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STRESS AND SCENARIO TESTING FOR UK RESIDENTIAL MORTGAGE-BACKED SECURITIES; A METHODOLOGY FOR LOAN-BY-LOAN TESTING

In this Discussion Paper, Dr Stephen Satchell, Economics Fellow, Trinity College, Cambridge and Director of Research MIAC | Acadametrics Ltd, notes that a revival of the residential securitisation market is likely to involve a requirement for loan-level stress and scenario testing and that prime on-balance sheet lenders and others are already taking the appropriate steps. Dr Satchell suggests why typical IRB methodologies, used for such testing, depend too much on individual judgement and cannot provide the reliability required to restore investor confidence.

Although recognising that macroeconomic data at the time of a future "worst case" are likely to be very different from those at the time of the 1989-1991 housing crisis, Dr Satchell argues that risk levels are likely to be comparable and that historic default data provide the best foundation for reliable estimation. His Macro-Risk Model measures UK mortgage book risk, in what he describes as a "significant spike" in repossessions in 1991, at 2½ times the 20 year long-run average. Following 12 years with risk at less than half the long-run average, rising default in 2008 led to forecasts that 75,000 families would lose their homes. However, Macro-Risk Model shows that risk in 2008/9 reached at most only 1½ times average and reverted to average, earlier this year.

Dr Satchell explains the use of UK risk levels to scale the hazard rates, used in loan-level stress and scenario testing, according to the likely risk implicit in different macroeconomic scenarios.

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STRESS AND SCENARIO TESTING FOR UK RESIDENTIAL MORTGAGE-BACKED SECURITIES; A METHODOLOGY FOR LOAN-BY-LOAN TESTING 26TH SEPTEMBER 2011

Dr. Stephen Satchell (Economics Fellow, Trinity College, Cambridge and Director of Research MIAC | Acadametrics Ltd)

PREFACE A sequence of governmental and regulatory initiatives has taken place from 2009 aimed at improving the transparency of the information, provided by lenders engaged in the securitisation of loan portfolios, in order to revive the market. However, although the UK Residential Mortgage-Backed Securities (RMBS) market for new issues showed some activity in 2010 and the covered bond market is active, a significant renaissance of UK RMBS is, as yet, far from an immediate prospect.

In commenting upon the state of the RMBS market, we express our appreciation for very helpful insights from practitioners including regulators and lenders. The subdued nature of the European RMBS market contrasts with the rather small number of defaults experienced. It is clear that behavioural biases are at work. Having seen demand disappear recently, current potential investors seem inhibited by their past experience; ignoring perhaps the potential of new issues to be highly remunerative. Traditional holders of RMBS, that is banks, virtual banks and money market funds, all practised a similar strategy which could be simplified to that of issuing short-term paper to finance the purchase of (relatively long-term) RMBS. This inter-institutional market seems slow to pick up and we recognise that demand may not re-emerge for some time. It would be a separate, rather fascinating topic, to explore this further using the concepts of behavioural finance.

Whilst the above initiatives, emanating from the Bank of England, the EC and the USA, have yet to result in transparency in UK RMBS, our discussions with lenders, consultants and other market participants confirm that a move towards loan-by-loan stress testing is already underway.

It is not apparent, however, that a widespread understanding exists of how such testing can be undertaken under alternative macroeconomic scenario projections. This Discussion Paper suggests a procedure for doing so based upon a range of work on mortgage portfolios, starting in 1990, during the 1989-1991 housing crisis, and continuing for most of the decade. Any comments would be most welcome.

LOAN-BY-LOAN STRESS AND SCENARIO TESTING

Model Constructs A typical current procedure for loan-by-loan stress and scenario testing by an Internal Ratings Based (IRB) modeller, under Basel II requirements, would allocate risk to loans based on a scorecard. Each loan ends up in a risk class/group that can be ranked from low to high risk. Different macroeconomic scenarios are allocated different 'degrees of severity', which are then translated into shifts across risk classes depending upon the applicable degree of severity. In practice, this may apply to the allocation of the Probability of Default (PD) as well as to Loss Given Default (LGD) modelling. For example, a new severe scenario, akin to the period of peak emergence between 1990 and 1992, might justify a move across three risk groups in a model which incorporates, say, 25 different risk classes in all. The difficulty with this exercise is that different experts, independently validating the same loan book, would arrive at what might prove to be very different answers; there is too much arbitrariness in such a system. As we have seen in the past, arbitrariness leads inevitably to outcomes that can be gamed.

