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## Session 16PD
## Financial Market Volatility: Modeling and Management

**Track:** Investment

**Moderator:** Francis P. Sabatini

**Panelists:** Aleksandar Kocic*
Francis P. Sabatini


*Summary: Financial market volatility affects a life insurer's financial results. This session covers different methods for estimating future volatility, how to predict the effect of volatility on results, alternative approaches to managing volatility and the impact of volatility management on the choice of modeling method.*


**MR. FRANCIS P. SABATINI:** This session is titled "Financial Market Volatility: Modeling and Management." We're going to have two very different presentations on the subject of market volatility. One is from more of a practical point of view in terms of measuring and managing insurance products in a volatile environment, and then Aleks is going to talk more from a capital markets point of view around the whole subject of volatility.

So from a marketplace point of view, the world we live in is much different today than it was 20 years ago or, for that matter, five years ago. For those of us who are part of publicly traded organizations, GAAP earnings are important, as is the fact that we want them to grow in an increasing pattern, not a decreasing pattern. Not only do we want to have them grow, but we also want to have them be stable over time. There's increased need for transparency in terms of what's going on and what's being reported externally to the various constituencies. Those groups of constituencies are seeking comfort that the risks that are being taken on by the insurance industry are being properly measured and managed. And, as always, there's the desire to leverage investment and risk-management actions into something that's meaningful. If you perform risk management, you should either have less risk or be more profitable or more competitive because of it.

I'm going to talk about the current investment environment in the context of interest rates, and I think Aleks is going to take a broader market view. Actually, we're probably perfectly positioned at this point. Maybe rates a little higher would be better for everybody, but lower interest rates, where they were several months ago, are not where we wanted rates to stay for any length of time. They were there long enough, and I'm sure we're glad they're higher. And what we've seen, interestingly enough, is increased persistency. Everybody figured out they had a pretty good deal in the contracts they had, particularly in the fixed deferred-annuity marketplace. So, staying low isn't where you want to go, and going up isn't particularly good unless you go up nice and slow and steady. Any sort of rapid rise in interest rates creates a problem, primarily through disintermediation.

Now a rise in interest rates puts you at a rate-competitive disadvantage, particularly for annuity and UL blocks. So, you either subsidize rates because the portfolio can't move as quickly as interest rates can, or you let the business leave, which isn't a particularly pleasant alternative. That event happened many years ago. I was a practicing actuary back in the late 1970s and early 1980s when we had one of those spikes, and although at the time deferred annuities weren't particularly a large portion of insurance company's balance sheet, the disintermediation was there. The consumer today is a lot more sophisticated than the consumer back then. So, I sincerely hope we don't have that rapid rise.

Interest rate volatility, particularly upward spikes, are unwanted events, and interest rates just staying where they are isn't a bad deal, although we may want them to be a little higher. It's the best that we can hope for. A lot of my comments are going to be pointed toward what is probably the most interest-sensitive business in the general accounts, which are deferred annuities, followed possibly by some of the UL products. What's the appropriate strategy in the current environment? Should we be long? Should we be short? Should we be matched?

As I interact with the insurance industry in what I do, I find that it's a question that gets a lot of debate now inside companies. There are some companies that have been particularly matched. I don't think anybody's been really short, but there have been companies that are matched and have paid the price in terms of earnings. Of course, I think there was a little bit of an inherent bet on a rise in interest rates that didn't come about. And, being long creates a lot of anxiety about what happens if we do have that spike. As that issue gets debated, one of the natural questions to ask is what are the earnings implications if we change our strategy, reposition the portfolio or implement a hedge strategy? And they're not talking statutory on these. They're talking GAAP.

So, it's an interesting problem because it's one that we've sort of always had, but it's probably getting more and more attention from management. It's not one that's easily been solved by practitioners over the years. A traditional approach that we would use is to go off and do an independent risk analysis. You get a bunch of the risk people and some of the investment people, and they go off and worry about the cash flows and economic values. These people do a risk analysis and come back and say we should be in Position A or B, or they may say should we implement Hedge Strategy A or B? And then somewhere along the line somebody asks the earnings impact question, and somebody goes off and does an analysis of the earnings impact, but you never really get a sense that it all hangs together.

Typically there's a real difficulty in reconciling risk in earnings analyses. Generally, that's because the strategy that you anticipate implementing isn't properly reflected in any of the analyses and it's also because of technology limitations. However, there is a new approach to leveraging technology, and it's a stochastic simulation approach. It leverages off of the traditional asset/liability (A/L) projection framework, and it incorporates functionality as you go through scenarios at each future projection point to permit a number of things that we wouldn't have been able to do before.

We need an accurate valuation of assets, including the embedded options. That doesn't mean a single-path valuation at a particular point along a path, but rather a true option-based valuation at a future point along the path. Which means you need to stop at every point along a path and generate a set of risk-neutral scenarios and do the proper valuation to capture the value. If you're able to do that, then you can do an option price on your assets and liabilities at each point and any future point along a projection path. That would allow you to capture the duration of both assets and liabilities. Having done that, if you know where your assets are relative to your liabilities on some sort of metric at any point in a future projection, it then allows you to reposition a portfolio to where you would want it to be.

One of the biggest problems with traditional methods was you'd have a book of assets and you'd have a reinvestment strategy, but your reinvestment strategy would either be to buy or sell certain assets in certain proportions or amounts, or sell the highest or lowest duration. But you never knew if you were matched or unmatched at a particular point along a path. You knew that you weren't because your liabilities had convexity that was in the opposite direction as the convexity in the assets. No matter what you did, you were never matched. So you knew that whatever analysis you were doing, whether it was a risk analysis or an earnings analysis, it was only directionally correct. It wasn't really giving you a true indication, particularly around any kind of an earnings analysis.

With computers, there is a variety of different platforms out there today that allow you to implement what's called the nested stochastic methodology. And within the stochastic simulation approach, it would allow you to do a lot of the accounting stuff, and that includes deferred acquisition cost (DAC) amortization and unlocking DAC along a path for actual experience. It would also allow you to do a Financial Accounting Standard (FAS) 133 calculation, to mark to market certain assets that are part of a FAS 115 calculation, and then last but not least, bring in the deferred tax liability.

So that leads you to a financial projection capability that allows you to produce a fairly robust analysis of Strategy A versus Strategy B. And within that same model, operating on the same cash flows, it allows you to produce an analysis of the GAAP earnings implications. Now, you do need a lot of computers to get this done, and typically it's not done for a 30-year projection horizon, but that doesn't mean you can't do it. It just depends on how many computers you throw at it. So, the basic technology is to leverage what we call the nested stochastic technology and be able to do either a risk-neutral or a real-world valuation at any point along a path.

