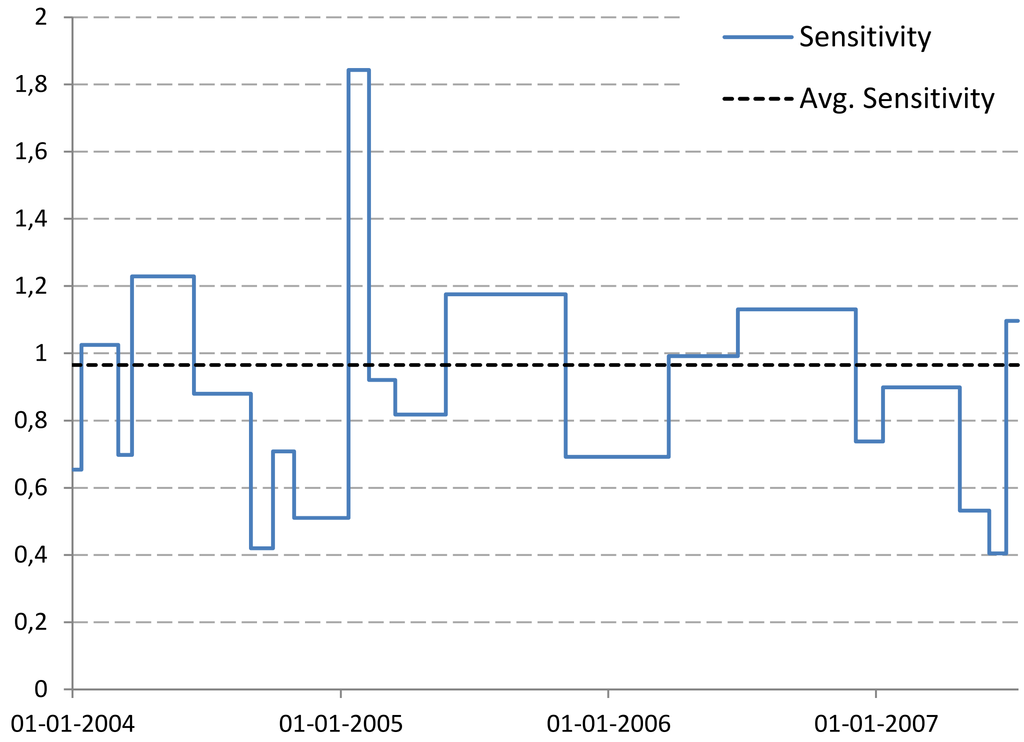

Figure 21. Price-wise endurance-times-amplitude weighted sensitivity of EM IG portfolio along the pre-crisis period (01.01.2004 – 13.07.2007).

Although the dynamics of sensitivity exhibits certain volatility, the value of sensitivity coefficient always remains positive. For the major part of time, it is situated within 0.7 - 1.2 range, centered at its average value of 0.96. When the value of sensitivity coefficient is below 1, the impact of risk-free interest rate changes is damped. On the contrary, when the value of sensitivity coefficient is above 1 the impact of risk-free interest rate changes on EM IG portfolio prices is amplified.

4.4.1.2. Pre-crisis price-wise interest rate sensitivity of EM HY portfolio

Similarly to the case of IG, Table 9 represents 20 major moves in the over-1-year price changes of EM HY portfolio during the "old normal" pre-crisis period (01.01.2004 – 13.07.2007). For each of these 20 time windows we calculate the corresponding 1-year price change deltas for both, the UST and EM HY modeled portfolios. We also present the respective sensitivity coefficient calculated as the ratio of the value change delta observed in the EM HY portfolio to the "inducing" value change delta observed in the UST portfolio. For informative purposes we present our calculations of arithmetic average, endurance window weighted average, amplitude weighted average and endurance-times-amplitude weighted average of sensitivity coefficients. These values are averaged over three different aggregated arrays of the windows; the aggregate array of the UST positive deltas, the aggregate array of the UST negative deltas, and for the entire span of the "old normal" pre-crisis interval.

Date	Endurance window (days) (A)	Δ in UST 1Y price change (B)	Δ in EM IG 1Y price change (C)	Sensitivity D = C / B	Endurance weighted sensitivity E = A x D	Amplitude weighted sensitivity F = |B| x D	Endurance and Amplitude weighted sensitivity G = A x |B| x D
01-01-2004							
13-01-2004	13	32,69	-6,45	-0,20	-2,6	-6,5	-84
03-03-2004	50	-17,31	-99,99	5,78	288,9	100,0	5000
22-03-2004	19	43,08	4,74	0,11	2,1	4,7	90
14-06-2004	84	-83,17	-159,91	1,92	161,5	159,9	13432
31-08-2004	78	122,43	124,53	1,02	79,3	124,5	9713
30-09-2004	30	-38,80	31,42	-0,81	-24,3	-31,4	-943
29-10-2004	29	25,07	7,77	0,31	9,0	7,8	225
11-01-2005	74	-33,74	40,98	-1,21	-89,9	-41,0	-3032
08-02-2005	28	11,50	32,09	2,79	78,1	32,1	898
16-03-2005	36	-39,45	-5,54	0,14	5,1	5,5	199
24-05-2005	69	71,71	28,26	0,39	27,2	28,3	1950
03-11-2005	163	-60,44	-98,82	1,64	266,5	98,8	16108
24-03-2006	141	39,13	36,83	0,94	132,7	36,8	5193
26-06-2006	94	-42,31	-30,74	0,73	68,3	30,7	2890
04-12-2006	161	70,08	40,87	0,58	93,9	40,9	6580
10-01-2007	37	-20,35	-2,99	0,15	5,4	3,0	111
25-04-2007	105	23,27	29,22	1,26	131,8	29,2	3068
04-06-2007	40	-25,41	-9,60	0,38	15,1	9,6	384
27-06-2007	23	5,70	4,01	0,70	16,2	4,0	92
13-07-2007	16	-12,89	-9,35	0,73	11,6	9,3	150
Total (Average): UST gain windows	666	444,66	301,85	0,79	0,85	0,68	**0,77**
Total (Average): UST loss windows	624	-373,86	-344,54	0,94	1,13	0,92	**1,19**
Sensitivity Averaged over the whole period				0,87	0,99	0,79	**0,96**

Table 9. Price-wise IR sensitivity of EM HY bonds along the pre-crisis period.

As could be seen in the right-most column of Table 9, the endurance-times-amplitudes weighted sensitivity of EM HY portfolio averaged over the whole "old normal" pre-crisis period (01.01.2004 – 13.07.2007), i.e. 0.96, is very closed to 1 as well as in the case of the EM IG portfolio. It means that price changes relative to EM HY portfolio on average closely mirror price changes of UST portfolio. In other words, a move in the risk-free interest rate is almost entirely passed through to the yield of EM HY bonds.

While comparing EM HY sensitivity averaged over the windows of the positive UST price deltas (risk free-rates downtrend intervals), i.e. 0.77, with EM HY sensitivity averaged over the windows of the negative UST price deltas (risk free-rates uptrend intervals), i.e. 1.19 we could infer that decreases of risk-free interest rates affect EM HY bonds in a weaker manner than the increases of risk-free interest rates. In other words, the EM HY portfolio suffers from risk-free rate increases more than benefits from risk-free rate decreases. Although as stated above for the entire span of the pre-crisis period, a move in the risk-free interest rate is almost entirely passed through to the yield of EM HY bonds, for the risk free-rates downtrend intervals roughly only 77% of a move in the risk-free interest rate is passed through while for risk free-rates uptrend intervals roughly 119% is passed through to the yield of EM HY bonds.

Figure 22 below represents historic behavior of endurance-times-amplitude weighted sensitivity; see the right most column of Table 9. The value of the sensitivity is depicted constant for the entire interval along which it was calculated.

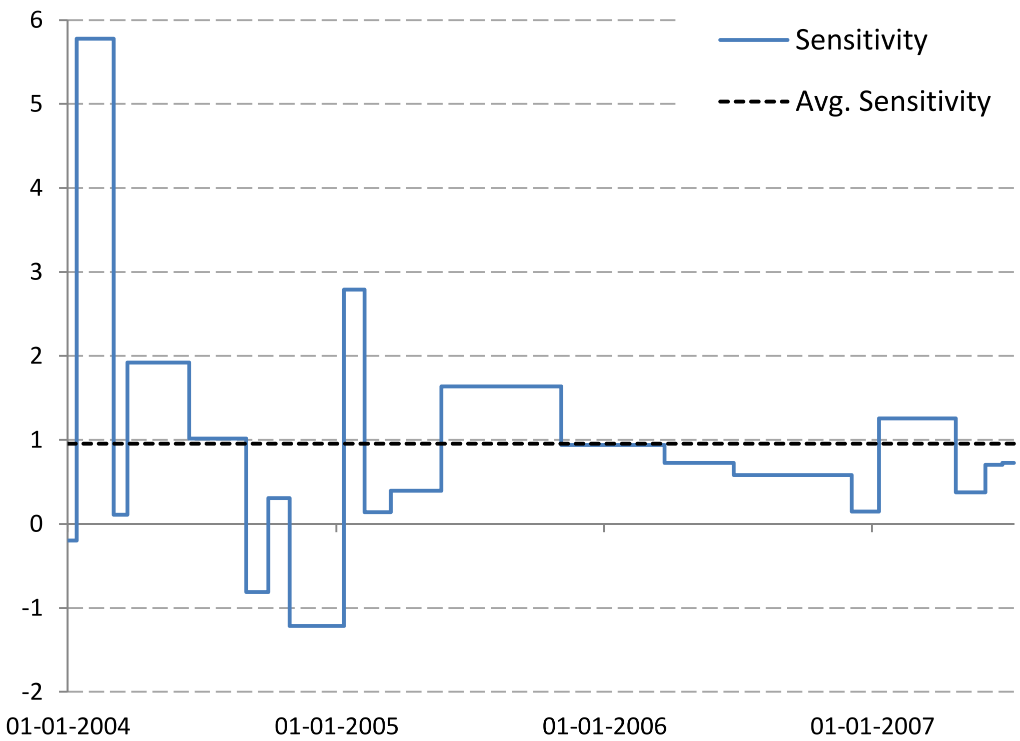

Figure 22. Price-wise endurance-times-amplitude weighted sensitivity of EM HY portfolio along the pre-crisis period (01.01.2004 – 13.07.2007).

In this case of the EM HY portfolio the dynamics of sensitivity exhibits considerable volatility in such a way that the value of sensitivity coefficient for a few intervals becomes negative. The range of volatility -1.2 – 5.8 is roughly four times larger than the range observed in the case of the EM IG portfolio: 0.4 – 1.8, see Figure 21. It may also mean that certain factors common for EM HY debt, but different from risk-free interest rate consideration, could impact prices of EM HY bond portfolio in a much more severe manner than prices of EM IG bond portfolios, either amplifying (sensitivity above 1), or reducing (sensitivity between 0 and 1), and even inverting (sensitivity below 0) impacts of the respective UST portfolio dynamics. These common EM HY debt factors could be represented, for instance, by sudden changes in HY risk perception, risk-on/risk-off market attitude switches, and EM specific flights-to-quality. Nevertheless, the average sensitivity over the entire pre-crisis period is equal to 0.96, i.e. closed to 1 meaning that on average all these impacts of leads and lags-like imperfections are cancelled out.

4.4.2. Price-wise interest rate sensitivity during the crisis period

4.4.2.1. Through-the-crisis price-wise interest rate sensitivity of EM IG portfolio

Similarly to the results presented in the Section 4.4.1 for the pre-crisis period, Table 10 represents 31 major moves in the over-1-year price changes during the "distressed" through-the-crisis period (13.07.2007 – 03.04.2013). For each of these 31 time windows we calculate the corresponding 1-year price change deltas for both, the UST and EM IG modeled portfolios. We also present the respective sensitivity coefficient calculated as the ratio of the value change delta observed in the EM IG portfolio to the "inducing" value change delta observed in the UST portfolio. For informative purposes we present our calculations of arithmetic average, endurance window weighted average, amplitude weighted average and endurance-times-amplitude weighted average of sensitivity coefficients. These values are averaged over three different aggregated arrays of the windows; the aggregate array of the UST positive deltas, the aggregate array of the UST negative deltas, and for the entire span of the "distressed" through-the-crisis interval.