We anticipate a need for external advice and validation and note the full Walker Review recommendation 25 that a board risk committee be *"attentive to the potential added value from seeking external input to its work as means of taking full account of relevant experience elsewhere and in challenging its analysis and assessment"*. Loan-by-loan procedures which would lead to different risk managers with the same loan book arriving at the same, or very similar, answers are desirable and could, no doubt, be offered by a number of external advisors, such as exist in the UK. Each is likely to have its own individual procedures, probably dependent upon the data available. Whilst no process currently exists by which such

procedures could be agreed upon, organisations with historic data will be able to validate the results of their model by back-testing.

Arbitrariness of Existing Loan-Level Modelling Approaches On close inspection, the procedure employed by IRB modellers and others is very close to that which comprises an expert judgement model; different factors are specified, correctly or otherwise, and weights (risk exposures) are attached to each factor. Whilst this can be reasonably effective if the modeller is good at these matters, there is little scope for validation by clients as there is usually no statistical database underpinning the proceedings available to the client. Validation requires some sort of statistical framework. Our approach, which is discussed below, creates a statistical framework based on our past data. Whilst some of our data and the hazard rates which we derive from them are proprietary, we fully explain our model to clients.

The Problem of Non-Factor Random Variation Whilst a goal of loan-by-loan risk assessment is conceptually attractive, the inadequacies of the available data do require some degree of compromise. To explain the difficulties, it is worth taking a digression by looking at the same problem in the evaluation of macroeconomic risk in equities. It is widely recognised that virtually all firms are exposed to significant risk from changes in the macroeconomic environment. Notwithstanding this, when one tries to run regressions of individual stock returns against different macroeconomic growth rates, the level of non-factor random variation is very high. The problem is typically solved by aggregating the stocks into groups that are deemed to have common exposures to these macroeconomic risks, thereby reducing the stock-specific risk and raising the importance of the macroeconomic risk. The group information is used to estimate intra-group parameters; the risk information is then used on a stock by stock basis.

If this is a problem with equity returns, the problem is many times worse when we come to individual loan histories. For this reason, a certain degree of aggregation is necessary and our modelling will be based on the calculation of risk numbers involving groups of loans with common characteristics. These common characteristics may be: year of origin; LTV band; amount of loan; arrears etc. Such aggregation sounds a little like the IRB solution which we criticised earlier; it is a matter of judgement as to the degree of granularity with which we carry out the analysis. However, our analysis is still done on a loan-by-loan basis, albeit with what may be thought of as a common factor structure. The answer will still depend upon the assessor's judgement but, we would suggest, not by as much. We may quote the Bank of England's Andrew Haldane who, referring in his February 2009 paper "Why Banks Failed the Stress Test" to the *"financial crisis of the past 18 months"*, said that *"risk management models ... failed Keynes test - that it is better to be roughly right than precisely wrong"*. Whilst uncertainties exist even as to the source of this quotation, it does illustrate our dilemma. There is a tension between the statistical uncertainties of idiosyncratic risk, if we fully go down the loan by loan path, versus the loss of individual information, if we group our data. We shall refer to this point later in the paper. The use of aggregated data is seen as a problem by regulators; however, whilst, as described above, we do aggregate data, for statistical reasons, to derive the probability of repossession, this probability and the expected loss are calculated individually, depending upon the details of the loan concerned.

Our Loan-by-Loan Stress and Scenario Testing Model As indicated above, a choice of modelling procedures is likely to depend upon the available data. The work, which we undertook as a result of the 1989-1991 housing crisis, provided data on a large number of defaults, such that we can place a current loan within a cohort of past loans with similar characteristics and identify a Probability of Possession (PP) based upon the data. As indicated, this probability is shown as a hazard rate, as is the probability of redemption. Once the Probability of Possession is calculated, our data then enable us to estimate a Loss in the Event of Possession (LIEP) based upon detailed past data. The hazard rates are flexed to account for arrears status and for the macroeconomic scenario concerned.