Now I'm going to show you some actual results, to sort of illustrate what's going on from a modeling point of view. Chart 1 contains the results for a single scenario for a block of single-premium deferred annuities. And not only are we doing this with an inforce block, but also we're laying in new business over time. That's pretty interesting because that's actually the way your business goes. You continue to write new business and grow your inforce. So, it's a deferred annuity block with new business production period-to-period and an asset portfolio that includes your typical corporate bonds and asset-backed securities. I think there are some collateralized mortgage obligations (CMOs), mortgage pass-throughs and ABS in that group.

The bottom of the chart contains the results for this single scenario over a 39-month period in which we took the asset portfolio and marked the liabilities to market at every point along the path. So, you can see the progression of value of surplus along the path. We calculate the duration of the assets and the liabilities along the path. And in this particular algorithm we have a rule set that basically says we're willing to have an acceptable duration mismatch of two, and you want to reinvest in such a way that you're always moving toward that target if you're out of balance.

So, you're not immediately repositioning the asset portfolio to get to the target duration mismatch, but you're doing things along the way based on a particular rule set that allows you to reinvest toward that target. So, we start off only about 1.4-year mismatch, and over time you see that mismatch grows. It sort of grows and converges and continually moves toward the two-year target. So, it's just an illustration of the mechanics. I'm not sure people would actually manage to a two-year mismatch, but it's designed to illustrate the point.

Now, you could take this same application and examine what it would look like if we had a strategy that says we want a different or a more dynamic rebalancing algorithm so that my duration target is a function of where interest rates are. Or, it could be a function of where they have been or on the shape of the level of the yield curve or any other set of criteria that you can think of. And you can get some pretty interesting results if you start looking at it from that perspective.

But the point here is that the nested stochastic technology allows you to ask those kind of questions, run through those simulations and start to really look at the value of a particular strategy. You might have your portfolio managers, if you're on the liability side, saying to you that if interest rates move in a certain direction, you’re not going to maintain the same position or you’re going to put less or more convexity into the portfolio. Well, here's a chance to test what they're talking about in a simulation context on a sort of real-time basis and trying to evaluate whether it's a good or bad thing to do. So now we go through all the mechanics, and some member of senior management shows up and says this is all great, but what's it mean on a GAAP basis? So Table 1 is a full GAAP presentation for that scenario, showing the typical GAAP development for a deferred annuity with the cost of insurance, net investment income, benefits and expenses, and the DAC amortization period-to-period along the path. This, again, is adjusting for things like actual-to-expected lapses, deaths and interest credits, and adjusting the DAC amortization to produce a net income before and after federal income tax (FIT) on a full GAAP presentation basis.

Table 1

## Understanding The Strategy’s GAAP Implications

| INCOME STATEMENT | 0.25 | 1 | 2 | 3 |
|---|---|---|---|---|
| **REVENUE** | | | | |
| Cost of Insurance, Surrender, and Expense Charges | 55.6 | 243.5 | 342.4 | 533.8 |
| Net Investment Income | 1,055.9 | 6,063.9 | 8,422.3 | 11,265.4 |
| Total Income | 1,111.5 | 6,307.4 | 8,764.7 | 11,799.1 |
| **EXPENSES** | | | | |
| Death Ben in excess of reserves for FAS 97 | - | - | - | - |
| Credited Interest | 711.6 | 4,232.1 | 6,377.2 | 8,660.1 |
| General Expenses | 93.8 | 483.0 | 693.1 | 916.7 |
| DAC Amortization | 55.5 | 724.5 | 1,183.1 | 1,738.6 |
| Total Expenses | 860.9 | 5,439.5 | 8,253.4 | 11,315.4 |
| Net Income Before FIT | 250.6 | 867.9 | 511.3 | 483.7 |
| Current Taxes | (3.3) | 647.0 | 728.2 | 383.9 |
| Deferred Tax Expense | 91.0 | (343.3) | (549.3) | (214.6) |
| GAAP Income after FIT | 162.9 | 564.1 | 332.4 | 314.4 |

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This type of analysis can be expanded from the single-scenario results shown above to a distribution of results for the set of stochastic scenarios. It naturally then leads to Strategy A can produce this sort of distribution from a risk point of view and this sort of distribution from an earnings volatility point of view. You can now start looking at the problem with two conditions in terms of acceptable levels of risk and acceptable levels of earnings volatility. You can add balance sheet information such as a reconciliation of GAAP equity period-to-period. And even analysis that shows what's going on inside the model in terms of the DAC can be added.

So the typical approach to addressing these kinds of business issues is to identify the potential strategies and analyze each, both on an economic and a GAAP basis. I didn't really spend too much time on how you build the metrics, but it's sort of obvious that you can start looking at some economic-based metrics at the same time you're looking at GAAP-based metrics. Use a stochastic analysis. Use scenario analysis. Test and quantify the benefits of one approach versus another. That leads you to a conclusion. And, of course, we ultimately need to talk to management and then implement and monitor.

Even though you build all this sophisticated modeling, you're going to have to balance risk and reward. It's hard to get anything for free anymore, and, if you take more risk, you'll potentially get more reward. There is a downside to the action. The neat thing about it is that with the advancements in technology we now have the capability to start communicating with management and being able to demonstrate or illustrate the relative pros or cons of each. This is probably one of the things we haven't been able to do primarily because of technology limitations, not because we didn't have the intellect.

And, of course, we're moving into an era where things like risk-based capital and the introduction of C-3 types of measures makes some of this technology even more important. Now you can start using this technology to calculate path-dependent capital, which is what some of the C-3 proposals are going to do, at least on the variable-annuity side. So, how does one invest in a volatile interest rate environment? Well, you pick the right strategy, and the right strategy is the one that you can understand, quantify and assess.

**MR. ALEKSANDAR KOCIC:** I work as a derivatives strategist at Deutsche Bank, fixed income. I'll give you a highly compressed overview of how we like to think about volatility and how we look at the interest rate derivatives market. My strategy in this presentation will be extremely simple. I'll give you a top-down view on volatility. I will try to treat volatility as a separate asset class on the same footing as we treat bonds and stocks. Then I will define a framework that will be based on several exceedingly simple and plausible assumptions. The emphasis in the presentation will be on simplicity and parsimony.

I will make these assumptions to facilitate the argument, but at the end of the presentation I'll come back and revisit these assumptions and show you that although they are innocuous-sounding, they are heavily dependent on the structure of the U.S. market in principle. I will not mention it in the beginning, but at the end I will have to tackle the issue of the mortgage market, which basically catalyzes this framework, and I’ll show you what happens when you don't have a developed and large mortgage market, like, for example, in Europe.

To give you a top-down view on volatility, we'll have to revisit the basic building blocks of the interest rate universe, which are macro numbers. I will give you really a quick overview of what is relevant among these macro numbers. Basically, we are looking for just two numbers. So, I'll show you how to extract two out of 10 or 12 different relevant macroeconomic numbers. Then I'll put the volatility in the perspective of a general asset class, and I will discuss how the volatility talks to the market fundamentals and, in particular, remind you how the curve talks to the fundamentals, and finally how curve and volatility talk to each other.

