Statistical Data and Models Used for Analysis and Management of Financial Stability at the Macro Level

Marcin Lupinski, University of Warsaw, National Bank of Poland

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1. Introduction—new perspective of supervision and financial stability management[1]

The scope and severity of the last global financial crisis revealed serious drawbacks of the financial stability policy based on the first two Basel Accords microeconomic regulations, but monitored and managed with models using aggregated data taken mainly from balance sheets of financial institutions. The crisis proved that a particular institution, although often conscious of its systemic importance, does not have enough incentives to contribute to the soundness of the whole financial sector. On the contrary, old and well known theory of moral hazard was embodied in practice of many financial entities across various jurisdictions, as some bankers and insurers tried to capture all possible profits during time of prosperity and to distribute their losses at counterparties' and taxpayers' expense during time of turbulence. Moreover, it turned out that this hazardous processes can take place in a particular institution on the portfolio and business line levels, which had not been noticed for a long time by financial supervisory authorities working with consolidated data.

National and international central bankers and supervisors quickly understood this lesson and started organizing enhanced support for their policy embodied with macro prudential toolkits. These toolkits embrace: systemic risk analysis and management, surveys on transmission channels between the financial and real sectors, mitigation of the counterparty risk spilling over residencies, off-balance sheets positions monitoring and fine-grained data modeling. New analytical solutions were employed to evaluate networks

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of dependencies between portfolios of financial institutions operating in interconnected markets. This approach generated substantial challenges for statistical data systems. It is worth mentioning the following five most important ones:

1. Ensuring proper trade-off between the level of granularity, accuracy of description and reporting burden of reporting financial data.
2. Introducing off-balance sheets data analysis allowing to observe the evolution of the quality and prices of financial instruments used for hedging or speculation.
3. Extending data coverage to analyze closely connected financial and real sectors, whose entities (agents) are affected by different types of interdependent risks (credit, market, operational, liquidity and solvency).
4. Analyzing relations among institutions operating within financial subsectors of a particular economy (like banking, insurance, hedging entities), and among institutions operating in different subsectors of a single jurisdiction, and among institutions from various jurisdictions.
5. Putting more emphasizes on data quality, highlighting the importance of data timeliness, integrity and completeness.

The main goal of this article is to present statistical systems used to analyze stability of the financial sector on the macro level with special focus on their data requirements. We discuss how the challenges affecting these models (*inter alia* requirements enumerated above) were faced, and to what extent further improvement of data input to macro prudential toolkits can be applied. Within our discussion we try to verify the hypothesis that the optimal current (after-the-crisis) approach to financial stability analysis is a statistical model-driven one based on (composite) indicators or stress-testing formula (or combined) with integrated systemic risk modeling and broad access to high-quality fine-grained data collected from financial entities operating in the surveyed sector with the application of FINREP and COREP standards.

2. Literature survey

Bell and Pain [2000] gave a general description of macro-stability analysis systems based on financial crises' leading indicators. They also formulated intuitive rules, which should be used for data selection. Jiménez and Saurina [2006] emphasized the importance of credit cycles analysis for macrostability evaluation systems. Another approach to statistical models construction based on real estate credit turbulences, was shown by Kannan, Rabanal and Scott [2009]. Allessi and Detken [2009] enumerated statistical data requirements for early warning indicators of price boom/bust cycles, highlighting the importance of global liquidity measures.

Sorge [2004] was one of the first cataloging alternative approaches for stress-testing of macro prudential risk and applying them in financial stability analysis systems. Five years later Drehmann [2009] wrote a very compre-

hensive outlook of current stress-testing methodologies and differences of data requirements for their input. Borio and Drehmann [2009] focused on the cross-section of methods used for macro prudential analysis (early warning indicators, single measure methods—VaRs, stress-testing procedures) and broadly discussed the selection of data for their input. Alfaro and Drehmann [2009] emphasized the relevance of adequate historical scenarios construction for stress-testing procedures and described possible sets of macroeconomic data, which could be a starting point for these scenarios.

A different approach to financial stability analysis was taken by Brunnermeier and Sannikov [2009]. They presented an extension of the existing structural macroeconomic model with the financial sector and surveyed the importance of complementary financial data for this augmented approach. An extension of Dynamic Stochastic General Equilibrium model (DSGE) framework used for financial stability analysis on the macro level was described in detail in a paper by de Walque, Pierrard and Rouabah [2008].