Date	Endurance window (days) (A)	Δ in UST 1Y price change (B)	Δ in EM IG 1Y price change (C)	Sensitivity D = C / B	Endurance weighted sensitivity E = A x D	Amplitude weighted sensitivity F = |B| x D	Endurance and Amplitude weighted sensitivity G = A x |B| x D
13-07-2007							
26-11-2007	136	43,60	-35,00	-0,80	-109,2	-35,0	-4760
26-12-2007	30	-26,26	-2,19	0,08	2,5	2,2	66
22-01-2008	27	56,38	14,17	0,25	6,8	14,2	383
27-02-2008	36	-39,44	-20,30	0,51	18,5	20,3	731
06-06-2008	100	-5,67	29,48	-5,19	-519,5	-29,5	-2948
01-07-2008	25	-20,75	-11,26	0,54	13,6	11,3	282
08-09-2008	69	-29,85	2,14	-0,07	-5,0	-2,1	-148
07-10-2008	29	35,21	-42,91	-1,22	-35,3	-42,9	-1244
29-10-2008	22	-29,36	-113,74	3,87	85,2	113,7	2502
24-11-2008	26	-16,25	57,61	-3,54	-92,2	-57,6	-1498
16-12-2008	22	57,41	36,56	0,64	14,0	36,6	804
17-03-2009	91	-91,12	33,09	-0,36	-33,0	-33,1	-3011
27-04-2009	41	57,98	49,81	0,86	35,2	49,8	2042
08-06-2009	42	-47,43	37,37	-0,79	-33,1	-37,4	-1569
22-07-2009	44	41,75	35,13	0,84	37,0	35,1	1546
29-10-2009	99	-25,97	174,54	-6,72	-665,4	-174,5	-17279
30-12-2009	62	-54,23	-126,40	2,33	144,5	126,4	7837
10-08-2010	223	147,54	-173,05	-1,17	-261,5	-173,0	-38590
10-09-2010	31	-29,52	-23,33	0,79	24,5	23,3	723
04-11-2010	55	26,23	15,70	0,60	32,9	15,7	863
17-11-2010	13	-32,48	-20,40	0,63	8,2	20,4	265
01-07-2011	226	-53,29	53,55	-1,00	-227,1	-53,5	-12102
09-09-2011	70	40,89	3,34	0,08	5,7	3,3	234
12-10-2011	33	-37,06	-28,81	0,78	25,7	28,8	951
14-02-2012	125	71,96	58,55	0,81	101,7	58,6	7319
19-03-2012	34	-42,67	-4,59	0,11	3,7	4,6	156
10-04-2012	22	31,96	3,41	0,11	2,4	3,4	75
31-05-2012	51	-29,62	-14,42	0,49	24,8	14,4	736
03-10-2012	125	-33,81	51,86	-1,53	-191,7	-51,9	-6482
29-01-2013	118	-15,88	-44,72	2,82	332,4	44,7	5277
03-04-2013	64	37,32	-12,37	-0,33	-21,2	-12,4	-792
Total (Average): UST gain windows	858	648,23	-46,66	0,06	-0,22	-0,07	**-0,51**
Total (Average): UST loss windows	1233	-660,65	29,46	-0,33	-0,88	-0,04	**-0,55**
Sensitivity Averaged over the whole period				-0,14	-0,61	-0,06	**-0,53**

Table 10. Price-wise IR sensitivity of EM IG bonds along the through-the-crisis period.

As could be seen in the right-most column of Table 10, the endurance-times-amplitudes weighted sensitivity of EM IG portfolio averaged over the whole “distressed” through-the-crisis period (13.07.2007 – 03.04.2013) is negative and equal to -0.53. It means that on average price changes of the EM IG portfolio exhibit inverted behavior while compared to price changes of the UST portfolio.

The sign of a price change delta relative to the EM IG portfolio is opposite to the price change delta observed in the portfolio of US government bonds, while amplitude of a price response observed in the EM IG portfolio is equal to 53% of the price change relative to UST securities. In other words, during "distressed" through-the-crisis period while the yield on a US government debt is rising, the spread of EM IG debt over the UST yield is narrowing in such a way that it is absorbing all the increase in risk-free rates and even causes a decrease in the EM IG yield. On the contrary, while the yield on a US government debt is decreasing, the yield on EM IG bonds is increasing. This behavior corresponds to the outcomes of structural Merton´s (1974) model, positing the influence of interest rate changes upon creditworthiness of corporate obligors.

It is also worth noting that the endurance-times-amplitude average sensitivity varies drastically, if averaging is performed over three different types of the time windows, namely gain-gain intervals (blue shadow), loss-loss intervals (beige shadow), and opposite moves intervals (violet shadow). The sensitivity coefficient (not presented in Table 10) equals 0.62, 1.38, and -1.22, respectively. If one applies the endurance-times-amplitude averaging to these three figures, result will be the overall negative sensitivity equal to -0.53, as stated in the previous paragraph.

Figure 23 below represents historic behavior of endurance-times-amplitude weighted sensitivity; see the right most column of Table 10. The value of the sensitivity is depicted constant for the entire interval along which it was calculated.

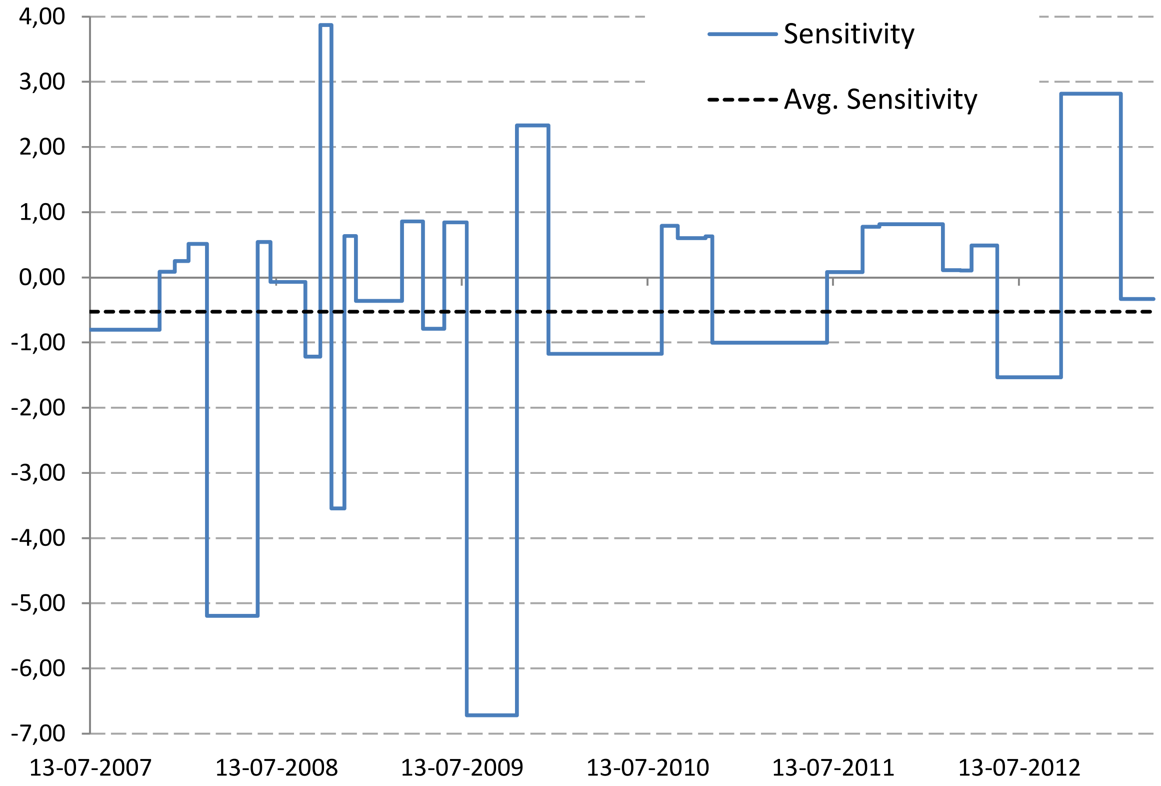

Figure 23. Price-wise endurance-times-amplitude weighted sensitivity of EM IG portfolio along the through-the-crisis period (13.07.2007 – 03.04.2013).

In this case of the "distressed" through-the-crisis period the dynamics of the EM IG portfolio sensitivity exhibits volatility considerably superior to the pre-crisis period. The width of the -6.7 – 3.9 volatility range equals to 10.6 being many times wider that the pre-crisis width of 1.4 as per Figure 21. Although the sensitivity coefficients values exhibit several negative and also positive spikes, this volatility range is centered at the negative level of -0.53 certifying that the overall price-wise sensitivity of EM IG portfolio is negative though attenuated if compared to the amplitude of "inducing" price changes of UST portfolio.

4.4.2.2. Through-the-crisis price-wise interest rate sensitivity of EM HY portfolio

Similarly to the results presented in the Section 4.4.2.1 for the EM IG portfolio sensitivity, Table 11 represents 31 major moves in the over-1-year price changes during the "distressed" through-the-crisis period (13.07.2007 – 03.04.2013). For each of these 31 time windows we calculate the corresponding 1-year price change deltas for both, the UST and EM HY modeled portfolios. We also present the respective sensitivity coefficient calculated as the ratio of the value change delta observed in the EM HY portfolio to the "inducing" value change delta observed in the UST portfolio. For informative purposes we present our calculations of arithmetic average, endurance window weighted average, amplitude weighted average and endurance-times-amplitude weighted average of sensitivity coefficients. These values are averaged over three different aggregated arrays of the windows; the aggregate array of the UST positive deltas, the aggregate array of the UST negative deltas, and for the entire span of the "distressed" through-the-crisis interval.

Date	Endurance window (days) (A)	Δ in UST 1Y price change (B)	Δ in EM HY 1Y price change (C)	Sensitivity D = C / B	Endurance weighted sensitivity E = A x D	Amplitude weighted sensitivity F = |B| x D	Endurance and Amplitude weighted sensitivity G = A x |B| x D
13-07-2007							
26-11-2007	136	43,60	-49,29	-1,13	-153,7	-49,3	-6704
26-12-2007	30	-26,26	0,83	-0,03	-0,9	-0,8	-25
22-01-2008	27	56,38	-5,99	-0,11	-2,9	-6,0	-162
27-02-2008	36	-39,44	9,70	-0,25	-8,9	-9,7	-349
06-06-2008	100	-5,67	33,85	-5,96	-596,5	-33,8	-3385
01-07-2008	25	-20,75	-15,14	0,73	18,2	15,1	379
08-09-2008	69	-29,85	10,73	-0,36	-24,8	-10,7	-741
07-10-2008	29	35,21	-155,80	-4,42	-128,3	-155,8	-4518
29-10-2008	22	-29,36	-211,54	7,21	158,5	211,5	4654
24-11-2008	26	-16,25	83,11	-5,11	-133,0	-83,1	-2161
16-12-2008	22	57,41	60,64	1,06	23,2	60,6	1334
17-03-2009	91	-91,12	45,16	-0,50	-45,1	-45,2	-4109
27-04-2009	41	57,98	133,60	2,30	94,5	133,6	5478
08-06-2009	42	-47,43	147,17	-3,10	-130,3	-147,2	-6181
22-07-2009	44	41,75	77,97	1,87	82,2	78,0	3431
29-10-2009	99	-25,97	473,43	-18,23	-1805,0	-473,4	-46869
30-12-2009	62	-54,23	-169,78	3,13	194,1	169,8	10526
10-08-2010	223	147,54	-559,37	-3,79	-845,4	-559,4	-124740
10-09-2010	31	-29,52	-44,34	1,50	46,6	44,3	1374
04-11-2010	55	26,23	-23,14	-0,88	-48,5	-23,1	-1273
17-11-2010	13	-32,48	-15,88	0,49	6,4	15,9	206
01-07-2011	226	-53,29	96,64	-1,81	-409,9	-96,6	-21840
09-09-2011	70	40,89	-38,69	-0,95	-66,2	-38,7	-2708
12-10-2011	33	-37,06	-48,80	1,32	43,5	48,8	1611
14-02-2012	125	71,96	144,67	2,01	251,3	144,7	18083
19-03-2012	34	-42,67	23,89	-0,56	-19,0	-23,9	-812
10-04-2012	22	31,96	-14,90	-0,47	-10,3	-14,9	-328
31-05-2012	51	-29,62	-0,39	0,01	0,7	0,4	20
03-10-2012	125	-33,81	206,58	-6,11	-763,9	-206,6	-25823
29-01-2013	118	-15,88	-129,50	8,16	962,5	129,5	15281
03-04-2013	64	37,32	-39,89	-1,07	-68,4	-39,9	-2553
Total (Average): UST gain windows	858	648,23	-470,19	-0,46	-1,02	-0,73	**-1,81**
Total (Average): UST loss windows	1233	-660,65	495,71	-1,03	-2,03	-0,75	**-1,69**
Sensitivity Averaged over the whole period				-0,75	-1,62	-0,74	**-1,76**

Table 11. Price-wise IR sensitivity of EM HY bonds along the through-the-crisis period.