DESIGN OF ECONOMIC SCENARIOS FOR STRESS TESTING

How do we choose scenarios? Use of History The difficulty with scenario analysis is that we can make a loan book look good, or bad, depending upon the scenarios which we choose. Not unreasonably, we use the past as our guide but we do not exclude the possibility of allowing "black swans" into the picture. Such an approach is essential in loan risk analysis, since many data series exhibit no historical default but are clearly intrinsically risky. We employ two distinct 'standard' scenarios, each with different hazard matrices that correspond to the "roll-out" or evolution of risk for particular mortgages. One of these is our "historic worst case" and the other is our "historic severe case". For each of these two

past events, we hold sufficient default data to be able to establish distinct hazard rates for the likelihood of redemption and repossession. In addition to estimating outcomes were risk to be resumed at historic levels, we provide, as standard procedure, estimates for a "current scenario" and for a "client scenario". The client might choose to provide the former scenario but which we can otherwise specify; for the latter, we require the client to complete an "input parameters" sheet. Our estimation of the outcomes for these two scenarios is based upon scalars of the historic risk, as we describe below.

Our "historic worst case" hazard rates are based upon real repossessions, representing what was by far the worst experience to take place in the housing market after World War 2. These hazard rates enable us to forecast the possessions and arrears, which we consider will be likely to arise in a future 'worst case' macroeconomic scenario. We believe that our result is likely to be far closer to any ultimate outcome than one derived from the use of more recent data, such as are likely to be employed by those lenders lacking data from the historic 1989-1991 housing crisis. Of course, the macroeconomic factors behind a "black swan" event are unlikely to precisely replicate those which pertained in any past worst case or those which govern our "historic worst case" hazard rates. However, a scenario in which interest rates rise from say 3% to 6% may well have the same devastating effect on borrowers as did the 14% rate which pertained during the period 1989–1991. Nevertheless, our basic belief, which we have had no reason to modify to date, is that the mortgage crisis of the future will behave in a similar pattern to the mortgage crisis of the past, in most respects. It may well be that government initiatives that promulgate forbearance among lenders will make our forecasts of default relatively severe; in which case our outcomes can be adjusted or treated as latent defaults.

It may be noted that our "historic worst case" reflects a significant spike in repossessions which occurred in 1991 but which, for a number of reasons, was not reflected in the CML data until 1992. Our "historic severe case" includes the effect of the spike but reflects a subsequent slowing in repossessions over the next two years and the results accord with the experience of lenders immediately following the crisis, as published by the CML and shown in the Bank of England chart to which we refer below. By using the parameters observed from the previous housing crisis, we have a means by which loans can be 'stressed' on a case by case basis and an estimate of expected losses made with a reasonable level of accuracy, confirmed in practice.

How then do we assess a scenario that might be put forward as one that would comprise a "black swan" event and how do we measure the effect of the possible future crisis suggested in the FSA "anchor scenario"? In order to do so, it would be theoretically appealing to link any such particular set of macroeconomic factors to a particular sample of mortgage outcomes and build our hazard matrices accordingly. However, this is challenging in practice, as it requires a quality and quantity of data that are simply not available. Because of this lack of data, we do not attempt a statistical model to relate the macroeconomic factors to the repossession data which we hold; instead we employ scalars to account for different levels of macroeconomic stress severity, as further described.

MACROECONOMIC RISK

In regard to macroeconomic risk, it may not be realised that, whilst it recently peaked in 2008, macro-risk during the past two years was far from the levels experienced in the early 1990s. We substantiate this assertion by analysis which we describe below. The methodology which we employ is to estimate relationships between aggregate CML data for arrears and repossessions and the various macro-variables which we consider important. This is done via a probability model (known as a logit), which, by the use of grouped data, can be transformed into a linear regression model. We then transform the output so that it is normalised relative to average weight. This means that terms such as high, low and average are dependent upon the sample period used, as further discussed.

MEASURING RISK

Whilst terms such as high, low and average do not provide an invariant measure, it may be said that neither does such a term as 'worst case'. We define our worst case as a "historic worst case" and base it upon the repossessions from mortgages originated in 1989 which peaked in 1991 - a specific repossession experience which reflects the mortgage market in shock.