It's very difficult to get money just by playing the curve or volatility separately. So, this is the new game. I'll show you what I think is the paradigm of the new game, how to execute curve trades in volatility space, and the other way around. After that I will summarize what has come out of this framework. I will put all the volatilities together and see who talks to whom, where the fragmentation is, why, and how.

And, finally, although I will not discuss this in great detail, it will emerge from this discussion that short-dated volatility requires separate treatment. I'll give you bold strokes in terms of short-dated volatility. Finally, I will end with a few comments about the structure of the U.S. market and, more than mentioning what the mortgage market is doing in this context; I will try to show you what happens when the mortgage market is absent.

I'm going to start with something I think everybody is aware of. Basically, we have the two parts of the interest rate market. One is the yield curve and the other one is options. The basic assumption is that these two markets all see the same information. We all read about or get some kind of macroeconomic news through unemployment numbers, inflation and so on. In principle, if these are the drivers of the economy, you would expect both derivatives and interest rate markets to have a consistent reading of these numbers. So, in order to simplify things, first let's look at seven relevant macroeconomic numbers that we talk about on daily basis and that we hear a lot about. Chart 3 shows the unemployment nonfarm payrolls, help wanted index and industrial production on one side, and on the other side CPI, PPI, personal consumption price deflator.

What I want to point out is that these seven numbers can, roughly speaking, be put into two different groups. One is the activity group, which is the first four numbers, and the other one is the inflation group. What happens is members of each group are highly correlated, which implies that there is a high degree of overlapping information within members of each group. So we really don't need all these numbers. It's just a matter of organizing them in an appropriate way to extract the relevant independent information from them. We can do it either by taking some kind of weighted average or first principle component in each group. The point is that each group is very well explained by just a single first-principle component or weighted average.

So we can basically extract the activity factor that is roughly or loosely correlated in terms of its main trends with the slope of the yield curve. Similarly, with inflation we can extract the first principle component that roughly tracks the level of rates. The reason why I'm insisting on this type of wording and choice of variables is because we want roughly to mimic the way the fed makes decisions. Typically fed, when it decides the level of the target rate, looks at the level of inflation and activity and accordingly sets the short end of the curve.

So what we want to find implicitly is some kind of Taylor Rule for both the entire curve and volatility. Chart 4 shows what happens when you try to explain the yield curve in terms of inflation and activity. This shows what fed is doing and the response of each point on the curve to both of these factors. So, if you look at the fed’s target rate, you see that the distribution between activity and inflation is roughly 50/50. This is what we know as the Taylor Rule. As we go along the curve, we see that response to activity dies out as we go to the long end of the curve, whereas the inflation tends to linger on, meaning that it affects the curve pretty much like a parallel shift. This is well known, but what is not known and not widely used is that the volatility market or volatility surface has its own Taylor Rule, meaning that each point on the surface responds very strongly to the level of economic activity and inflation. For example, if you think of low activity, in order to give the boost to the economy, the fed starts lowering the rate in response to low activity. So, as a consequence, rates go down. However, when the fed becomes active, volatility ignites because we expect short-term fluctuations in rate and, therefore, the short end of the surface gets a bid until it's over and so on. So basically, as a consequence, negative shocks to activity tend to drive short-dated volatility high. This is what we see as the first thing on the graph. Three-month options get the highest response when activity is low.

So, basically what we found just by looking at this picture is that obviously both markets are driven by the same economic fundamentals, and therefore, they see the same information. It's logical. There is a logical connection between the two markets. So it's just a matter of finding what that connection is, namely, reading the fundamental content in one market and transcribing it into the other market. It can be done.

The complications surround how to do it because we have a volatility surface that has about 90 tradable points and curve that has about 30 tradable points as shown in Chart 5. So, how do you link the two? One way is just to summarize each of them with the one or two numbers and then link those two numbers. Instead of going through how we've done it, I would like to show you what this procedure does and then discuss where we are at the moment.

First of all, in Figure 1 we have identified some kind of rate combination that links to option volatility. In Chart 6, one line is the history of actual three-month-into-ten volatility, and another line is basically where that volatility should be according to the shape of the curve and level of rates. It is where the volatility should be, given the current fundamentals in the market. What's interesting , first of all, is that they share the common trends, namely, when one goes down, pretty much the other one follows and the other way around. Also what's interesting is that current volatility levels are very close to where the volatility has been during the 1998 financial crisis.

Figure 1

**Factoring out Fundamentals (The Procedure: Part 2)**

The Regression:

| Vol | | Curve | | |
|---|---|---|---|---|
| 1st Principal component | = | 3 Principal components | + | Residuals |
| 1Y10Y | | 10s, 2s/10s, 10s, 30s | | |

Each vol has a distinct loading, but the rate combination is always the same

$$T_t = 12 + 0.11 \bullet Y_t^{10} + 0.18 \bullet (Y_t^{10} - Y_t^{2}) + 0.34 \bullet (Y_t^{30} - Y_t^{10})$$

However, in 1998 these high levels of volatility showed up as large, idiosyncratic spikes. So they were not driven by fundamentals. They were short-lived excursions away from the fundamentals. Current volatility levels are not like that. Such high levels are commanded by current fundamental risks in the market. So, unlike '98, which was screaming with the arbitrage opportunities, the current market is very tight. It is very difficult to make money if you want to look for these locations. Simply, everything is high. Curve is very steep. Bond prices are high. And the market is extremely tight. So, knowing how the two markets communicate is probably one of the last frontiers that remain unexplored in this fed cycle.

I want to try to link the two markets and show you how they talk to each other and basically how to treat volatility as an asset class. Now that we defined the framework in which volatility and interest rates talk to economic fundamentals, we can basically put them in a context of a portfolio where we can offset fundamental risk by going long in one sector of the curve, going short in the other sector of volatility curve, and so on. Now, again, this is conceptually what happened. What can we do with this? First of all, we can use the current curve shape and level of rates to define where each point on the volatility surface should be according to economic fundamentals. Based on that, we can look for dislocations in the volatility surface in terms of rich/cheap signals.

So, if we put the whole surface in that context, we get the picture in Chart 7 where we currently see one-month options being driven mostly by seasonal effects, sensitivity to unemployment numbers, and so on. This was taken before the last payrolls. And where we see basically that given the level of market fundamentals, long-dated volatility appears slightly cheap in that context. Chart 8 will give you an idea of what has happened in the past. After Sept. 11, 2001, the market thought we were in a state of recovery and there was this huge sell-off and surge in the rates. The efficiency in supply of volatility in the market and the short-dated volatility surged.