As could be seen in the right-most column of Table 11, the endurance-times-amplitudes weighted sensitivity of EM HY portfolio averaged over the whole "distressed" through-the-crisis period (13.07.2007 – 03.04.2013) is negative and equal to -1.76. It means that on average price changes of the EM HY portfolio exhibit inverted behavior while compared to price changes of the UST portfolio.

The sign of a price change delta relative to the EM HY portfolio is opposite to the price change delta observed in the portfolio of US government bonds, while amplitude of a price response observed in the EM IG portfolio is equal to 176% of the price change relative to UST securities. In other words, during "distressed" through-the-crisis period while the yield on a US government debt is rising, the spread of EM HY debt over the UST yield is narrowing in such a way that it is absorbing all the increase in risk-free rates and even causes a decrease in the EM HY yield. On the contrary, while the yield on a US government debt is decreasing, the yield on EM HY bonds is increasing. As in the EM IG case, this behavior corresponds to the outcomes of structural Merton´s (1974) model, but in the EM HY case the amplitude of the response is amplified. It certifies that in EM HY case the influence of interest rate changes upon creditworthiness of EM HY corporate obligors is stronger than in the case of EM IG debt issuers.

It is also worth noting that the endurance-times-amplitude average sensitivity varies drastically, if averaging is performed over three different types of the time windows, namely gain-gain intervals (blue shadow), loss-loss intervals (beige shadow), and opposite moves intervals (violet shadow). The sensitivity coefficient (not presented in Table 11) equals 1.96, 3.25, and -3.02, respectively. If one applies the endurance-times-amplitude averaging to these three figures, result will be the overall negative sensitivity equal to -1.76, as stated in the previous paragraph. It is worth noting that during the "distressed" through-the-crisis period EM HY portfolios are more than trice sensitive while compared to EM IG portfolios with average sensitivity coefficient equal to -0.53.

Figure 24 below represents historic behavior of endurance-times-amplitude weighted sensitivity of the EM HY corporate debt; see the right most column of Table 11. The value of the sensitivity is depicted constant for the entire interval along which it was calculated.

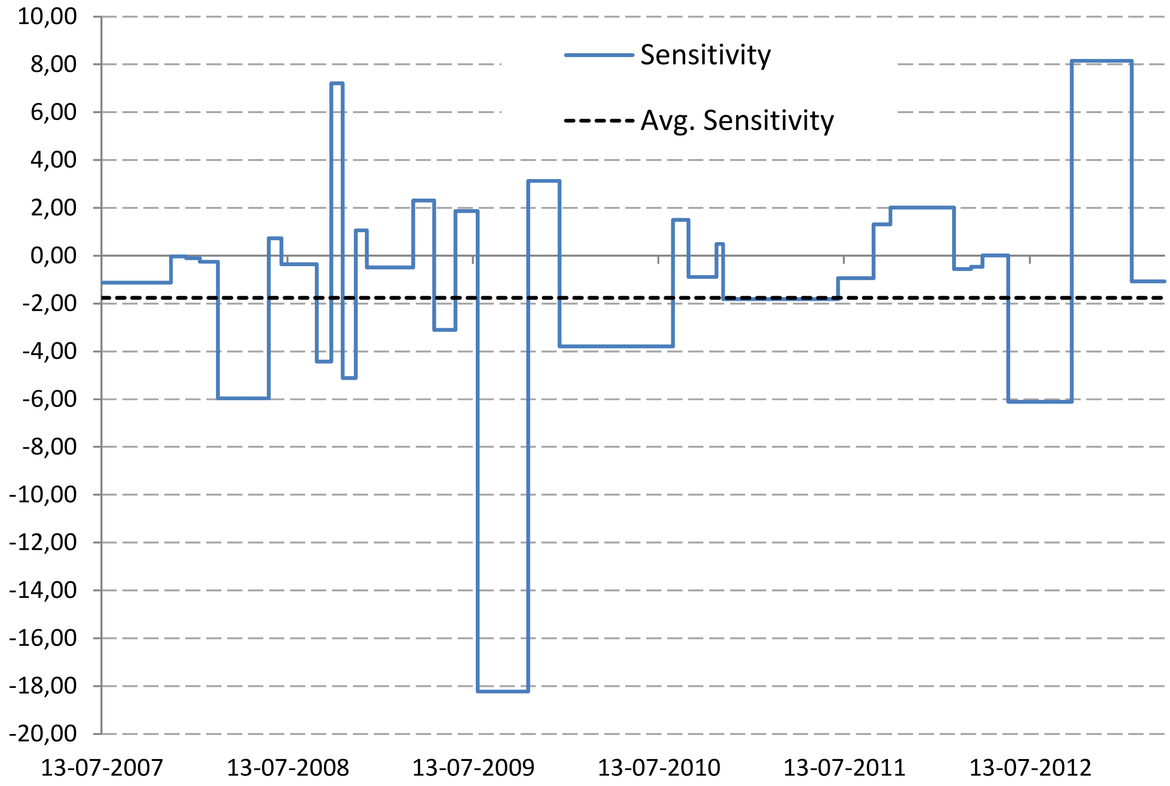

Figure 24. Price-wise endurance-times-amplitude weighted sensitivity of EM HY portfolio along the through-the-crisis period (13.07.2007 – 03.04.2013).

In this case of the "distressed" through-the-crisis period the dynamics of the EM HY portfolio sensitivity exhibits volatility considerably superior to the pre-crisis period. The width of the -18.2 – 8.2 volatility range equals 26.4 being many times wider that the pre-crisis width of 7.0 as per Figure 22. On the other hand, the range of EM HY volatility -18.2 – 8.2 is roughly 2.5 times larger than the range observed in the case of the EM IG portfolio: -6.7 – 3.9, see Figures 23 and 24.

Although the sensitivity coefficients values exhibit several negative and also positive spikes, this volatility range for EM HY corporate debt is centered at the negative level of -1.76 certifying that the overall price-wise sensitivity of EM HY portfolio is negative and amplified if compared to the amplitude of "inducing" price changes of UST portfolio.

4.4.3. Price-wise interest rate sensitivity during the post-crisis period

4.4.3.1. Post-crisis price-wise interest rate sensitivity of EM IG portfolio

Table 12 represents 20 major moves in the over-1-year price changes during the "new normal" post-crisis period (03.04.2013 – 26.06.2016). For each of these 20 time windows we calculate the corresponding 1-year price change deltas for both, the UST and EM IG modeled portfolios. We also present the respective sensitivity coefficient calculated as the ratio of the value change delta observed in the EM IG portfolio to the "inducing" value change delta observed in the UST portfolio. For informative purposes we present our calculations of arithmetic average, endurance window weighted average, amplitude weighted average and endurance-times-amplitude weighted average of sensitivity coefficients. These values are averaged over three different aggregated arrays of the windows; the aggregate array of the UST positive deltas, the aggregate array of the UST negative deltas, and for the entire span of the "new normal" post-crisis interval.

Date	Endurance window (days) (A)	Δ in UST 1Y price change (B)	Δ in EM IG 1Y price change (C)	Sensitivity D = C / B	Endurance weighted sensitivity E = A x D	Amplitude weighted sensitivity F = |B| x D	Endurance and Amplitude weighted sensitivity G = A x |B| x D
03-04-2013							
05-07-2013	93	-49,98	-52,51	1,05	97,7	52,5	4883
08-08-2013	34	23,37	-2,42	-0,10	-3,5	-2,4	-82
05-09-2013	28	-21,51	-14,16	0,66	18,4	14,2	396
24-10-2013	49	39,78	28,88	0,73	35,6	28,9	1415
27-12-2013	64	-17,94	5,20	-0,29	-18,5	-5,2	-333
03-02-2014	38	26,43	16,98	0,64	24,4	17,0	645
03-04-2014	59	-18,88	17,61	-0,93	-55,0	-17,6	-1039
25-06-2014	83	51,83	72,50	1,40	116,1	72,5	6017
30-07-2014	35	-12,31	-19,10	1,55	54,3	19,1	669
05-09-2014	37	21,49	18,21	0,85	31,4	18,2	674
06-11-2014	62	-27,69	-40,52	1,46	90,7	40,5	2513
15-01-2015	70	33,83	-16,77	-0,50	-34,7	-16,8	-1174
03-03-2015	47	-36,43	-7,29	0,20	9,4	7,3	343
02-04-2015	30	23,96	5,90	0,25	7,4	5,9	177
18-08-2015	138	-33,29	-34,45	1,03	142,8	34,5	4755
02-10-2015	45	18,14	15,31	0,84	38,0	15,3	689
14-01-2016	104	-38,24	5,12	-0,13	-13,9	-5,1	-533
10-02-2016	27	37,97	8,38	0,22	6,0	8,4	226
25-04-2016	75	-23,51	1,63	-0,07	-5,2	-1,6	-122
27-06-2016	63	37,94	26,30	0,69	43,7	26,3	1657
Total (Average): UST gain windows	705	-279,78	-138,49	0,45	0,45	0,49	**0,53**
Total (Average): UST loss windows	476	314,73	173,25	0,50	0,56	0,55	**0,63**
Sensitivity Averaged over the whole period				0,48	0,50	0,52	**0,58**

Table 12. Price-wise IR sensitivity of EM IG bonds along the post-crisis period.

As could be seen in the right-most column of Table 12, the endurance-times-amplitudes weighted sensitivity of EM IG portfolio averaged over the entire "new normal" post-crisis period (03.04.2013 – 26.06.2016), is equal to 0.58. Differently to the "old normal" pre-crisis period the average sensitivity coefficient is not closed to 1, certifying a kind of reduced sensitivity of the EM IG portfolio to price changes of the corresponding UST portfolio. The sign of a price response relative of the EM IG portfolio is the same as the sign of the "inducing" price change occurred in the portfolio of US government bonds, but amplitude of the price response observed in the EM IG portfolio is equal just to 58% of the price change relative to UST securities. In other words, a move in the risk-free interest rate is only partially passed through to the yield of EM IG bonds.

While comparing EM IG sensitivity averaged over the windows of the positive UST price deltas (risk free-rates downtrend intervals), i.e. 0.53, with EM IG sensitivity averaged over the windows of the negative UST price deltas (risk free-rates uptrend intervals), i.e. 0.63 we could infer that decreases of risk-free interest rates affect EM IG bonds in a weaker manner than the increases of risk-free interest rates. In other words, similarly to the "old normal" pre-crisis period, during the "new normal" post-crisis conditions, the EM IG portfolio also suffers from risk-free rate increases more than benefits from risk-free rate decreases.