One of the first very few articles about different methodologies of systemic risk analysis and their integration with macro prudential analysis frameworks was the work of De Bandt and Hartmann [2000], which described a new important "branch" of risk analysis and management in its infancy. Huang, Zhou and Zhu [2009] showed the advantages of granular banks balance sheet data usage for systemic risk assessment. A very interesting insight into the topic of systemic risk modeling was given by Courana [2010]. This paper tackled an important issue of data gaps in supervisory and central bank data which imposes some serious consequences on the ability of the financial sector contagion process analysis.

Almost all the mentioned literature included a suggestion that very broad and deep data gaps exist (especially on the fine-grained data level) and a lot of effort should be put in to align datasets to the requirements of sophisticated models used for macroprudential surveys.

3. Micro basis of macroprudential analysis

The main components of macro prudential oversight are: risk diagnosis, risk assessment and the resulting policy decisions. All three components are highly depended on well-organized micro level data reporting. The key factors in this field are: adequate coverage of the reporting population, appropriate scope of the reported data, and the possibility of measuring relations between institutions[2]. Moreover, the quality of statistical data is of key importance.

[2] Three main components of data reporting on micro level are data coverage (population of reporting entities), data scope (collection of data describing the situation of financial institutions) and measures of data interconnectedness (direction and strength of relations between institutions).

3.1. Institutional coverage

Regarding the institutional coverage effective cooperation between European supervision authorities (ESAs) and European Systemic Risk Board (ESRB) requires data reporting from financial institutions, including non-IFRS ones (entities which haven't yet applied the International Financial Reporting Standards, IFRSs), and other non-banking financial institutions providing credit in considered residencies. Special attention should of course be paid to systemically important financial institutions (SIFIs) and large banking groups (LBGs), reporting on a consolidated basis. First of all, lists of these institutions have to be regularly updated. One of the challenges is the preparation of common identifiers of the supervised SIFIs and LBGs. A good example is the European Central Bank's extended register of financial institutions and groups (RIAD). It seems that for better understanding of the processes affecting SIFIs/LBGs, data collection from their branches and subsidiaries on a "solo" basis (a particular institution level) would be useful.

Systemic risk analysis requires monitoring of the directions and strengths of interconnections between institutions operating within one sector, the whole jurisdiction (economy) or between different jurisdictions. Counterparty credit risk exposures between SIFIs/LBGs and other entities (countries, banks, non-financial firms) are planned to be reported to supervisors. This part of the macro prudential analysis highlights the importance of large exposures (LE) package. Potential contagion channels can also be identified based on information about cross-holdings of financial instruments (equity, mutual fund shares and hybrid debt instruments). Moreover, it is crucial not to limit exposures monitoring to individual institutions. Stylized facts coming from the last crisis show that the risk generated by groups of small financial entities[3] affected by an abrupt worsening of their financial situation can also be dangerous for the banking sector as a whole. Therefore, measures of credit risk concentration fund raising by similar financial institutions and non-financial corporations need to be gathered and analyzed. In the context of cross sector data analysis, the forthcoming CRD IV (Capital Requirements Directive) has opened floor for cooperation between the European Banking Authority (EBA) and the European Insurance and Occupational Pensions Authority (EIOPA).

3.2. Data scope

The second very important issue for the macro prudential analysis is the scope of required data. Introduction of the new Basel Committee of Banking Supervision's FINREP (Financial Reporting framework), COREP (Common REPorting framework) and Large Exposures packages will substantially increase the scope of available information. In the case of new FINREP, more

[3] Good example of this situation could be the Spain case where cooperative banks (called "Caixas") contributed substantially to the risk of the whole banking sector.

detailed breakdowns of assets and liabilities are being considered. Additionally, credit exposures are planned to be more fine-grained. In particular, maturity (initial and residual), currency and geographical dimensions are planned to be detailed enough to capture different risk vulnerabilities of the analyzed institutions. For COREP, indicators of leverage, liquidity, correlation and concentration are intended to be gathered from financial institutions. The impact of off-balance sheet items on the overall banks' risk profiles observed during the last crisis justifies the need of more detailed data to be included into reporting requirements. The ESRB expects that the portfolio level granularity of balance sheets and off-balance sheet accounts will allow constructing bottom-up models of credit, market and liquidity risks at the national level. The analysis of statistical data availability for macro prudential oversight on the European level indicates the existence of harmonization problems. They mainly stem from the accounting standards[4] applied by financial institutions. Moreover, the existing version of FINREP is not useable for complete macro prudential oversight as its application is not mandatory in all EU countries. Countries applying FINREP do so only for some templates and/or at semi-annual or annual frequency and FINREP is followed mainly by IFRS banks. In order to overcome these obstacles, it would be recommended to make FINREP a binding reporting standard from 2013 onwards, to amend its format in order to make it suitable also for non-IFRS banks, and to require a quarterly reporting frequency for the templates affected by the Consolidated Banking Database (CBD) requirements[5].