Given the fundamentals at that time, volatility was overpriced. So Chart 9 shows what happens and how the history looks along different sectors of the volatility surface. Basically, you have one common trend for all the points, and they only differ by how much they have idiosyncratic discrepancy from that trend.

So now that we defined the fundamental drivers of each point on the surface -- again we have 90 points -- we are obviously able to define and identify the common trend of all these points basically by knowing just two numbers. Next, we clearly have to conclude that there is so much overlapping information on the volatility surface that you really need, instead of 90 points, only two points. This is a very powerful statement because it is telling us that we can define where all the volatility should be just by knowing two numbers. If they don't, we have trading signals, and this is what can be done basically in this context. Using Chart 10, I want to summarize this by showing you who is talking to whom and what else we need to get a more detailed description of the volatility universe. So let's say that we offset those fundamentals and look at what is left over after those fundamentals are taken out. Then we line up those so-called residuals against each other, and we look like the short-dated sector. If we regress two randomly picked residuals, let's say three-month into five-year versus three-month into 10-year, we notice first that these residuals are large. So although fundamentals explain the bulk of it, there is lots of it that remains unexplained. It is idiosyncratic, but these variations are large. Second of all, all of these residuals are highly correlated, which means that what is left over is driven by a single risk. That is good news. Now, look at long-dated volatility. Here we see that all of the residuals are shown on the same scale, so you have some visual kind of control of how big each part of that is and how strong the correlations are.

Long-dated volatility is usually less responsive to the market moves and operates on a lower frequency than the short-dated volatility. We see that residuals are much smaller, meaning that fundamentals actually explain much more. However, those residuals are not as highly correlated as short-dated volatility. And, finally, if you compare the residuals of short-dated and long-dated volatility, you get the best news here, which is that, apart from the size, they are actually almost not correlated at all. This means that the excess risk on top of fundamentals, the risk that is not common, is completely different between two markets. So basically we can trade them simultaneously, which is great.

So far, we have linked volatility and current market in a static way saying that basically for each shape of the curve there is a fair value of volatility. That is OK if we are talking about long-dated volatility, but we haven't specified at all how we go from one shape of the curve to the other. If we have, let's say, a curve that is spread between two stances, 150 or 200 today, and you ask me what is the volatility level if the curve steepens by 50 basis points, I'll tell you what it is. But I also need to tell you what the time horizon over which that curve steepening would occur.

If it occurs over one-year period, I know exactly what's going to happen, but if it occurs over the next two weeks, I know that market volatility, especially short-dated volatility, is going to freak out. There will be large spikes in volatility that are not persistent. They will be there for maybe a few weeks, but it's going to affect the short-dated volatility much stronger than the long. So in that sense we need additional information to understand the short-dated volatility because it not only depends on the curve shape and the levels, but it also depends on the process in which the market changes. So in that sense we need additional information about the short-dated volatility.

So Chart 11 more or less goes into more detail about how to link different volatilities along the surface. I'm going to try to answer the question of how many points on the surface you need to describe the whole volatility surface. How many factors do you have? This is showing the fundamental content along the volatility surface, showing us the dependence of volatility on different fundamental factors. I'm not going into any detail, but the point is that these sensitivities between different points on the surface are related in a very simple way. This means, again, that there is a well defined, rigid structure on the surface and that you really don't need more than two or three points to describe everything. So to summarize this in a graphical way, Chart 12 looks at the end of the long-dated sector of the surface, and plots it on a log scale. You see that the volatilities always fall under the straight line, and there is a theoretical reason for that.

So when the volatility surface moves, you have a stick on which you have different options. Either the stick moves up or down or pivots around an arbitrary point. So to describe a straight line you really need two points, and to add the short-dated volatility you just have that rigid structure along which the short-dated volatility flip-flops. So you need just three degrees of freedom. And if you try to explain the entire volatility surface in terms of two numbers, this is what you get, which is the residuals of the long-dated sector I explained. So you really don't need to go beyond that. And, again, if you want to go to the short-dated volatility, you get rather good idiosyncratic mean-reverting residuals, but they are large. So, either you want to take some risk in that case or you want to refine your analysis and explain some of these fluctuations.

To close this, I think it might be appropriate to mention the mortgage market. Although I haven't mentioned it before, this type of framework has had implicitly the mortgage market in it. Why? Because we assume that both options in current markets have to have consistent reading of the economy. In the long run, they have to agree. The question is why. If they don't, however, there is a mortgage market that will arbitrage away these discrepancies. When mortgage hedgers or mortgage services or convexity players in general decide how to hedge their convexity exposure they can either delta hedge it or buy an option depending on what is cheaper. So if there is any inconsistency between the rates in the current market, the mortgage market will arbitrage them away. So in that sense the mortgage market is a catalyst of this communication.

Chart 13 is the final picture that illustrates what happens if you don’t have mortgages, such as what happens in Europe. The first picture is just a selection of several points on the volatility surface in the United States. I want you to notice that these lines are drawn just to guide the eye; they basically determine the trends of volatility. No matter what selection I make, you would notice that all of these histories have the same common trends. So there is one common trend in the U.S. volatility market, which is demand-driven because of mortgages. All the volatilities are summarizable by a single trend. So when one goes up, all the volatilities go up. So in that sense we can summarize it with a simple number and extract the information from a handful of points on the surface.

In Europe, however, there is a supply-driven market. There are no mortgages. There is nothing like one common trend. One volatility may go up for two years. The other one goes down for two years. There is no communication. The market is completely fragmented. If you just look theoretically, you would say this is screaming with arbitrage opportunity. Yes, but there is no liquidity between two sectors. There is no one to arbitrage them away. So this is the role that mortgages are playing here. This is a risk that is specifically mortgage-related. It’s not something that’s contained in the rest of the interest rate market. So large spikes in the realized volatilities are something that can be explained outside of the context of rates and volatility.

So, now I want to summarize for you three things that are the main points of this framework. The first is that volatility and the curve should interpret the economy in a consistent way. They do talk to each other because they respond to the same set of fundamentals. This gives rise to the framework that is basically a directional volatility model that tells you how the volatility and curve communicate to each other. The second thing is that because of the simplicity of the structure we can, in principle, describe the entire surface with just a handful of points, which gives rise to a simple so-called spline model for the volatility surface.

And finally, gamma, being specific in the sense that it depends not only on the current information but on the process and how that information percolates in the market, requires separate treatment.

**FROM THE FLOOR:** My question is for Frank. The stuff you were showing, what type of software are you using it for?

**MR. SABATINI:** In that particular application we're using Moses, but there are other software applications you could use. You can get any of the vendor applications that allow you code access to do that, which is one of the keys. That particular illustration was done on Moses.

**FROM THE FLOOR**: What is the most effective way of communicating your stochastic results to upper management? Your example showed higher mean returns with less volatility. That's easy to understand, but how do you approach it when it's not quite as cut and dried?