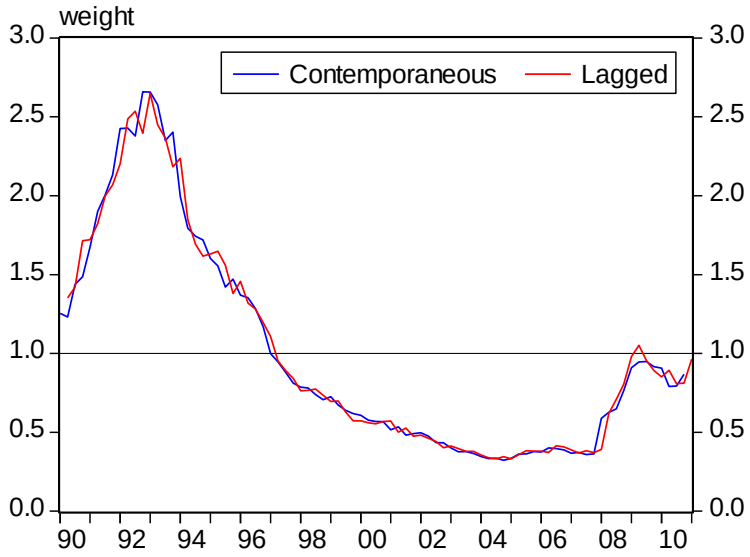
Ideally, it would be possible to measure risk using a default rate, in the same way that IRB models are "tuned" to the outputs of rating agencies which, in turn, reflect different default rates. However, as an example of how widely the performance of individual loans may vary from the mean and of the need for loan-level stress testing, Table 23 of our "Mortgages in Shock" paper on the 1989-1991 housing crisis (available upon request) shows a 1989 loan of £43,640, selected ***at random*** from our data, which resulted in a loss of £24,234 compared with one of £1,183 under a rating agency AAA benchmark and one of £8,083 under a BBB rating, as quoted in the "Fitch UK Mortgage Market Default Model 1996".

Essentially, our Macro-Risk Model converts the arrears and possession experience of the national mortgage book (as represented by the aggregate CML data) into a weighted measure of the default risk experienced over the last 20 years. Our graphs below are very comparable with Chart 2.16 in the Bank of England Financial Stability Report June 2010, showing *"Arrears and possession rates on secured lending to UK households ... based upon CML and Bank calculations".* However, we show our macro-estimated risk weightings for arrears and repossessions, whilst the Bank's chart shows the published arrears and possessions numbers. The Macro-Risk Methodology is available to clients employing our Stress and Scenario Testing (SST) procedures.

As our graphs show, risk can be measured by arrears or by repossessions. The first graph shows arrears risk; the second graph shows repossession risk. We define arrears as CML mortgages 6-12 months in arrears as a percentage of all mortgages at the end of the period. Possessions are defined as CML mortgages taken into possessions as a percentage of all loans, in the period.

We present two versions in each case; one with contemporaneous risk factors and one with lagged risk factors that can be utilised for forecasting. Broadly speaking, both lagged and current versions give a very similar picture; indeed, qualitatively, there is not a great deal of difference between using arrears and repossessions. We slightly favour repossessions in that it is a much more unequivocal definition. Note that our Macro-Risk Model weights fall within the range c.0.25 (low risk) and c.2.5 (high risk).