The EBA has already finished drafting new FINREP and COREP frameworks, and is supposed to take into account the request from ESRB users and recommendations made by the Joint Group of Data Requirements (JGD).

Within central bankers and supervisors cooperation initiatives aimed at providing relief to the financial sector in their task of data reporting workload were initiated. A good example of such an initiative is the activity of EBA/ECB Joint Expert Group on Reconciliation (JEGR) which initialized process of identifying common reporting areas in macro prudential and monetary statistics. Moreover it will improve the transparency of financial data monitoring.

3.3. Data quality

As it was already mentioned, the key aspect of each statistical system is data quality. Statisticians distinguish numerous dimensions of data quality, namely: accessibility, accuracy, completeness, extensibility, flexibility, in-

[4] It means IFRS 9 multistage implementation standard (replacing IAS 39) is supposed to be completed no earlier than in 2015. But our current expectation is about 2013.

[5] The National Bank of Poland provides necessary input to the CBD. NBP reports to CDB data of the banks with ROE of 15–20%, who hold about 4% of Polish banking sector assets.

tegrity and timeliness. Depending on the purpose the data is going to serve, the given particular aspects of data quality need to be emphasized.

For example, given the goals of macro prudential analysis aiming at monitoring risks, providing decision-makers with ex-ante knowledge of possible scenarios of future development and, to some extent, formulating recommendations on what operational tools can be used, it seems natural that priority is given to data timeliness. The EBA's proposal to set a target transmission period of LBGs quarterly data for NSAs to T+6 weeks can be perceived as ambitious, but feasible in a longer perspective. Similarly, after some transition period, T+8 weeks timeliness for the provision of validated and aggregated data from EBA to ESRB could be fulfilled. For other (non-systemically important) institutions T+5 months timeliness could be maintained. Obviously, in the case where the data is used for ex-post analysis, more attention may be devoted to data accuracy.

When it comes to the selection of further data quality dimensions, priority should be given to data integrity and completeness. Given the need of harmonization, statisticians should put emphasis on assuring data comparability. Also completeness perceived as a function of properly set and enforced data coverage, scope and granularity needs to be assured.

4. Quantifying dependencies between the financial and real sectors

It is needless to say that macro prudential data plays paramount role as an input feeding supervisory toolkits. Observing the activities of EBA, ESRB, IMF, some trends in the development of analytical tools supporting macro prudential oversight can be observed. These trends have strong implications for statistical requirements.

4.1. Early warning indicators

The first observed trend is to establish a system of financial stability indicators (early warning indicators) which will allow the identification of financial crisis symptoms at the earliest possible stage of risk development. Good examples of such an approach are EBA's Key Risk Indicators (KRI) and International Monetary Fund's Financial Soundness Indicators (FSI) program. FSI initiative consists of the compilation of two sets of indicators: "core" ones (focusing mainly on capital adequacy, quality and concentration of assets, liquidity and profitability) and "encouraged" ones (i.e. large exposures ratio, geographical distribution of assets, market liquidity, situation of borrowers, situation of non-financial sector, households and real-estate markets). The core set of FSIs is ready for operational use and assures (to some extent) compatibility of data across different supervisory jurisdictions. However, the availability of encouraged indicators still needs some improvement. Many gaps exist, in particular in non-financial corporations' indicators and

market liquidity. Moreover, substantial delays are also observed when aggregated measures of financial soundness are compiled.