**MR. SABATINI:** It depends on the management you're dealing with, but you generally try to focus on metrics that they can relate to. That is why I've always been a proponent of helping them look at GAAP numbers. They relate to GAAP numbers, and they can understand a distribution. So I'm a big fan of saying how much GAAP earnings volatility you want over what horizon. I think they can relate to that very well. On the economic side, it's any number of measures. Typically market value measures tend to work best because they can generally relate. Particularly in some of the new accounting, they have to understand market value measures. So you give them the distribution on a mark-to-market basis, the corresponding results on a GAAP basis, and then find a way to sort of equate the two sets of results.

**FROM THE FLOOR**: So you're concentrating on the mean?

**MR. SABATINI:** Well, I'm concentrating on the whole distribution, and typically you want them to communicate how much tolerance they have, which is hard. Typically they can't tell you what it is, but if you show them something, they can tell you whether it's too much or too little. Then you end up with sort of a convergence process until the too much and the too little start to get to be the same thing.

**FROM THE FLOOR**: Do you get into the downside risk versus standard deviation?

**MR. SABATINI:** Yeah, and that's why I said scenario analysis a lot of times. Just reducing the conversation to a couple of scenarios can make your case.

**MR. WILL MITCHELL:** It looked like the presentation on volatility was just interest rate volatility. Would stock market volatility be different?

**MR. KOCIC:** Yes, it’s very different. Basically we have a curve, and we have less of a microstructure in the market. The stock market depends on completely different factors. Very often there is some relationship between interest rates, stock levels, and so on. However, just to give you an example of how different it is, I think we have seen record high levels for interest rate volatility and almost record lows for stock volatility. I think they have completely different drivers. For example, while the level of rate influences, to some extent, stock prices, it’s certainly maybe a second- or third-order effect for volatility in the stock market. So, I think the drivers in the stock market are less fundamental and more idiosyncratic, more kind of price and earnings and corporate structure. This is a more macroeconomic fundamental.

**MR. MITCHELL:** The other question I have is on the volatility surface. What were the two axes, the two independent variables?

**MR. SABATINI:** You have a yield curve. Each curve has certain maturity. So, each point on the curve is a rate, like the two-year rate, five-year rate, or 10-year rate. So, you can have an option on that particular rate. One axis is the expiration of the option. So, a three-month option on a five-year rate. The other axis is the rate tenor. So, three-month into five means a three-month option on a five-year rate.

Chart 1

Dynamic Rebalancing to A Target Duration

| Dynamic Reinvestment Strategy | 0 | 3 | 6 | 9 | 12 | 18 |
|---|---|---|---|---|---|---|
| Total Market Value of Asset (incl. Cash) | 91,482 | 105,008 | 122,016 | 139,768 | 158,040 | 194,748 |
| Total Market Value of Liabilities | 87,353 | 103,092 | 119,071 | 135,148 | 151,347 | 183,387 |
| Market Surplus | 4,129 | 1,915 | 2,945 | 4,620 | 6,694 | 11,361 |
| Cash Available before Purchases | - | 19,828 | 19,177 | 20,231 | 20,052 | 39,450 |
| Market Value before Reinvestment | 91,482 | 86,006 | 102,947 | 119,993 | 138,310 | 155,778 |
| Asset Duration | 2.91 | 3.07 | 4.49 | 5.01 | 5.29 | 4.82 |
| Liability Market Value - Base | 87,353 | 103,092 | 119,071 | 135,148 | 151,347 | 183,387 |
| Liability Duration | 2.50 | 2.53 | 2.54 | 2.53 | 2.49 | 2.43 |
| Asset/Liability Duration Mismatch | 0.94 | 0.94 | 1.48 | 1.84 | 2.13 | 1.90 |
| Acceptable Duration Mismatch | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Target Effective Duration for Reinvestment | - | 9.14 | 7.32 | 5.47 | 3.62 | 4.81 |