Figure 25 below represents historic behavior of endurance-times-amplitude weighted sensitivity; see the right most column of Table 12. The value of the sensitivity is depicted constant for the entire interval along which it was calculated.

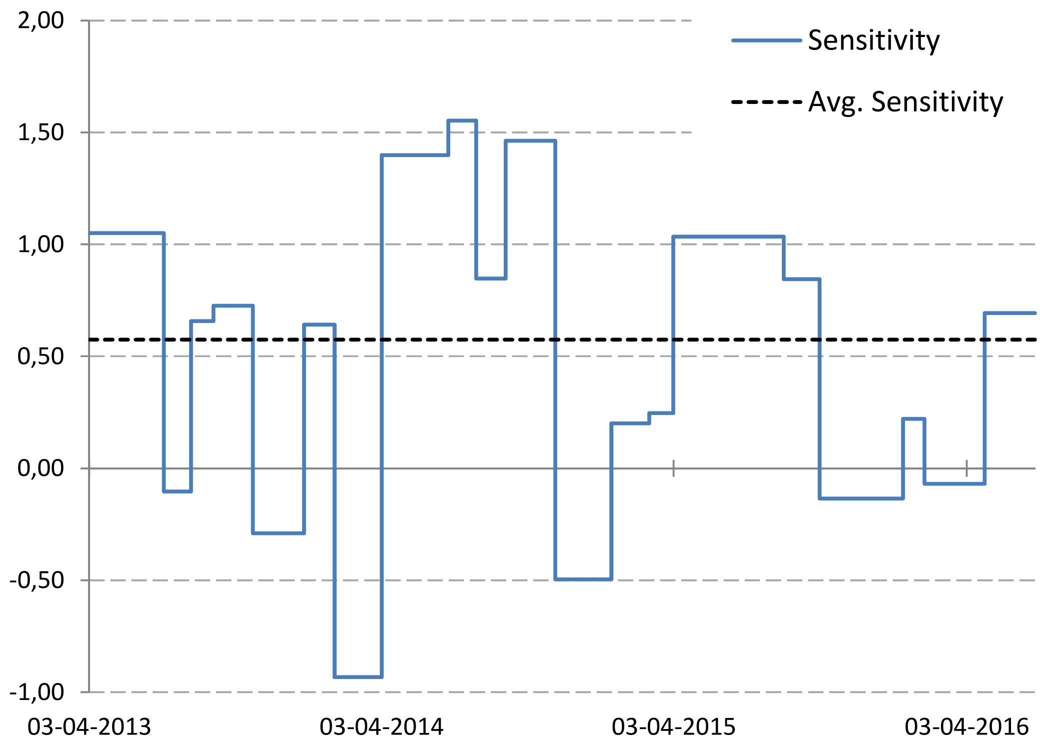

Figure 25. Price-wise endurance-times-amplitude weighted sensitivity of EM IG portfolio along the post-crisis period (03.04.2013 – 27.06.2014).

In this case of the "new normal" post-crisis period the dynamics of the EM IG portfolio sensitivity exhibits volatility somewhat superior to the "old normal" pre-crisis period, but considerably inferior to the volatility range of the "distressed" through-the-crisis period. The widths of volatility ranges are equal to 1.4, 10.6, and 2.5, respectively; compare Figures 21, 23, and 25.

Although the sensitivity coefficients values in the case of the "new normal" post-crisis period exhibit several positive and also a few positive spikes, this volatility range is centered at the positive level of 0.58 certifying that the overall price-wise sensitivity of EM IG portfolio is positive though attenuated if compared to the amplitude of "inducing" price changes of UST portfolio.

4.4.3.2. Post-crisis price-wise interest rate sensitivity of EM HY portfolio

Table 13 represents 20 major moves in the over-1-year price changes during the "new normal" post-crisis period (03.04.2013 – 26.06.2016). For each of these 20 time windows we calculate the corresponding 1-year price change deltas for both, the UST and EM HY modeled portfolios. We also present the respective sensitivity coefficient calculated as the ratio of the value change delta observed in the EM HY portfolio to the "inducing" value change delta observed in the UST portfolio. For informative purposes we present our calculations of arithmetic average, endurance window weighted average, amplitude weighted average and endurance-times-amplitude weighted average of sensitivity coefficients. These values are averaged over three different aggregated arrays of the windows; the aggregate array of the UST positive deltas, the aggregate array of the UST negative deltas, and for the entire span of the "new normal" post-crisis interval.

Date	Endurance window (days) (A)	Δ in UST 1Y price change (B)	Δ in EM HY 1Y price change (C)	Sensitivity D = C / B	Endurance weighted sensitivity E = A x D	Amplitude weighted sensitivity F = |B| x D	Endurance and Amplitude weighted sensitivity G = A x |B| x D
03-04-2013							
05-07-2013	93	-49,98	-72,22	1,45	134,4	72,2	6717
08-08-2013	34	23,37	-8,95	-0,38	-13,0	-8,9	-304
05-09-2013	28	-21,51	-23,13	1,08	30,1	23,1	648
24-10-2013	49	39,78	12,86	0,32	15,8	12,9	630
27-12-2013	64	-17,94	5,20	-0,29	-18,6	-5,2	-333
03-02-2014	38	26,43	3,71	0,14	5,3	3,7	141
03-04-2014	59	-18,88	20,97	-1,11	-65,5	-21,0	-1237
25-06-2014	83	51,83	101,21	1,95	162,1	101,2	8401
30-07-2014	35	-12,31	-24,69	2,01	70,2	24,7	864
05-09-2014	37	21,49	13,32	0,62	22,9	13,3	493
06-11-2014	62	-27,69	-41,81	1,51	93,6	41,8	2592
15-01-2015	70	33,83	-57,74	-1,71	-119,5	-57,7	-4042
03-03-2015	47	-36,43	33,17	-0,91	-42,8	-33,2	-1559
02-04-2015	30	23,96	8,98	0,37	11,2	9,0	269
18-08-2015	138	-33,29	-14,73	0,44	61,1	14,7	2033
02-10-2015	45	18,14	-27,52	-1,52	-68,3	-27,5	-1238
14-01-2016	104	-38,24	54,09	-1,41	-147,1	-54,1	-5625
10-02-2016	27	37,97	-14,77	-0,39	-10,5	-14,8	-399
25-04-2016	75	-23,51	13,67	-0,58	-43,6	-13,7	-1025
27-06-2016	63	37,94	21,29	0,56	35,4	21,3	1341
Total (Average): UST gain windows	705	-279,78	-49,50	0,22	0,10	0,18	**0,14**
Total (Average): UST loss windows	476	314,73	52,40	0,00	0,09	0,17	**0,33**
Sensitivity Averaged over the whole period				0,11	0,10	0,17	**0,22**

Table 13. Price-wise IR sensitivity of EM HY bonds along the post-crisis period.

As could be seen in the right-most column of Table 13, the endurance-times-amplitudes weighted sensitivity of EM HY portfolio averaged over the whole "new normal" post-crisis period (03.04.2013 – 26.06.2016), is equal to 0.22. Differently to the "old normal" pre-crisis period the average sensitivity coefficient is rather closed to 0 than to 1, certifying a kind of quite a weak sensitivity of the EM HY portfolio to price changes of the corresponding UST portfolio. The sign of a price response relative of the EM HY portfolio is the same as the sign of the "inducing" price change occurred in the portfolio of US government bonds, but amplitude of the price response observed in the EM HY portfolio is equal to just 22% of the price change relative to UST securities. In other words, less than one quarter of a move in the risk-free interest rate is passed through to the yield of EM HY bonds.

While comparing EM HY sensitivity averaged over the windows of the positive UST price deltas (risk free-rates downtrend intervals), i.e. 0.14, with EM HY sensitivity averaged over the windows of the negative UST price deltas (risk free-rates uptrend intervals), i.e. 0.33 we could infer that decreases of risk-free interest rates affect EM HY bonds in a much weaker manner than the increases of risk-free interest rates. In other words, similarly to the "old normal" pre-crisis period, during the "new normal" post-crisis conditions, the EM HY portfolio also suffers from risk-free rate increases significantly more than benefits from risk-free rate decreases.

Figure 26 below represents historic behavior of endurance-times-amplitude weighted sensitivity; see the right most column of Table 13. The value of the sensitivity is depicted constant for the entire interval along which it was calculated.

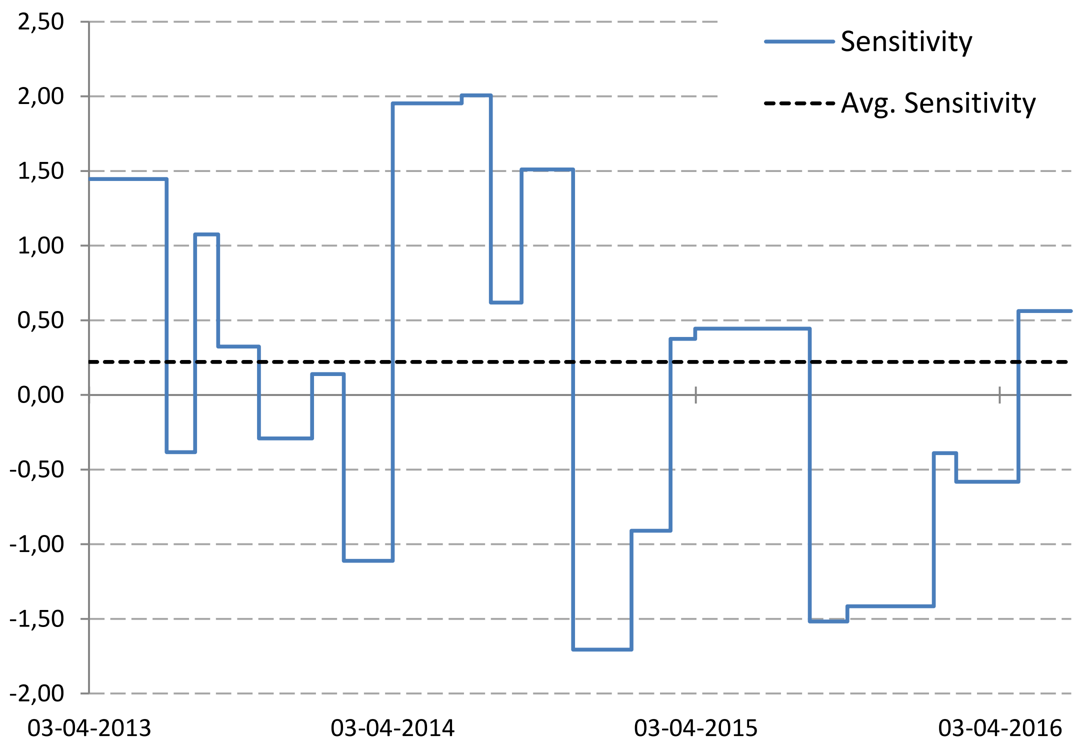

Figure 26. Price-wise endurance-times-amplitude weighted sensitivity of EM HY portfolio along the post-crisis period (03.04.2013 – 27.06.2014).

In this case of the "new normal" post-crisis period the dynamics of the EM HY portfolio sensitivity exhibits volatility somewhat inferior to the "old normal" pre-crisis period, but considerably inferior to the volatility range of the "distressed" through-the-crisis period. The widths of volatility ranges are equal to 7.0, 26.4, and 3.7, respectively; compare Figures 22, 24, and 26. On the other hand, during the "new normal" post-crisis period the range of EM HY volatility -1.7 – 2.0 remains somewhat wider than the range observed in the case of the EM IG portfolio: -0.9 – 1.6, see Figures 25 and 26.

Although the sensitivity coefficients values in the case of the "new normal" post-crisis period exhibit several positive and also a few positive spikes, this volatility range is centered at the positive level of 0.22 certifying that the overall price-wise sensitivity of EM HT portfolio is positive though strongly attenuated if compared to the amplitude of “inducing” price changes of UST portfolio.