4.2. Stress testing financial stability

Another observed trend is the macro stress testing approach. Macro stress testing exercises are conducted regularly by the EBA (EU wide stress tests), the IMF (Financial Sector Assessment Program, FSAP) and the Federal Reserve (Supervisory Capital Assessment Program, SCAP). This approach rooted in micro prudential analysis can be defined as ALM[6] modeling framework based on the bottom-up schema applied on the national or international financial sector level. The goals of such a "global ALM" are common with its micro-level counterparties: the necessary aggregated economic capital of the financial sector, including liquidity buffer, needs to be estimated and implemented. Observing the growing number of relations within financial sector and bi-directional dependencies between this sector and the real one, macro stress testing framework can be perceived as one of the most complex structures in the present economic and financial modeling. However, this framework's undoubted advantage is the possibility of detecting directions and strengths of transmission channels that distribute risks among entities operating within the financial sector or its subsectors, and from the financial sector to the real one and vice versa.

A great variety of statistical and econometric models is used in macro stress testing exercises. Each class of these models generates different requirements for statistical systems. The scope of the demanded data is correlated with the types of shocks considered in the analysis, and the transmission mechanisms via which they are spread into the financial and real sectors. Macro stress testing exercise starts from the identification of macroeconomic scenarios which can disturb financial stability. These scenarios are constructed mostly on experts' arbitrary judgments, however, these judgments are very often based on a group of subsidiary models (called satellite models) used for forecasting the main macroeconomic and financial aggregates such as GDP, inflation, rate of unemployment and the structure of forward interest rates. In practice, standard analytical framework used for monetary policy, like Dynamic Stochastic General Equilibrium (DSGE) or big structural models, are applied for this purpose. Hence, this part of framework does not generate additional burden for statistical systems as the data necessary for these models has been gathered for a long time.

From the perspective of macro prudential analysis it is important to study the risks affecting the financial sector. The greatest importance can be assigned to (market and funding) liquidity and solvency risks. They, in turn, re-

[6] Asset and Liability Management (ALM) is the practice of managing risks that arise mainly due to mismatches between the assets and liabilities (debts and assets) of the bank.

sult from the industry principal risks: credit and market risks. They need to be supplemented with systemic risk analysis.

Macroeconomic models of credit risk can be estimated without or with feedbacks to the real sector. The first class is dominated by regression-based and unobserved components models. The other class, more realistic and useful, is based on vector auto regression models (VARs). A common feature of both models classes is that aggregated credit risk associated with agents operating in a given economy is measured by using certain indicators, for example, probability of default, PD and loss given default, LGD. Lessons learnt from the last crisis and the requirements of the Third Basel Accord have forced supervisors to modify the inputs into both models. For example, anti-cyclical buffer needs to be estimated.

Models of credit risk on the macro level can use a number of macroeconomic variables taken from monetary policy modeling framework. However, estimation of sectoral PDs and LGDs is definitely a more demanding task. In this case, credit registers are the key sources of information about credit soundness of firms operating in a particular economy. Credit quality data can also be supplemented with data provided with repositories of corporations' financial statements. Such databases contain detailed information on corporations' balance sheets and P&L accounts which are ready to use for ratio analysis of the liquidity and profitability of reporting entities. Moreover, fiscal databases can be used as supplementary data, mainly for cross-checking and validation. In order to ensure a consistent set of aggregated data on the financial situation of industries and their subsectors as well as the quality of credit/debt instruments the use of fiscal and National Statistical Offices' (NSOs) databases could be considered.

A general problem with the data mentioned above is time series short length as first observations for many indicators and ratios are often available from the second half of the last decade. For example, IFRSs was implemented in the banking sector in 2005 and FINREP templates have been used for about 3 years. So it is not enough to fully rely on inference, based on such data.

Apart from that, the aggregation of credit risk measures for different sectors or groups of entities can generate some challenge as the links of risk distributions are non-linear and their strength can change dramatically over time. It seems that there is a lot of room for additional academic surveys on credit risks correlations on the individual, subsector and sector levels.

The next issue is macro market risk modeling which, at a glance, can be perceived as less demanding from the statistical point of view than credit risk. Basic models in this area are based on the financial industry standard—aggregated VaRs. High frequency data on market risk subcomponents: interest rate risk, foreign exchange risk, etc., can be obtained relatively easily from commercial vendors such as Bloomberg or Thompson-Reuters. First obstacles can be met when it comes to exposures of a particular financial in-

stitution to particular market risks. To some extent this problem can be solved by the availability of micro level fine-grained data from balance sheets and off-balance sheets statements. The financial instruments could be analyzed based on the information included in the security-by-security databases established and maintained by the European Central Bank (ECB). Elementary granularity of this repository is its main strength as it allows focusing on selected classes of instruments or a group of issuers. Security-by-security database (CSDB) could be analyzed and used as a benchmark and mechanism for the validation of data provided by financial institutions in their FINREP reports. Besides, the planned Securities Holdings Statistic Database (SHSD) will be complementary in the area of monitoring cash flows on securities markets. Even with access to this data one should bear in mind that using different data sources requires a lot of specialized knowledge, flexible IT systems and huge workload.