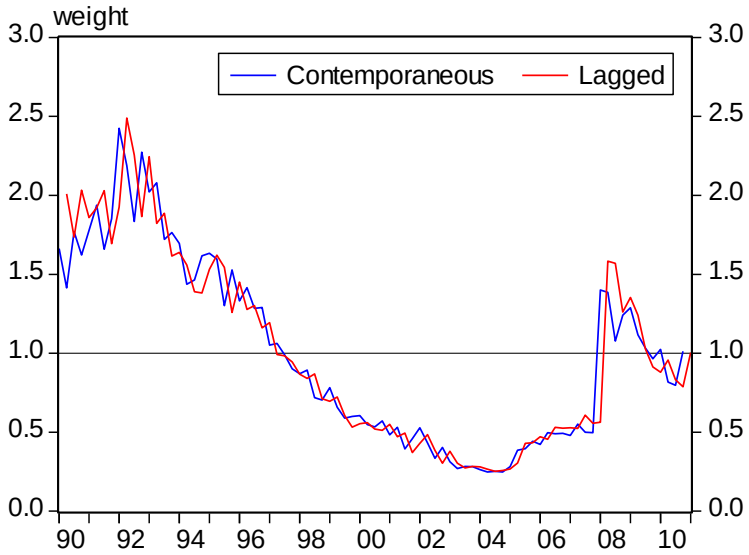
ARREARS RISK



We have noted that terms such as high, low and average are dependent upon the sample period used. Measuring repossessions at a past date inevitably involves a timing issue, insofar as a question arises as to the years of origin of the loans in default and as to the period over which the repossessions take place. Our "historic worst case" narrows these dates to a 1989 year of origin with, as stated, the repossessions peaking two years later. Our "historic severe case" reports a spread of loans originated from 1988 to 1991 with repossessions peaking from two to four years later, thereby providing a more averaged result. Under both scenarios, repossessions can occur up to ten years following origination.

Our Macro-Risk Model measures how the results of our "historic severe case" are affected by change in the macroeconomic factors.

REPOSSESSION RISK



Our second graph shows how far below the average level repossession risk was from 1997 to the start of 2008. Whilst repossession risk recently peaked at just under 50% above average – relative to the last 20 years – according to the lagged model (and at 30% above average according to the contemporaneous model), risk around the end of 2008 did not compare with 1992, when the level was 150% above average. Our model also shows that risk returned to past average levels earlier this year. We note the steep rise in repossession risk toward the end of the sample. This was due to a fall in GDP by 0.6% in the fourth quarter of 2010, compared with an increase of 0.7% in the previous quarter.

Macroeconomic scenarios which would bring about any reversion to 1992 levels of risk, or worse, are what will concern senior management. Risk committees should be trying to discover risk levels and combinations of macroeconomic risk factors that might bring about very high default rates, for use in reverse stress testing. To assess whether such combinations would be extreme would require the estimation of joint probabilities of macroeconomic events. This would be possible but would require a significant enhancement to our Macro-Risk Model since, currently, we do not build a separate macroeconomic model that attempts to forecast an array of macro-aggregates; these are available from the well known economics houses.

A complication, as mentioned, is the degree of forbearance now being exercised by lenders. Whilst we could include this in our analysis, we are of the view that, here, we are measuring latent repossession in terms of fitting. We could correct the repossession data to include those mortgages that have benefited from forbearance and subtract them from our arrears total, were this to be requested.

COLLATERAL VALUATION

Revaluing the collateral behind the loans: the use of a lender index at regional level for revaluation was a long established procedure; this can result in substantial valuation differences, including those arising for individual properties and at portfolio level; errors which we have calibrated. Our above platform employs, for our standard revaluation, our Acadametrics Residential Asset Calculator (ARAC) house prices based on Land Registry data whilst being able to accommodate client revaluations from any chosen index or AVM.

A "Current" scenario and other future scenarios as may be selected under "client" Using our Macro-Risk Model, we are able to account for other scenarios by "de-stressing" (or otherwise) on a case by case basis, from the historic data. Such scenarios would include those employed by on balance-sheet lenders and by investors in RMBS bonds for forecasting

cash flow as well as likely borrower distress outcomes. It will be possible to apply the Macro-Risk Model in a dynamic process and e.g. to differentiate between interest only and repayment mortgages.

The FSA *'anchor' scenario* The FSA Prudential Risk Outlook 2011 specified the 'anchor scenario as: *"one of weak global growth"; "a decline in UK GDP of 4.3% from Q4 2010 to Q4 2012, with gradual recovery thereafter"; "a rise in the UK unemployment rate to a peak of 12.4% in Q1 2013"; "a 'double-dip' in UK property prices, with house prices falling by 20.7% from the beginning of the scenario to the trough."* Where the FSA 'anchor' is included as a "client" scenario, we insert the proposed macroeconomic scenario, including the 20.7% fall in house prices, into our Macro-Risk Model to obtain a macro-risk weight measure and we scale the hazard matrices appropriately.

Cash Flow Our collateral valuation and loan level stress testing procedures are embedded in the OLAP database management and cash flow software platform, provided by our New York partners MIAC Analytics, for use by lenders in-house. Results can be provided, alternatively, prepared by ourselves using data placed on our secure UK server.