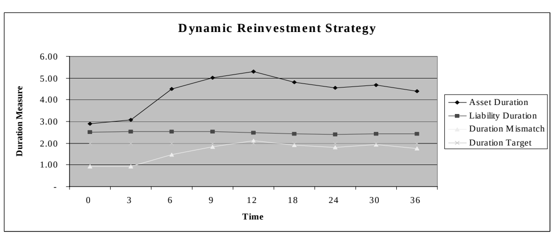


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Chart 2

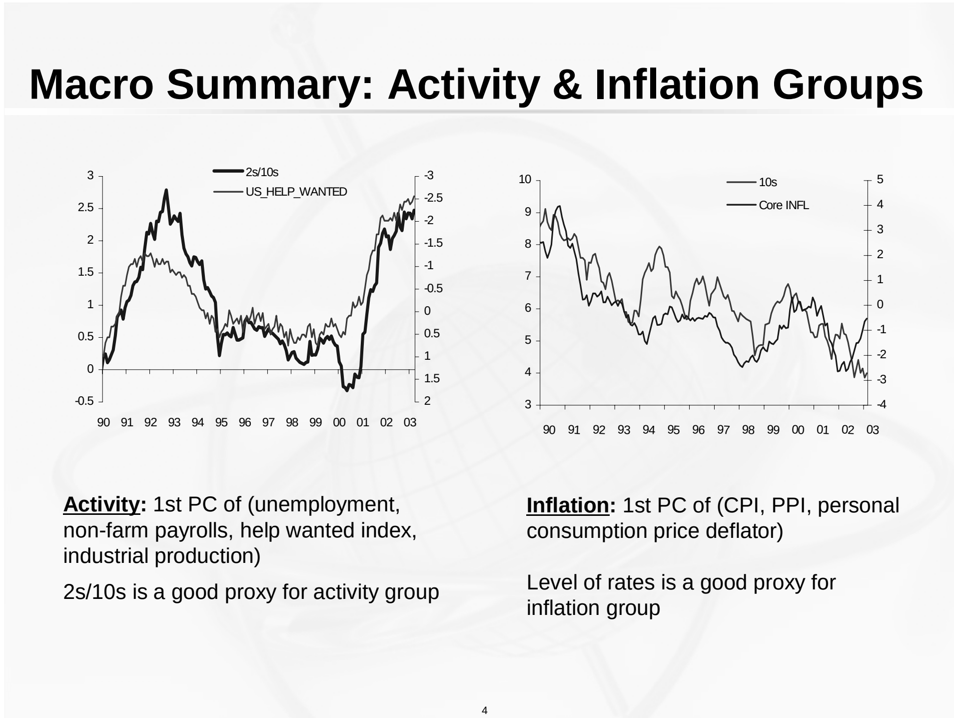



Chart 3

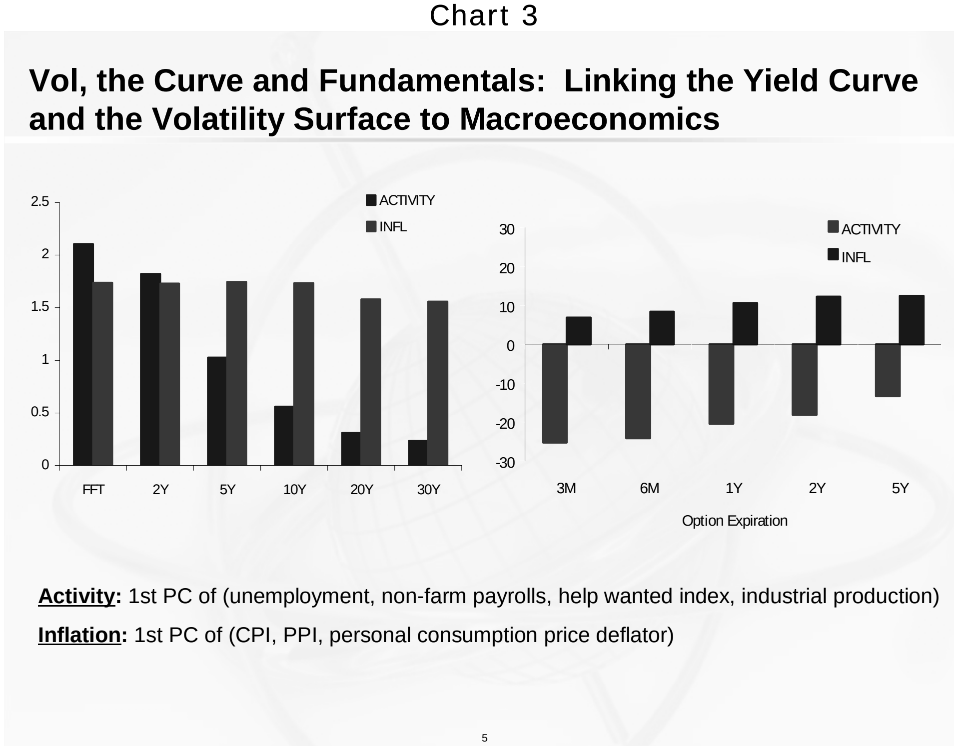


Chart 4

# Factoring Out Fundamentals: The Procedure (Pt. 1)

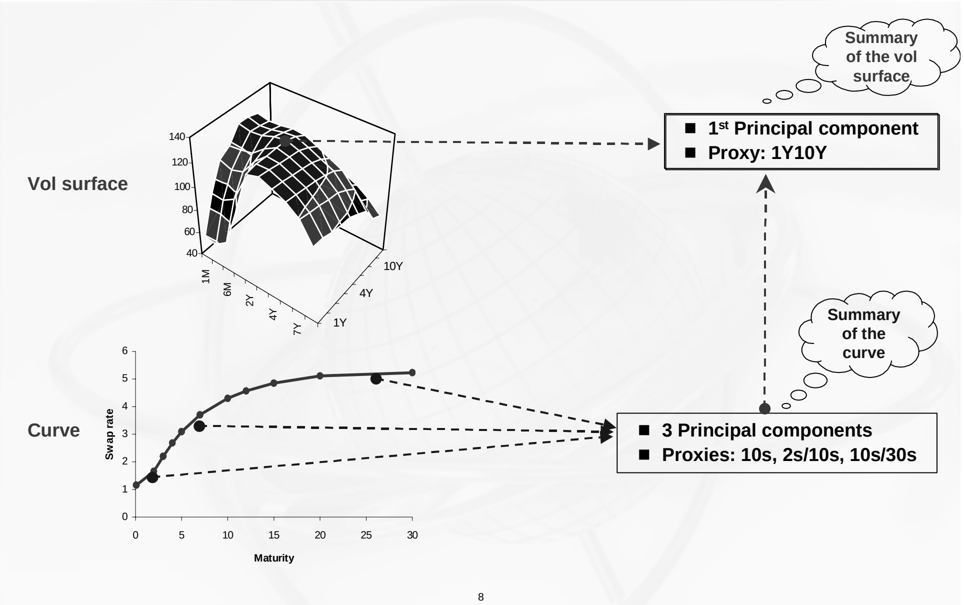



Chart 5

# Offsetting the Fundamentals: Vol and Curve in Practice

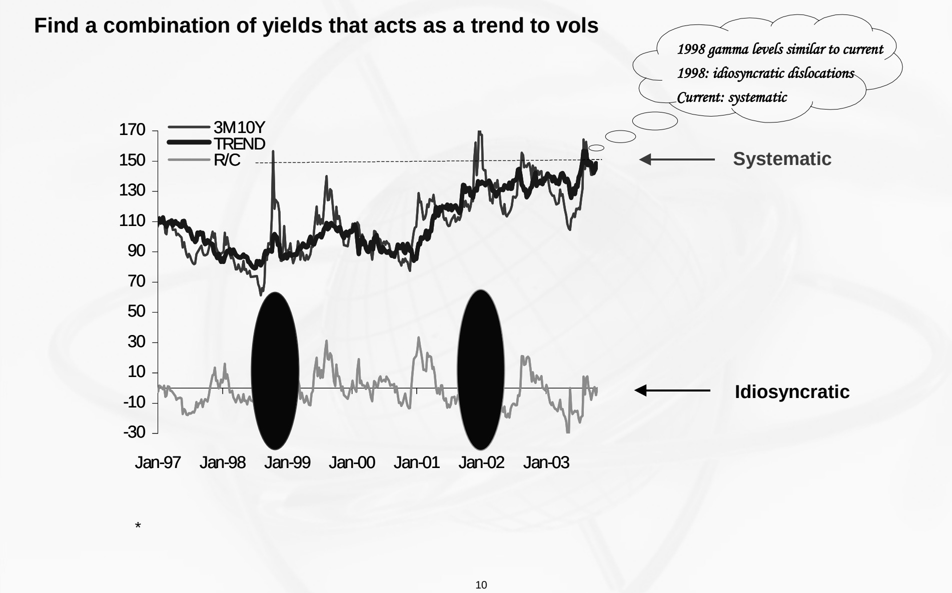


Chart 6

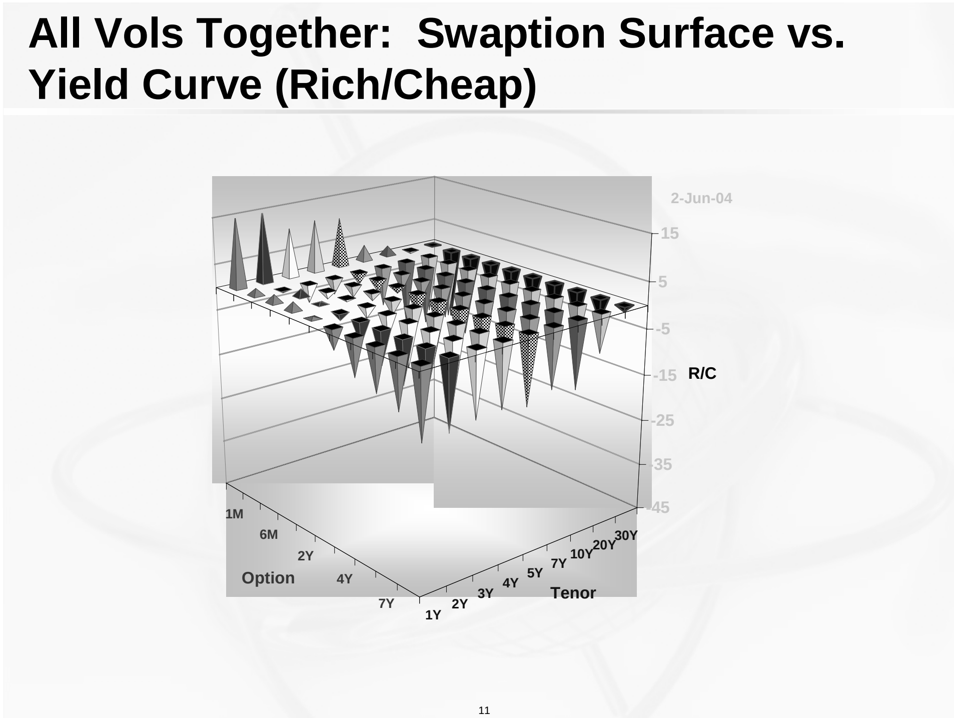



Chart 7

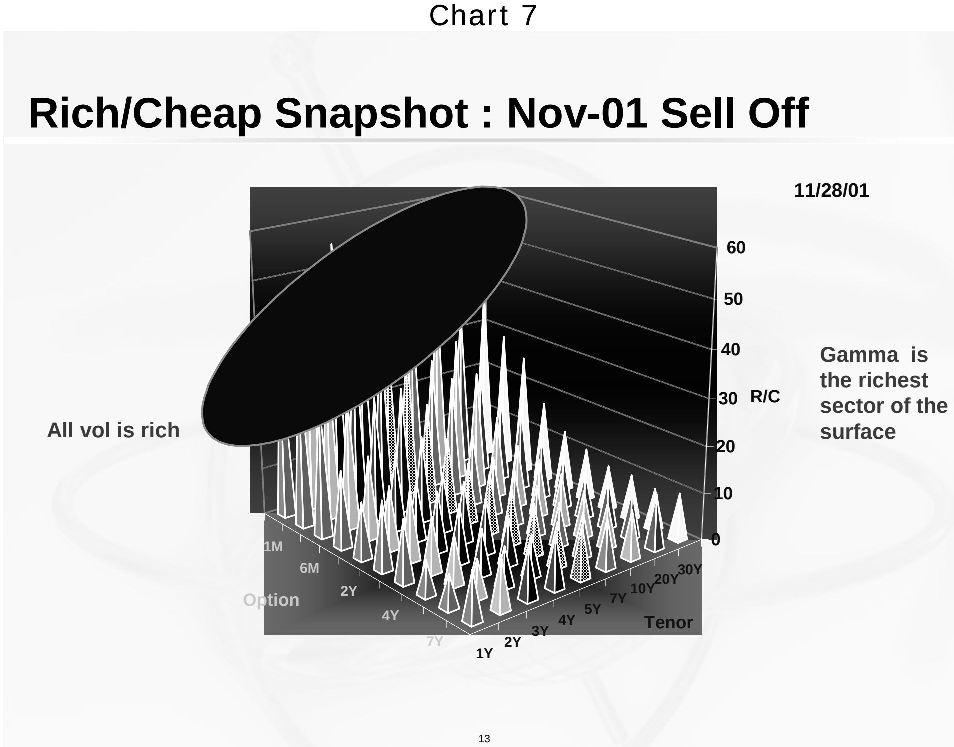


Chart 8

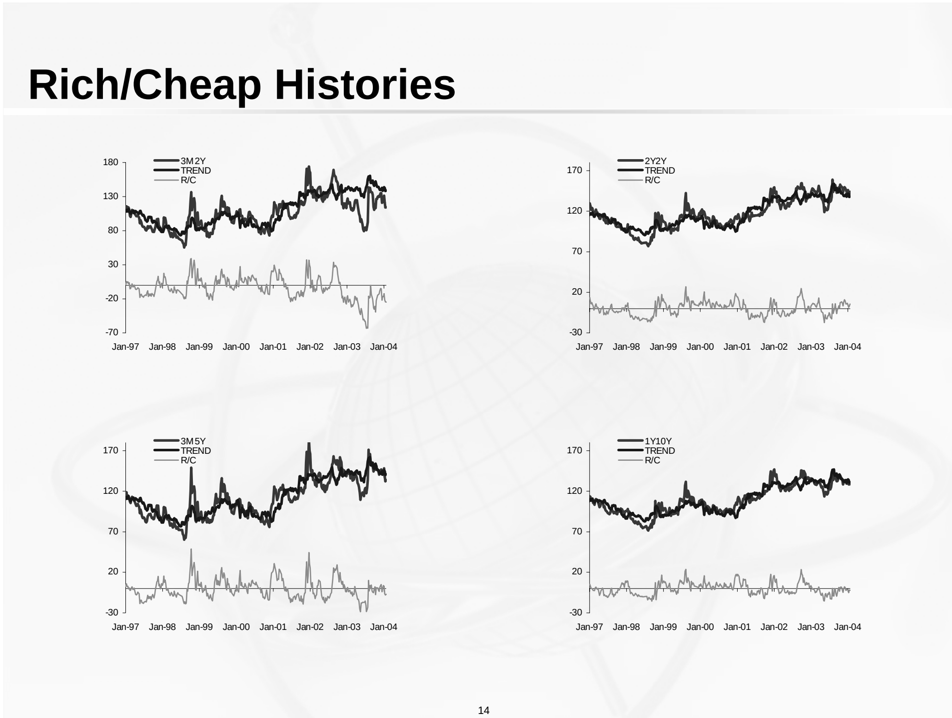



Chart 9

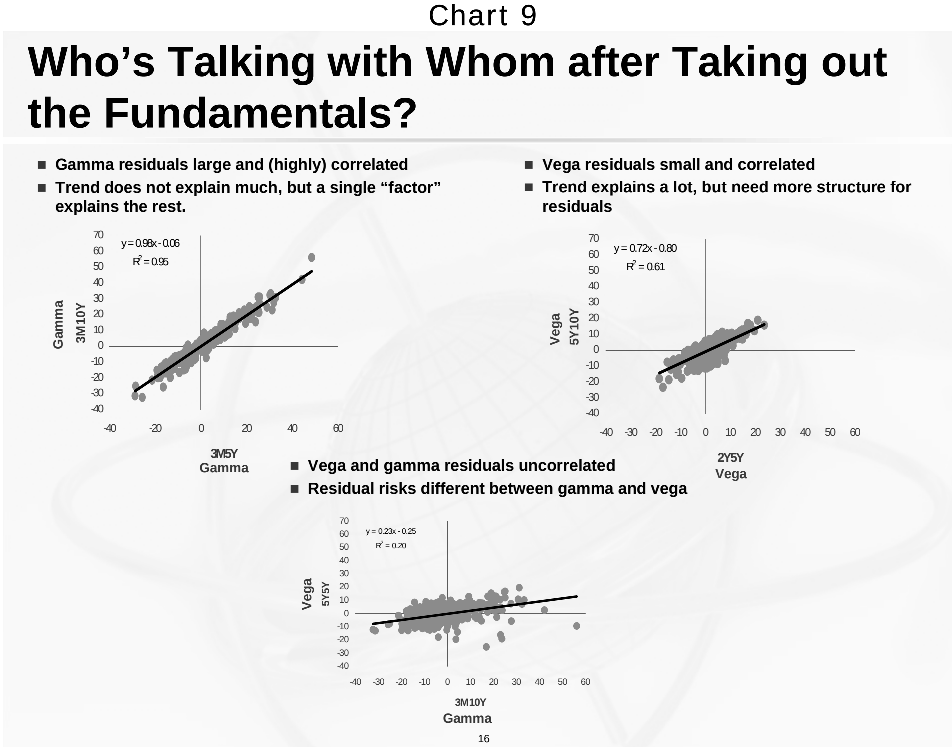