5. Systemic risk modeling

Taking into account the lesson from the last crisis it is impossible not to mention the perspectives opened with the systemic risk modeling. Quantification of this kind of risk requires detailed inspection of strengths and directions of links connecting financial institutions operating within particular subsector, across sectors and across economies. Economic models used to quantify relations between institutions are relatively new, although many of them originate from mathematical theory of graphs used for years to study e.g. connections among people in sociology or criminal law. Another challenge is to apply models worked out for the assessment of micro relations within balance sheets and off-balance sheets. A good example of such an approach is the Contingency Claims Model (CCM).

Regardless of the method of systemic risk modeling, data input depends heavily on broad coverage, adequate level of granularity and high quality of micro-data. Proper analysis of shock propagation across subsectors, sectors and economies requires the collection of data from SIFIs/LBGs on: leverage, liquidity, correlation, concentration, sensitiveness, immunization and connectedness. As mentioned above, the establishment of a list of SIFIs/LBGs is of substantial importance. The data for these groups of institutions is provided under the new FINREP, COREP and LE templates if they are about to be introduced in the expected scope in the expected future, namely:

- balance sheets, off-balance sheets, profit and loss accounts;
- aggregated portfolio holdings, with special focus on OTC derivatives;
- leverage and concentration ratios;
- large bilateral exposures.

Such data needs to be supplemented with a list of shareholders, investors and counterparties of SIFIs/LBGs. As regards portfolio holdings, detailed data analysis requires input of portfolio sensitivities to shocks in macroeconomic environment and endogenous turbulences in financial markets. The

practice of desk level stress-testing shows that this data could be provided by owners of portfolios, as soon as supervisors have worked out common methodology of conducting such exercises.

The aforementioned data can also be augmented with information on inter-connectedness derived from three sources: interbank clearinghouses, netting and RTGS[7] systems. Patterns of illiquidity or "crowded trades", detected based on these data, can be used as a good leading indicator of forthcoming contagion.

6. Conclusions

Summing up, in this article we wished to discuss statistical data and models requirements of macro prudential analysis integrated with systemic risk assessment. We have focused on model-driven approach, based on current state-of-art of financial stability analysis, and described necessary data inputs to frameworks used in this area. It seems clear that a sound macro prudential statistical system requires solid micro prudential pillars, with properly defined reporting population, the scope of reports, and fine-grained level of reporting. In our opinion the goals of micro-level reporting can be fulfilled with the introduction of new, extended FINREP and COREP templates, supplemented with LE package. Taking into account the characteristics of the last crisis, the idea of broad analysis of systemic risk contagion across sectors and economies may also be supported. Although it generates additional reporting burden, it assures substantial analytical payoff exceeding the costs of additional requirements implementation.

The reporting burden issue was also mentioned in broader contexts of expected problems with implementation of statistical data requirements for macro prudential analysis. One of the most noticeable obstacles is insufficient harmonization of financial reporting standards across economies and ambiguity of financial instruments classification. Some steps have been already taken to tackle the issue, e. g. the introduction of consecutive phases of IFRS, but still much work is left to be done to assure better integrity of data reported at the European level.

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[7] Real Time Gross Settlement Systems (RTGS) are funds transfer systems where transfer of money or securities takes place from one bank to another on a "real time" and on "gross" basis.

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Abstract **Statistical Data and Models Used for Analysis and Management of Financial Stability at the Macro Level**

In this paper we discuss statistical data requirements and modeling frameworks used for macro prudential analysis and policy making. We start with a short overview of causes, for which this kind of policy was introduced after the last financial crisis and its links with traditional micro-level supervisory and challenges generated for national and international statistical systems. We point out a group of implications which financial stability, seen from macro perspective, brings for data and models requirements, determined with introduction of consecutive Basel Accords and made operational with FINREP and COREP packages. Our special attention is paid to systemic risk models, which provide very precious knowledge about institutions' dependencies and probabilities of shock spillovers within and across sectors. Expected problems with statistical data requirements fulfillment and models structure specification are also discussed and some possible solutions are hinted.

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