Conclusion Regulatory and commercial initiatives make loan-by-loan risk assessment both timely and desirable. What is clear, at least to us, is that doing this will require a rather delicate balance of factor (group/common) and loan-specific information. There is no easy way to assemble the data necessary to construct such models but, having access to a good database of past loan repayments/ arrears/repossession/loss histories, whether originating from one's own book or common to some pool of books, is almost certainly the best way forward.

Footnote: Further detail is provided in our "Stress and Scenario Testing (SST) Methodology" paper.

ABOUT MIAC | ACADAMETRICS LIMITED

MIAC | Acadametrics Ltd is a joint UK company of Acadametrics Ltd and New York based MIAC Analytics. In the US, MIAC Analytics is a top provider of pricing, risk management and accounting solutions, with expertise in secondary and capital markets, price discovery methods and collateral behaviour analysis. In the UK, MIAC | Acadametrics combines MIAC software and Acadametrics mortgage stress testing and scenario analysis programs in a proven analytics platform provided for use on a UK based secure server. Whilst, in the US, MIAC currently integrates with the largest independent prepayment model vendors, credit risk model vendors and data vendors, such sources are largely unavailable in the UK, except as are provided on the MIAC | Acadametrics platform.

Aimed at supporting mortgage lenders, capital markets players and asset management businesses, MIAC | Acadametrics is a unique, independent, source of the leading edge risk analytics required of all participants in today's demanding markets.

MIAC ANALYTICS

Since 1989, a majority of the US industry's largest mortgage companies has trusted the purpose-built MIAC Analytics software, used on a monthly basis to hedge more than four trillion dollars in mortgage whole loans, MSR's, structured products and interest rate derivatives. MIAC's term structure *Libor Market Model* has an industry-leading calibration process to enable highly accurate volatility-based asset pricing. MIAC's clients include Fannie Mae, Freddie Mac and the Federal Deposit Insurance Corporation (FDIC)

MIAC valuation and analysis features these enhancements and support:

- *DataRaptor* – a purpose built database management tool to facilitate analysis of mortgage portfolios
- *WinOAS* cash flow modelling
- Asset valuations and software models are audited and validated - Annual SAS-70 Type ll Audits of IT Infrastructure, business controls, software development procedures by Grant Thornton, LLP
- Embedded Sarbanes-Oxley Compliance Tools - assumption tracking and control, permission and access control and cash flow validation support
- Fully validated asset cash flows, *Option-Adjusted Spread (OAS)* and asset/liability models

ACADAMETRICS LTD

Acadametrics is focussed upon risk and provides a range of products and services founded upon advanced academic research and macroeconomic modelling, led by Dr Stephen Satchell, Economics Fellow, Trinity College, University of Cambridge. In the early 1990s, Dr Satchell and Acadametrics staff forecast the mortgage and Mortgage Indemnity Guarantee losses likely to arise from the 1989-1991 housing crisis. The substantial downturn default and mortgage database employed has enabled the hazard rate forecasting methodology which Acadametrics uses to forecast loan-by-loan losses today. The LSL Property Services/Acadametrics House Price Index, reporting every transaction recorded by the Land Registry, including cash sales, is increasingly recognised as a benchmark index. It was given valuable launch support, as the FTHPI, by the Financial Times and was selected by the Chicago Mercantile Exchange for a proposed residential house price derivative.

Acadametrics risk work features:

- Collateral valuation – *Acadametrics Residential Asset Calculator (ARAC) with latest house price data and* Confidence Interval tables; Excel-based or programmed into *DataRaptor,* for lenders and residential property portfolio owners
- Stress and scenario testing & arrears analytics including:
  - *Stress and Scenario Testing (SST)*, providing forecasts of possessions and losses under alternative scenarios at loan-by-loan mortgage level integral with *DataRaptor*
  - *UK Arrears and Repossessions Forecasting (UKAPF)* modelling the UK mortgage book. Our related *Macro-Risk Model* provides input to SST and accounts for alternative macroeconomic scenarios
- House price data series - *Acadametrics Prices and Transactions (APAT)* data shows trends at county/London borough and property type level
- Custom data and model development - including the provision of LGD data from the Acadametrics downturn default database, model validation and model development

To learn more about MIAC | Acadametrics, please visit our website **www.miac-acadametrics.co.uk**

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