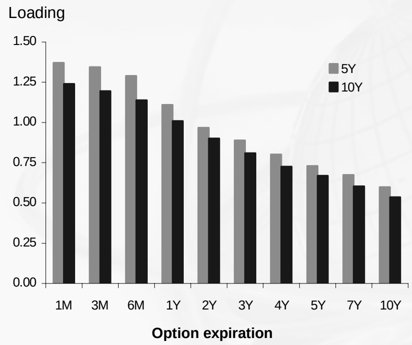


Chart 10

## Entire Surface Can Be Summarized with a Few Parameters

- **Vol & Curve: Loadings**

**Beta's: Response of Vols to the Change in Trend**




**Different Tenor Beta's Related in a Simple Way**

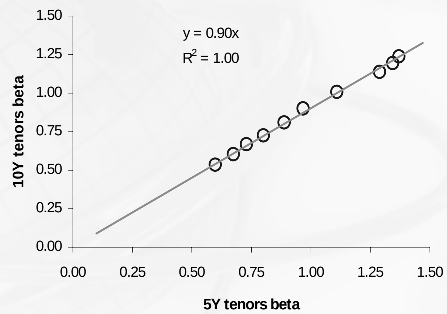



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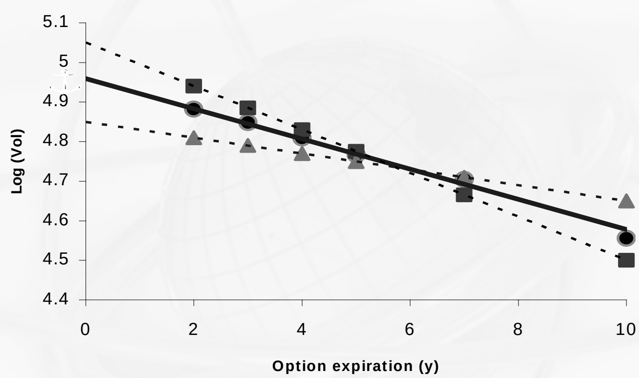
Chart 11

## Are Long Vols Interchangeable?

**Long-dated vols are log- linear**




**Same tenors always move together**

Each point on the surface is a weighted combination of 2Y5Y and 5Y5Y