5. Discussions and implications

5.1. Binary behavior of price-wise interest rate sensitivity of EM bond portfolios

The novelty of our research resides in a fact that to the best of our knowledge we are unaware of any other study focused on interest rate sensitivity in terms of asset prices appreciation/depreciation over rather long - annual, biannual, and triennial periods. We argue that such approach makes all the sense from the point of view of portfolio risk management, but seemingly the difficulty always was to have an aggregate price data. We overcame this difficulty by recalculating average prices of modeled portfolios from the available blended yield indexes following our newly developed proprietary methodology. Fortunately, our approach permitted us to uncover a phenomenon of a binary behavior of price-wise interest rate sensitivity.

Below we present the detailed discussion of price-wise interest rate sensitivity per type of credit quality, IG and HY. Than we analyze negative and positive sensitivities in terms of responses of credit spreads to risk free rates. We also propose a plausible solution to an old controversy, namely between Merton´s model (1974) implying in negative responses and Kamin and Kleist approach (1999) resulting in positive responses of credit spreads to risk free rates, each of which is reportedly supported by diverse empirical observations.

5.1.1. Price-wise interest-rate sensitivity of IG EM corporate bond portfolios

Investigating the asset sensitivity to interest rate from the point of view of asset price changes allows us to present a few detailed and comprehensive conclusions. Figure 27 demonstrate the three different regimes of price-wise sensitivity of EM IG corporate bonds.

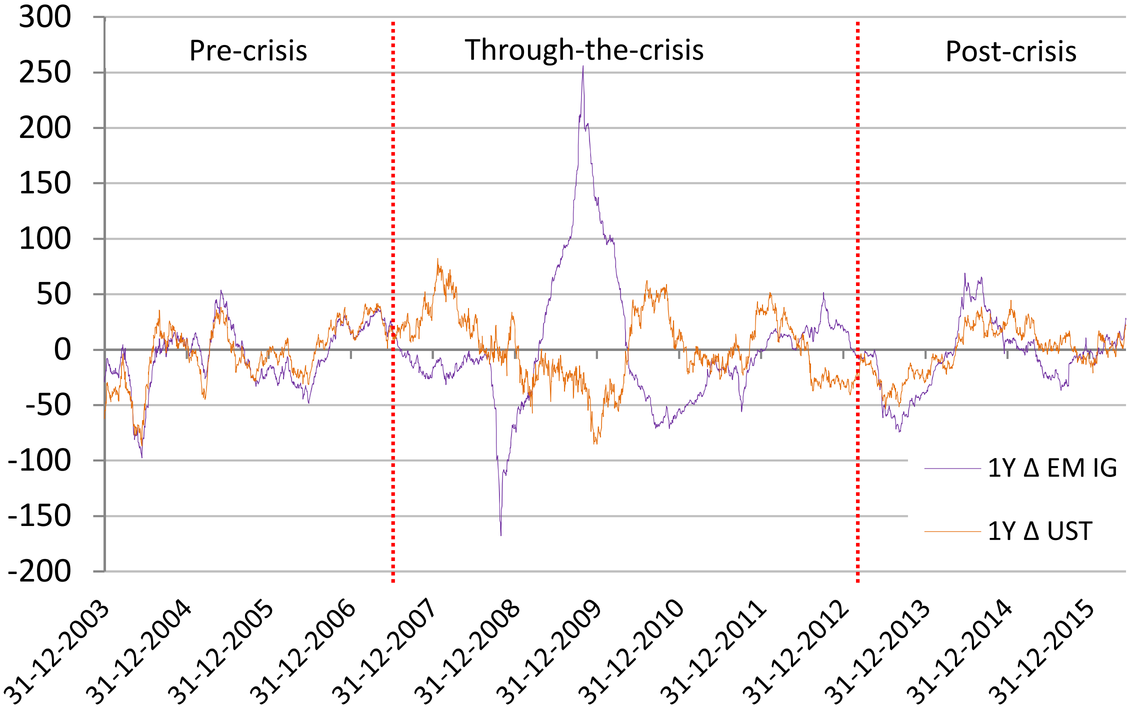

Figure 27. Regimes of price-wise IR sensitivity of EM IG corporate bonds

The pre-crisis period (01.01.2004 – 13.07.2007) and the post-crisis period (03.04.2013 – 31.12.2015) or, respectively, the "old normal" and the "new normal" regimes exhibit different kind of relation between price changes of EM IG and UST portfolios in comparison to the "distressed" through-the-crisis regime (13.07.2007 – 03.04.2013). Under the "normal" regime, Figure 27 attests that the variations in the present value of the modeled EM IG portfolio represent positive correlation with the variations in the present value of the modeled UST portfolio, as the respective price-change lines move closely and jointly within the "normal" regime intervals. On the contrary, along the "distressed" regime interval the sensitivity sign changes from the positive to negative: the changes in the present values of the portfolios composed by risk-free and risky assets behave in an opposite mode.

Another interesting feature to be observed is that under the "old normal" regime prior to the crisis (01.01.2004 – 13.07.2007) the EM IG portfolio price changes are related to the UST portfolio price changes roughly as 1 to 1. In Section 4.4 we presented the quantitative confirmation of this qualitative finding. The sensitivity ratio averaged over this period is found to be 0.96 to 1. Figure 28 illustrates the dynamics of EM IG and UST asset price changes under the pre-crisis "old normal" regime in more detail.

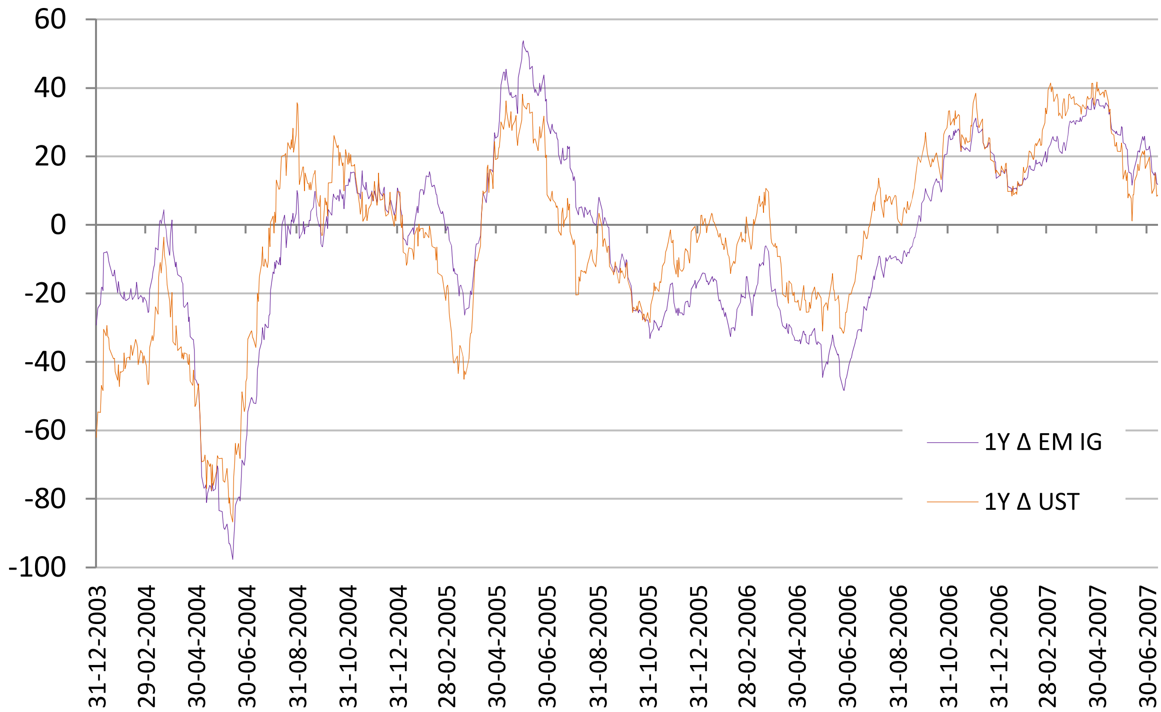

Figure 28. The pre-crisis "old normal" regime: 1-year price changes relative to the EM IG and UST portfolios.

As could be seen, the price responses of the EM IG model portfolio closely mirror the inductive price changes of the respective US government bonds portfolio.

On the other hand, under the "new normal" regime posterior to the crisis (03.04.2013 – 31.12.2015) for EM IG corporate bonds, we also observe positive although somewhat reduced price-wise sensitivity. The sensitivity ratio averaged over this period is found to be 0.58 to 1, which is about 60% of the pre-crisis figure. Figure 29 illustrates the dynamics of price changes under the post-crisis "new normal" regime in more detail.

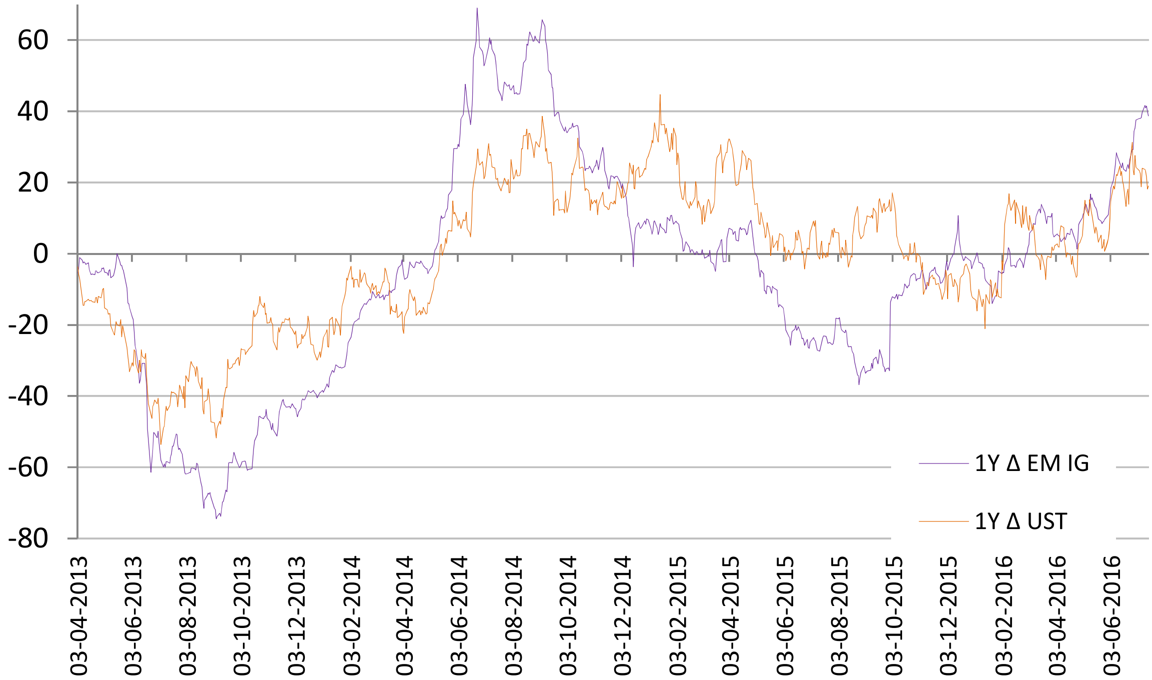

Figure 29. The post-crisis "new normal" regime: 1-year price changes relative to the EM IG and UST portfolios.

Still we could state that under the "new normal" regime IG bonds price changes exhibit positive average sensitivity to price changes of the respective UST bond portfolio, even though the respective price-change lines move not so closely and jointly as within the "old normal" pre-crisis period.

This situation changes completely and we observe negative price-wise sensitivity if the analyzed period spans over financial turmoil preceding and following the apogee of the global financial crisis. Under the "distressed" through-the-crisis regime (13.07.2007 – 03.04.2013), the sensitivity of the EM IG portfolio price changes to the UST portfolio price changes is rather complex and varies along the period. In Figure 27 we see that the volatility band for the EM IG price changes is 2.5 times larger than the respective UST volatility band. As could also be seen in Figure 27 for several time intervals within the "distressed" regime period, the impact of the risk free interest rate changes on EM IG bonds is inverted and amplified, while for other time intervals is amplified but not inverted.

Still these two kinds of amplified responses with different signs, if averaged over the entire "distressed" period damp one another with the predominance remaining on the side of negative sensitivity. The EM IG to UST sensitivity averaged over the "distressed" period is found to be -0.53 to 1, see Section 4.4.2.1. It means that in this case we could even propose using the term "anti-sensitivity" to highlight such inverted relation when on average a price increase in the UST portfolio leads to a price decrease in the EM IG portfolio and vice versa.

Note, that sensitivity ratio of -0.53 indicates that on average within the “distressed” period the amplitude of EM IG portfolio price response is attenuated as it equals roughly to one half of the amplitude of the inductive price change of the UST portfolio.

5.1.2. Price-wise interest-rate sensitivity of HY EM corporate bond portfolios

The conceptual analysis of the previous Subsection 5.1.1 still holds for the EM HY to UST price-wise sensitivity as could be inferred from Figure 30 below.

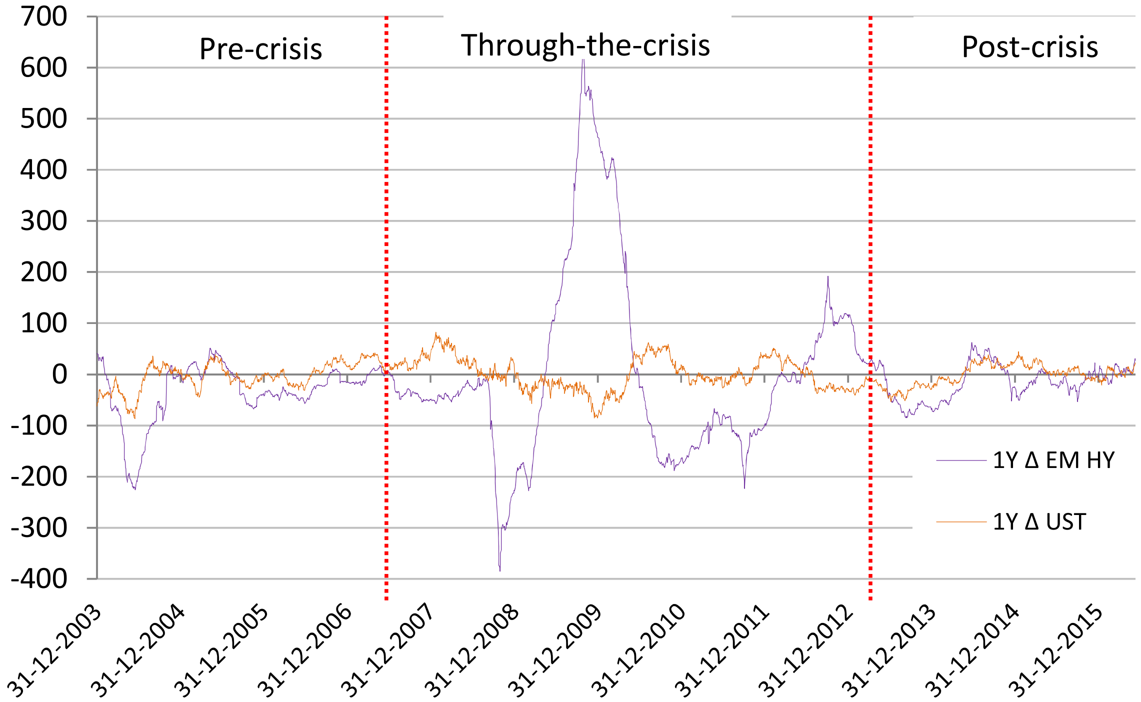

Figure 30. Regimes of price-wise IR sensitivity of EM HY corporate bonds

But as HY securities are riskier than IG securities and hence embed more pronounced idiosyncratic features of the obligors, the EM HY bond portfolio shows different degrees of price-wise interest rate sensitivity in comparison to EM IG bond portfolio; compare the vertical scales in Figures 27 and 30.

Similarly to the EM IG case, under the “normal” regime prior to the crisis (01.01.2004 – 13.07.2007) the EM HY portfolio price changes are related to the corresponding UST portfolio price changes roughly as 1 to 1. The sensitivity ratio averaged over this period is found to be 0.96 to 1, the same as in EM IG case. Figure 31 the dynamics of EM HY and UST asset price changes under the pre-crisis “old normal” regime in more detail.

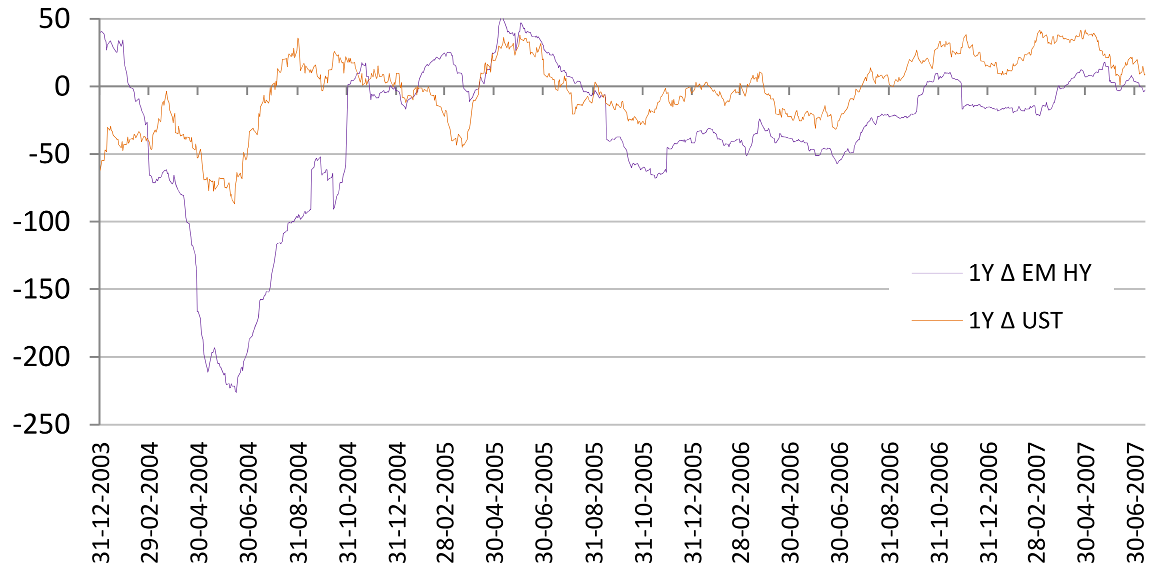

Figure 31. The pre-crisis "old normal" regime: 1-year price changes relative to the EM HY and UST portfolios.

As could be seen, the price responses of the EM HY model portfolio also mirror the inductive price changes of the respective US government bonds portfolio, although not so closely as in the case of EM IG debt.

On the other hand, under the "new normal" regime posterior to the crisis (03.04.2013 – 31.12.2015) for EM HY corporate bonds, we observe only slightly positive price-wise sensitivity. The sensitivity ratio averaged over this period is found to be 0.22 to 1, which indicates that in this case we should rather talk about insensitivity than about sensitivity to changes in the yields of risk-free assets, as on average only 22% of a price change in UST portfolio is passed through to the price of EM HY portfolio. Figure 32 illustrates the dynamics of price changes under the post-crisis "new normal" regime in more detail.

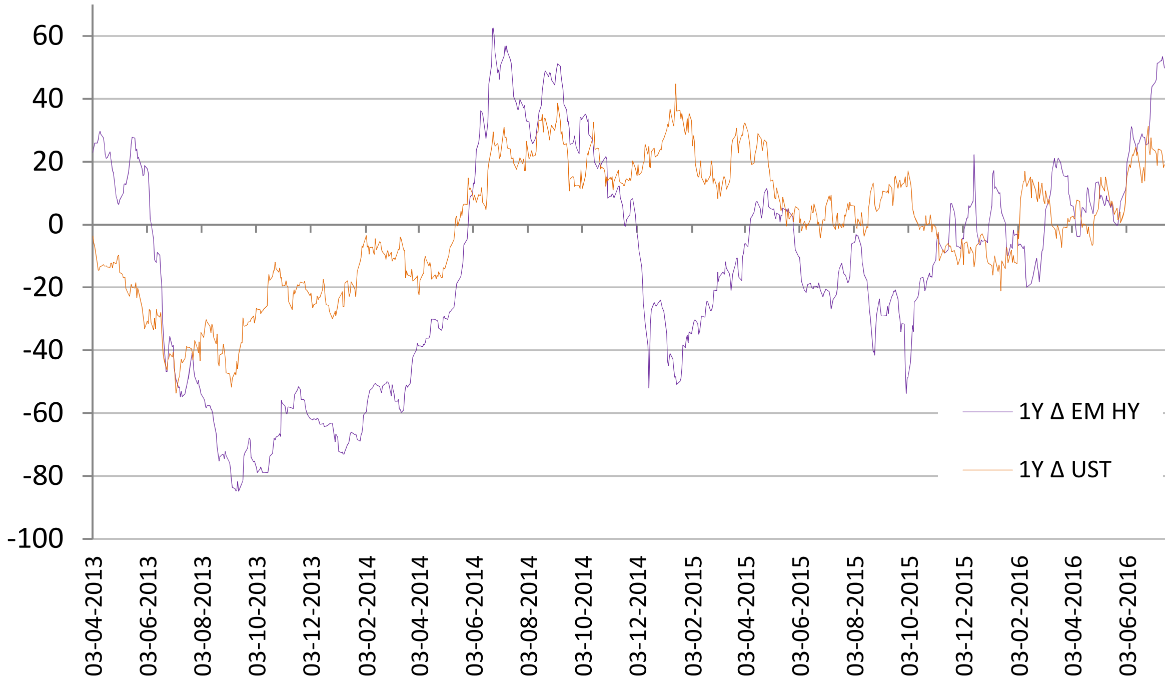

Figure 32. The post-crisis "new normal" regime: 1-year price changes relative to the EM HY and UST portfolios.

Still we could state that under the "new normal" regime HY bonds price changes exhibit positive average sensitivity to price changes of the respective UST bond portfolio, even though the behavior of the respective lines is not very similar.

One again, similarly to the EM IG case, if the analyzed period spans over financial turmoil preceding and following the apogee of the global financial crisis, in the EM HY case we also observe negative price-wise sensitivity. Under the "distressed" through-the-crisis regime (13.07.2007 – 03.04.2013), the sensitivity of the EM HY portfolio price changes to the UST portfolio price changes is rather complex and varies along the period. In Figure 30 we see that the volatility band for the EM HY price changes is 6 times larger than the respective UST volatility band. As could also be seen from Figure 30 for several time intervals within the "distressed" regime the impact of the risk-free interest rate changes on EM HY bonds is inverted and amplified, while for other time intervals is amplified but not inverted.

Still these two kinds of amplified responses with different signs, if averaged over the whole "distressed" period, damp one another with the strong predominance remaining on the side of negative sensitivity. The EM HY to UST sensitivity averaged over the "distressed" period is found to be -1.76 to 1. It means that in this case we also could propose using the term "anti-sensitivity" to highlight such inverted relation when on average a price increase in the UST portfolio leads to a price decrease in the EM HY portfolio and vice versa. Note, that sensitivity ratio of -1.76 indicates that on average within the "distressed" period the amplitude of EM IG portfolio price response is amplified as it equals 176% of the amplitude of the inductive price change of the UST portfolio. Thus, under "distressed" regime the absolute values of the sensitivity coefficient for HY bonds are superior to the sensitivity coefficients for IG bonds.