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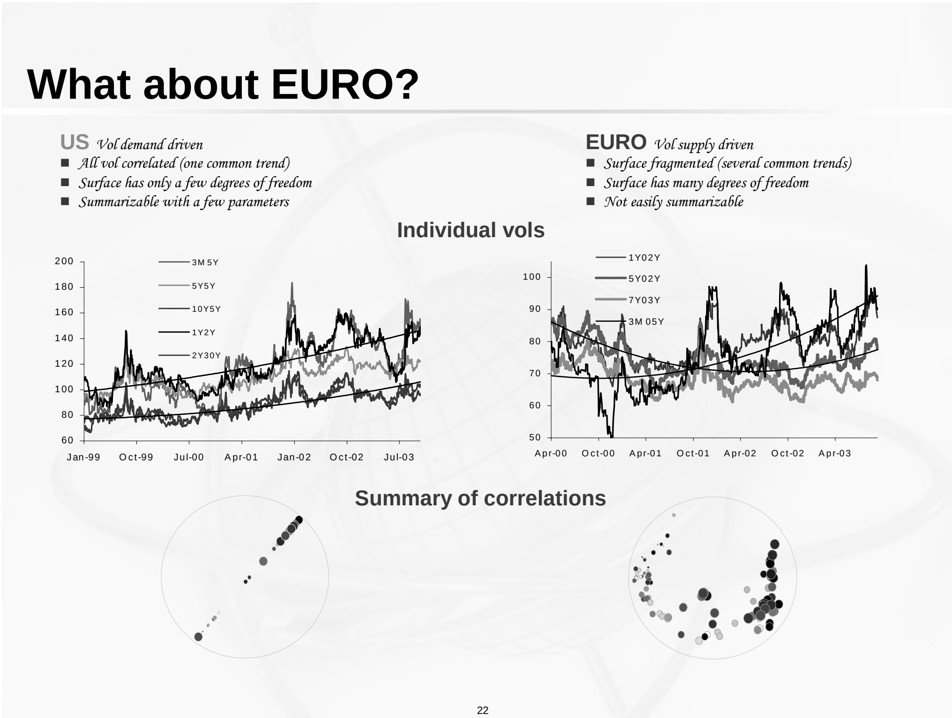
Chart 12


What about EURO?
US Vol demand driven
All vol correlated (one common trend)
Surface has only a few degrees of freedom
Summarizable with a few parameters
EURO Vol supply driven
Surface fragmented (several common trends)
Surface has many degrees of freedom
Not easily summarizable
Individual vols
3M5Y
5Y5Y
10Y5Y
1Y2Y
2Y30Y
Jan-99 Oct-99 Jul-00 Apr-01 Jan-02 Oct-02 Jul-03
1Y02Y
5Y02Y
7Y03Y
3M05Y
Apr-00 Oct-00 Apr-01 Oct-01 Apr-02 Oct-02 Apr-03
Summary of correlations
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