So, as in the EM IG case, for EM HY debt we observe positive and negative sensitivities for "normal" regime (01.01.2004 – 13.07.2007; 03.04.2013 – 31.12.2015) and "distressed" regime (13.07.2007 – 03.04.2013), respectively. In other words, for both, EM IG and EM HY debt we evidence a kind of binary behavior of price-wise interest rate sensitivity.

5.1.3. Negative and positive sensitivities and responses of credit spreads to risk-free rates

In our work, negative responses of credit spread to risk-free rates are especially well evidenced for the "distressed" through-the-crisis regime. In this case the amplitude of the credit spread narrowing (widening) is even superior to the amplitude of the increase (decrease) of risk-free interest rate. We infer it from the fact that during this "distressed" period we observe negative price-wise sensitivity for both, IG and HY EM bonds. It means that the yields of risky and risk-free assets move in the opposite directions. As for HY EM bonds the amplitude of the negative price-wise sensitivity is amplified while for IG EM bonds the amplitude of the negative price-wise sensitivity is dumped, the opposite moves for HY bonds yields is stronger. Thus, for the distressed "regime" we evidence that HY bonds show more negative relation of credit spreads to interest rates. Thus, we consider that our results corroborate with the findings of Dupoyet et al (2016). For 1973 – 2014 time interval Dupoyet and coauthors state that HY bonds show more negative relation of credit spreads to interest rates, than IG bonds do.

But conceptually our message goes far beyond the statement made above. Our results also make us to call the attention that it is very important to relate the observed sensitivities to the general risk-on/risk-off regime of the markets, as it could influence the sign, i.e. direction, and the strength of sensitivities. For example, for the second half of 2014 (within the "new normal" post-crisis period) we observe average price-wise sensitivity of EM HY portfolio of 1.52 to 1. This evidence that for certain periods, the increases (decreases) in risk free interest rates could worsen (improve) creditworthiness of issuers. For EM HY case, we also observe a few intervals of both, interest rate increases and decreases, with positive sensitivities above 1 within the "distressed" crisis period.

On the other hand, for EM IG case within the "distressed" crisis period, positive sensitivities above 1 are observed only for periods of increases in risk-free interest rates, meaning that the increases in risk-free interest rate could worsen the creditworthiness of EM IG issuers, while the improvement in the creditworthiness of EM IG issuers due to eventual decreases in risk-free interest rates usually is unlikely. Under the "normal condition the situation is different as for EM IG case, we also observe, as for EM HY case, a few intervals of both, interest rate increases and decreases, with positive sensitivities above 1.

One again it is worth noting, that as it is discussed in Section 4.4, for both EM HY and EM IG we observe average positive price-wise sensitivities under the “normal” regime (01.01.2004 – 13.07.2007; 03.04.2013 – 31.12.2015) and average negative price-wise sensitivities under the “distressed” regime (13.07.2007 – 03.04.2013). Thus, for both types of analyzed EM corporates we evidence a phenomenon of a binary behavior of price-wise interest rate sensitivity, and hence a binary behavior of credit spread reactions to changes in risk-free interest rates.

5.1.4. Solution of an old controversy: Merton´s model vs Kamin and Kleist approach

Based on the observed binary behavior of interest rate sensitivities we decided to revisit an old controversy, namely between structural Merton´s model, Merton (1974), resulting in negative relation of credit spreads to interest rates, and Kamin and Kleist approach, Kamin and Kleist (1999), which posits that changes in risk-free interest rates are passed through to yields of risky assets with the same or even amplified amplitude, and hence resulting in positive relation of credit spreads to interest rates. Kamin and Kleist (1999) in fact published their empirical findings for EM bonds supporting their theoretical thinking. On the other hand the negative relation of credit spreads to interest rates was observed in many recent research, see, for example, Boulkeroua & Stark (2013), Neal et al (2015), and Dupoyet et al (2016). These empirical studies corroborate with Merton´s model.

For all the three periods analyzed in our research, i.e. the “old normal” regime (01.01.2004 – 13.07.2007), “distressed” regime (13.07.2007 – 03.04.2013), and the “new normal” regime (03.04.2013 – 31.12.2015) our results evidence that for different periods different models provide better fit with our empirical findings. For instance, for the “old normal” period the price-wise sensitivity for both IG and HY portfolios equals 1 to 1. Thus, this is consistent with theoretical thinking of Kamin and Kleist (1999), as it predicts mostly positive response of credit spreads to risk free interest rates, as posits that the probability of default is not affected by changes in the risk-free interest rate, which we believe is true for normal economic conditions.

On the contrary for the “distressed” regime (13.07.2007 – 03.04.2013), negative sensitivity values are observed for both IG and HY EM corporate debt portfolios. This result is clearly in line with Merton´s model which implies a negative response of credit spreads to interest rates, i.e. it means that the probability of default is affected by changes in the risk-free interest rate which is clearly the case in times of financial turmoil. Further on, in Section 5.2 we present a theoretical explanation of the observed behavior.

In respect to the “new normal” regime (03.04.2013 – 31.12.2015) we posit that the “new normal” post-crisis regime is situated somewhere in between of the “old normal” regime with positive 1 to 1 sensitivities and the “distressed” regimes, with negative sensitivities. Still as we demonstrated, on average this regime is closer to fully recovered "old normal" than to the "distressed" conditions, as this "normal" post-crisis regime is characterized by positive price-wise interest rate sensitivities.

Thus we infer that the "new normal" post-crisis period could be successfully described by each of the models or by the mix of them both. According to the Merton´s model in the case of the "new normal" the probability of default is affected by changes in the risk-free interest rate, but less than under the "distressed" conditions.

On the other hand in terms of Kamin and Kleist approach we could talk about partial transmission of changes in interest rates to yields of risky securities. In other words, under the "new normal" conditions, changes in risk-free interest rates are passed through to yields of risky assets not with the same but with the reduced or damped amplitude. In a certain way this comprehensive amendment to their original theoretical arguments, allows to apply Kamin and Kleist approach for explaining all the range of positive sensitivity coefficients, i.e. with values between 0 and 1.

We also highlight perils of long run averaging, as such algorithms present considerable risks to "throw the baby out with the bathwater". This is so because averaging sensitivities over a long run could disguise the observable effects as spanning the window of observations over both, the "normal" market regime with positive sensitivity and the "distressed" market regime with negative sensitivity, one could occasionally find himself observing on average only one of them, the predominant one, but damped by the other. Fig. 21 below provides a conceptual illustration of this point in terms of yields and spreads behavior.

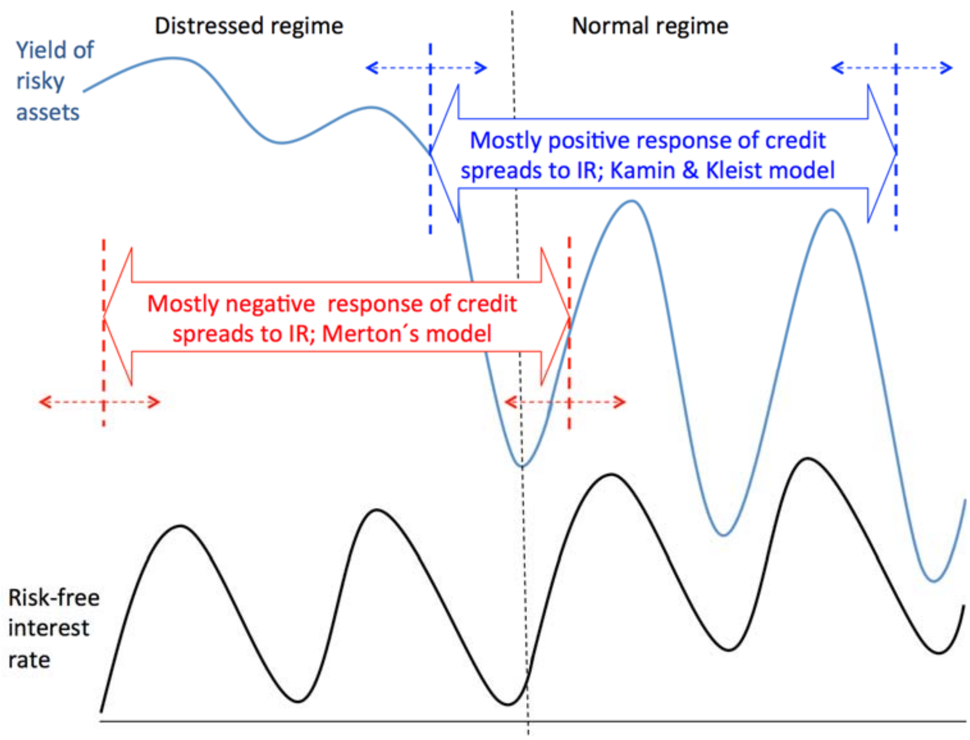

Figure 21. Negative and positive responses of credit spreads to interest rate under distressed and normal regimes, respectively.

Eventually, depending on the span of the window over the two regimes one even could observe insensitivity to interest rate, meaning that on average the sensitivity of one sign observed along certain intervals is damped to zero by the other sign sensitivity observed along the rest of the observation window. So it makes us doubt in a meaningfulness of the findings of Dupoyet et al (2016) as this paper reports consistent negative relation between credit spread and interest rates observed over quite a long period 1973-2014. Our research proves that it is not always the case, at least for the analyzed EM corporate portfolios along the years 2002-2015, especially as we observe several time intervals with positive price-wise sensitivities above 1. And once again, the long run averaging is capable of hiding time variation in sensitivities among the constituent short run intervals.

5.2. Interest rate sensitivity of EM bond portfolios in relation to phases of business cycles

Based on our analysis we proposed an explanation for both positive and negative price-wise interest rate sensitivities of the EM portfolios observed along changing economic conjuncture.

The novelty of our approach resides in the fact that positive price-wise interest rate sensitivities we ascribe to "normal" regime of sustainable economic growth, while negative price-wise interest rate sensitivities we attribute to both crisis-related turmoil phases, the preceding financial downturn and post-crisis recovery.

5.2.1. "Normal" regime

Under the "normal" regime, the sensitivity of price changes observed in the EM corporate debt portfolios to the UST portfolios price changes is positive. It means that the ups and downs in the risk-free interest rate are passed through to the respective bond yields practically unchanged (pre-crisis period) or attenuated (post-crisis period). For both, IG and HY EM portfolios, we posit that moderate and not abrupt increases and decreases in the risk-free interest rate do not affect the level of corporate creditworthiness if considered from the operations point of view. This is especially true under the "old normal" pre-crisis regime, as for both, the EM IG and HY portfolios, the price responses are related to the inducing price changes in the corresponding UST portfolio roughly as 1 to 1.

Under the "new normal" post-crisis regime, on average, the price changes of the UST portfolios are not passed through to EM portfolios entirely as they result in the responses of reduced amplitude. We attribute this behavior to the not yet completed transition from the "distressed" risk-off crisis-related phase with negative sensitivities to the fully recovered conditions of risk-on "normal" phase with positive 1 to 1 sensitivities.

During crises, the increases in risk-free interest rates are interpreted by market participants as recovery indicators for economic conditions. Thus, the negative average sensitivities are observed. Such increases in risk-free interest rates reduce the risk of default. The lower creditworthiness of an issuer, the stronger is the narrowing of the issuer´s credit spread. It is consistent with the fact, that for the "distressed" crisis period we observed -0.53 to 1 for the EM IG portfolio and -1.76 to 1 for the EM HY portfolio.

In any case we could say that this phase is not quite idiosyncratic, as usually it is characterized as "risk-off" meaning that generally speaking there is no risk appetite in the market. No one seems to be interested in idiosyncratic features of issuers and all attention is centered at risk-free interest rate behavior. Thus, this phase in fact is interest rate centered. One of the main drivers during the "distressed" period was a level of UST yield at 10 year points in the term structure. Credit spreads depended strongly on the level of risk-free rates. Changes in risk free-rates were negatively correlated with credit spreads. "Anti-sensitivities" were observed.

Under fully recovered economic conditions, the increases in risk-free interest rates are passed through to the respective bond yields being practically unchanged. The observed positive average sensitivities are approximately 1 to 1. It means that market participants interpret the creditworthiness of the issuers as not depending on risk-free interest rate, and hence the present value of securities for different credit quality in fact is affected in the very same way; through the discount factor. Once again all attention is centered at risk-free interest rate behavior. During the "old normal" pre-crisis period, the slope of the government bonds yield curve was is the center of investors´ attention. Thus, this phase in fact is also interest rate centered, but with opposite impacts if compared to the "distressed" period. Positive 1 to 1 sensitivities are observed.

We posit that the "new normal" post-crisis regime is situated somewhere in between of the fully recovered interest rate centered economic conditions with positive sensitivities and the "distressed" also interest rate centered economic conditions, but with negative sensitivities. Still as we demonstrated, on average this regime is closer to fully recovered than to the "distressed" conditions, as this "normal" post-crisis regime is characterized by positive price-wise sensitivities. In a certain way it is quite an intuitive conclusion, as passing from significantly negative to significantly positive sensitivities, we are close to insensitivity or attenuated positive sensitivity.

Although under these "new normal" post-crisis conditions credit spreads are influenced in some way by inflation expectations, in fact we could state that this phase is not interest rate centered, but rather major attention of market participants is focused on idiosyncratic features of issuers. The sensitivity ratio averaged over this period is found to be 0.58 to 1 for EM IG and 0.22 to 1 for EM HY bond portfolios. Thus, we could conclude that creditworthiness of issuers is only partially improved by the increase in risk-free interest rates: the stronger are idiosyncratic factors (EM HY), the more insensitive is portfolio under these “new normal” post-crisis conditions to changes in risk-free interest rates.

If considered from the operations point of view, under the “new normal” post-crisis regime the creditworthiness both of IG and HY EM issuers benefits, although to different degree, from increases in risk-free interest rate. For the sake of comparison, under the “old normal” pre-crisis regime the creditworthiness both of IG and HY EM issuers was not affected at all by increases/decreases in risk-free interest rate, as posited by Kamin and Kleist approach.

We ascribe such “normal” regime of interest rate sensitivity to periods of rather sustainable growth, i.e., growth that is not stimulated by non-conventional policy measures (and is not fueled by any apparent boom of bubble creation resulting in practices of “panic” buying and inflated prices of certain types of assets). Discussing geographically diversified EM portfolios we certainly refer to global economic growth. Still, we argue that our reasoning also holds for IG and HY assets in isolated geographies selected on a regional and/or country basis.

5.2.2. “Distressed” regime

Let us discuss now the negative price-wise sensitivities of EM portfolios observed under the “distressed” regime. We consider the “distressed” regime to span over the two consecutive phases: deterioration and recovery of economic conditions. In other words, in respect to the recent history, those phases are the crisis development and recuperation from the crisis lowest low. We could also think of “distressed” regime as of a passage through a bust of a bubble to the economic bottom and then back to the economy as usual.

5.2.2.1. “Distressed” regime during downturn

During the vicious cycle of a recession, markets enter into the risk-off mode and the risk-free rate behavior exhibits a downtrend dynamics due to the increasing demand for the safe assets. Additionally, central banks in a recession adopt a policy of reducing interest rates in order to stimulate the investment necessary to repair economic conditions. Hence, a recession makes yields on risk-free assets drop and price increases are registered in portfolios consisting of US Treasury securities.

In parallel, the worsening of global economy augments the credit risk of the EM corporates through several mechanisms. From an operations point of view, business conditions in recession get worse due to the lower demand for product and services as uncertainty increases. Regarding the financial side of businesses, it is worth mentioning deterioration in companies´ abilities to service their debt and obtain external financing due to worsening economic conditions. Financing costs keep growing.

Under such conditions there is a lot of uncertainty in the market. The demand for safe UST securities causes their yields to drop and prices to rise. Simultaneously, as a result of flight-to-quality phenomena, see Gubareva and Borges 2016, investors withdraw their funds from riskier EM corporate bonds. Thus, the yields on corporate bonds rise and the prices drop. Hence we observe the situation when risk-free rates are falling, but the credit spreads for risky corporate bonds is widening.

The increase in default risk, provoked by the above-mentioned factors, makes credit spreads for corporate bonds get wider in such a manner that yields on risk assets grow even though yields on risk-free assets drop and, hence, prices decreases are observed in risky EM portfolios. So, price-wise interest rate sensitivity of EM assets, in particular, and of risky assets, in general, reveals itself as negative under the downturn bust or deterioration of economic conditions.

Summarizing the point, when interest rates are decreasing, the credit premia are rising, but the credit spreads widening overtakes the drop in the risk-free yields. That is nothing but a well-known flight-to-quality phenomenon described through the prism of economic environment. This phenomenon results in price-driven losses suffered by risky asset portfolios accompanied by price-driven gains of portfolios composed by the US treasury instruments.

5.2.2.2. “Distressed” regime during recovery

During the recovery from a flight-to-quality, i.e., during a “flight-from-quality”, markets enter into the risk-on mode. In such periods of economic expansion, the demand for the safe assets drops, causing the risk-free interest rate rise. As central banks usually do not raise rates when large number of corporations and firms might have difficulties to service their debt, they normally try to raise rate when the economic conditions are recovering. Under such conditions central banks are potentially more likely to adhere to the tightening of monetary policy by increasing interest rates. As the economy recovers interest rate increases could even become necessary to avoid the overheating of the economy and keep inflation under control. In sum, yields on risk-free assets increase and price-driven losses are registered in UST portfolios.

Simultaneously, this economic recovery results in a decrease in the corporate default risk. From an operations point of view, corporations start to benefit from improved consumer confidence, augmented demand, and reduced uncertainty. Financing risk and costs also decrease. As a result, on average credit spreads of corporate bonds tighten in such a manner that yields on risk assets drop even though yields on risk-free assets grow and, hence, price-driven gains occur in risky EM portfolios.

So, price-wise interest rate sensitivity of EM assets, in particular, and of risky assets, in general, remains negative during the phase of recovery from crisis too.

Wrapping up, when risk-free interest rates are increasing, the credit premia are declining, but the credit spreads are narrowing faster than the risk-free yields are climbing. That is nothing but a recovery from a well-known flight-to-quality phenomenon described through the prism of economic environment. This "flight-from-quality" phenomenon results in price-driven gains experienced by risky asset portfolios accompanied by price-driven losses of portfolios composed by the US treasury instruments.

So, only for the "distressed" regime, to which we attribute pre-recession and post recession phase of business cycles, our research is in line with results of Dupoyet et al (2016), which state that the average change in interest rates (credit spreads) is negative (positive) during periods of recession while the average change in interest rates (credit spreads) is positive (negative) during periods of economic expansion. But for us the periods of economic expansion referred in the cited research seem to be rather the periods of recovery from economic cycle lows. We evidence and state that the negative relations between interest rates and credit spreads disappear and turn to positive relations for both, IG and HY, EM corporates under the "normal" regime which we ascribed to the period of moderate sustainable growth present in any business cycle after the recovery from the preceding recession but prior to boom and consecutive bust leading to the next downturn.

5.3. Additional Considerations

It is quite intuitive that interest rates for different types of bonds are not expected to change by the same degree in response to moves in risk free interest rates. In this way, our results also corroborate with the findings of Boulkeroua and Stark (2013), observing that interest rate sensitivities vary across ratings categories. In our case for the EM HY portfolios we observe weaker positive sensitivities under the "normal" regime and stronger negative sensitivities under the "distressed" regime than for the EM IG portfolios.

So now we need to address the question we tried to answer. At the end, does it make an economic sense to hedge interest risk of U.S. dollar denominated EM corporate debt by short positions in U.S. Treasury bonds or by pay-fixed receive-float interest rate swaps? As we have evidenced by our results, such hedge makes sense only over the periods of moderate sustainable growth. On the contrary, to hedge against downside risk in times of economic turmoil, as suggested by our findings, it is advisable to augment exposure to IRR, for example by contracting pay-float receive fixed IRS. In sum, we argue that the hedging of IRR and downside risk should not be mechanical, but ought to be a dynamic process linked to phases of business cycles.

6. Conclusion

In this research, we develop the proprietary framework to assess an interest rate sensitivity of corporate bond portfolios based on blended yield indexes. We apply our model approach to two types of EM corporates: IG and HY securities. Our research advances well beyond the correlation analyses and even beyond the widely performed studies of the relation between interest rates and credit spreads as we investigated the impact in present value of the modeled portfolios. Our approach addresses interest risk sensitivity from the point of view of the medium long term investment, and thus the investment horizons modeled here vary between one and three years.

We do consider that our framework presents a promising potential. Our results are innovative and convincing in a sense that in fact the relation between spreads and interest rate could serve only as guidance toward what it would look like the bottom line of real portfolios, while our approach is focused on the proper present value of the portfolios, i.e., on what matters at the very end. Thus our quantification of sensitivities is quite meaningful from the point of view of the interest rate risk hedging and downside risk management.

The historical span of our research covers the period 2002-2015, which enables us to assess interest rate sensitivity of assets during the development, apogee, and aftermath of the recent global financial and economic crisis. The results presented in this paper contrast with the result of previous empirical work and their theoretical interpretations, as previously both expansion and contraction phases of business cycle were used to explain negative responses of credit spreads to interest rates. In our research we explicitly indicate that the phase of a moderate sustainable growth can explain the observed positive relation between credit spreads and interest rates.

We have proved and documented an empirical evidence of a binary behavior of interest rate sensitivity along phases of business cycles. Under the “normal” pre-crisis and post-crisis regimes, which we ascribe to the periods of a moderate sustainable growth, the changes in the present value of EM portfolios the positively related to the changes in present values of UST bond portfolios. Resulting sensitivity is positive. On the other hand, under the “distressed” through-the-crisis regime, which we ascribe to the phases spanned over an entry to and exit form a recession, the changes in the present value of EM portfolios are negatively related to the changes in present values of UST bond portfolios. Under such conditions sensitivity is negative. This suggests that the hedging of downside risk ought to be a dynamic process linked to phases of business cycles.

Our approach permitted us to solve an old controversy between Merton´s (1974) structural model advocating the influence of interest rate on creditworthiness of obligors and Kamin and Kleist (1999) approach arguing that changes in the risk-free rates are passed through entirely or even augmented to the yields of risky assets. We demonstrated that for the phases of a moderate sustainable growth the sensitivity is positive and that the latter approach fits better our empirical observations while during the distressed conditions the Merton´s (1974) model provides the theoretical explanation of the observed negative sensitivities. Thus the clue to the solution of the controversy resides in a binary behavior of interest rate sensitivities of risky assets "privileging" either one or another models along the economic time scale.

Performing numerical quantification of interest rate sensitivities along the available history of data, we clearly detected three diverse regimes of sensitivity behavior relative to EM corporate debt, which are the "old normal" pre-crisis regime, the "distressed" through-the-crisis" regime, and the "new normal" post-crisis regime. The respective sensitivities are the positive 1 to 1 sensitivity, the negative, i.e. inverted sensitivity, and positive but weaker sensitivity of present value of EM corporates to changes in prices of risk-free governmental bonds.

Examining behavior of asset sensitivity to interest rate along phases of the recent business cycles we corroborate with our idea presented in previous research that an integrated treatment of the IRR and credit risk potentially allows for optimizing ECAP of banks and financial institutions. This research represents a contribution to the advancement of the discussion on the EM cross-geographies alignment of the Pillar 2 methodologies under Basel III capital accord.

Looking ahead, we can affirm that the applicability of the developed herein index-based framework to gauge interest rate sensitivity is considerably wider than the corporate debt of EM. Depending on availability of yield indexes and price indexes, it can be applied to diverse portfolios containing fixed income assets from diverse geographies, sectors and security rating categories. Thus, further research in this field is highly desirable for positively impacting overall efficiency of financial system. It potentially allows financial institutions to improve their risk assessment and ECAP management.

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