Policy Applications for
Global Macroeconometric Models:
Comments on Pesaran, Schuermann & Weiner (2003)

Richard Dennis and Jose A. Lopez
Economic Research Department
Federal Reserve Bank of San Francisco
101 Market Street
San Francisco, CA 94105-1530

Initiation date: February 25, 2003
Draft date: January 5, 2004

Acknowledgments: The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of San Francisco or the Federal Reserve System. These comments were prepared for presentation at the 2003 meeting of the American Statistical Association. We thank Alastair Hall for the opportunity to discuss the paper and Anita Todd for editorial assistance.

I. Introduction

We appreciate the opportunity to discuss the substantial body of work conducted by the authors in this paper as well as the companion piece Pesaran *et al.* (PSTW, 2003). The authors state that their motivation for developing the global vector autoregressive (GVAR) model was to create a concrete link between credit risk modeling and business cycle fluctuations so as to provide tools for better credit risk measurement and management. They also state that the GVAR model could perhaps be used by central banks, ostensibly for their monetary policy responsibilities. Hence, the authors clearly view their work on the GVAR model as having various policy applications.

As we are research economists at a public institution that is intimately involved in the policy issues of banking supervision and monetary policy, our comments regarding the paper will focus on these possible applications. On the whole, we agree with the authors that the GVAR model has many potentially fruitful applications in the field of credit risk measurement and management, but we are less optimistic about its policy usefulness with respect to macroeconomic and monetary policy applications.

II. Possible policy applications for bank supervision and regulation

The potential applications of the authors' work to banking supervision and regulation are extensive and are even larger now in light of the recently proposed modifications to the Basel Capital Accord. We provide a summary of the regulatory environment in which the GVAR modeling framework might be applied and describe several ways it could benefit bank supervisors.

II.A. Why is this important at all?

A reasonable question to ask is how a fundamentally macroeconomic model could be of interest to bankers and their government supervisors. Given the important relationships between banking and the macroeconomy discussed in the academic literature and experienced in practice, it is probably more appropriate to ask why these fields have not been combined within a consistent modeling framework sooner. This combination and the related empirical work constitute a large measure of the authors' contribution to the banking literature.

Given the potential losses faced by banks due to borrower default, bank counterparties and investors in bank securities insist that banks hold capital as a buffer against such losses. These agents would insist that banks hold capital even in the absence of any government intervention. Yet in fact, within most developed economies, governments have chosen to intervene in the banking system by imposing regulations and conducting some sort of supervisory monitoring. One of the key forms that this intervention takes is minimum capital requirements; that is, banks are required to hold a certain percentage of their assets as a reserve against potential losses. Having accepted this form of bank regulation as appropriate, the next policy question is how much capital should be required.

To help coordinate national bank regulatory efforts, the Basel Committee on Banking Supervision (BCBS) was formed in 1974. In 1988, the BCBS introduced a proposed international standard of minimum regulatory capital requirements that was set at 8% of risk-weighted assets. The Accord was established both to strengthen the stability of the international banking system and to establish a common set of bank capital rules that diminished competitive inequalities across countries; see Wagster (1996) for further discussion.

The 1988 Accord was almost universally accepted as a major success in setting standards for international banking, but by the mid-1990s, the banking industry had advanced sufficiently that the Accord's simple capital rules were becoming less useful. That is, sophisticated risk management systems permitted banks to engage in an increasing amount of regulatory arbitrage that undermined regulatory capital requirements. Hence, the BCBS launched a second effort to improve international capital requirements by making them more sensitive to the underlying credit risks in bank asset portfolios. This effort was facilitated by the increased use of credit risk modeling at the largest international banks. Currently, the proposed Basel II Accord is in the process of being implemented by mid-2004; see BCBS (2003) for complete details.

The introduction of Basel II's credit risk-sensitive capital requirements will lead bank supervisors to examine credit risk and its underlying drivers, both macroeconomic and others, more closely. However, even in the absence of this recent regulatory development, supervisors monitor the overall quality of bank portfolios in order to gauge the health of the banking system and of individual banks. A leading example of this effort is the Shared National Credit Program, established by U.S. bank supervisors to monitor the condition of large commercial and industrial loans. The GVAR model might contribute to such efforts by providing a framework for directly linking U.S. macroeconomic conditions to loan quality.

II.B. Which supervisory policy questions could be addressed?

As discussed by the authors, the proposed GVAR model generates economic scenarios that can be used to examine the implications of macroeconomic movements on firm-level debt values. The potential benefits of this modeling framework to bank supervisors manifests itself in the broadest terms with respect to the issue of systemic risk and more narrowly on the current attempts to craft, refine, and implement the Basel II regulatory capital requirements.

Systemic risk is the risk of experiencing events, whether arising from microeconomic or macroeconomic factors, which adversely affect the general functioning of financial institutions or markets. Systemic risk is obviously of concern to supervisors who are responsible for mitigating the effects of bank losses and failures on the financial system and the economy as a whole. With respect to monitoring systemic risk broadly, the ability of the GVAR model to capture the dynamics across various relevant macroeconomic series within and across countries presents supervisors with a tool that could have early warning capabilities. For example, a consistent forecast of the impact of a cyclical downturn on macroeconomic variables might provide insight regarding the increased probabilities of corporate defaults and hence potential upcoming weaknesses in the financial system. Furthermore, the GVAR modeling framework should permit supervisors to monitor macroeconomic factors with specific applications to bank loan portfolios in a consistent way. This type of "scenario" analysis is discussed in the paper with respect to bank portfolio values, but its usefulness for monitoring systemic risk could be significant as well. Note that this type of analysis, although related to monetary policy analysis, need not be identical; see our discussion in the next section.

With regard to the Basel II process, the GVAR modeling framework has potential applications in two general categories: supervisory assessments of credit risk conditions and refinements to specific aspects of the capital requirements. For credit risk assessments, the GVAR modeling framework could provide supervisors with an independent view of credit cycles, as compared to those provided by rating agencies or the banks themselves. This analysis is related to the issue of systemic risk, but is different in that it is applied to specific bank portfolios and not the financial system as a whole. By having at hand macroeconomic analysis focused on credit concerns, supervisors could better analyze the many assumptions underlying banks' credit risk models and management techniques. For example, supervisors could use the GVAR model to rank order the effects of different macroeconomic shocks on bank portfolios. Such an ordering might permit an alternative supervisory overview of specific bank credit quality concerns and risk management procedures.

Such analysis could be useful for banks' internal credit ratings, which will play a larger role within the Basel II capital requirements. External credit ratings provided by the ratings agencies form the background of this process, but research has shown that the meaning of these ratings are subject to change over time. Blume *et al.* (1998) found that rating standards for U.S. companies appeared to become more stringent for ratings assigned during the period from 1979 through 1995. Amato and Furfine (2003) found that such credit rating assignments were not strongly linked to business cycle fluctuations, but that both initial ratings and ratings changes did exhibit excess sensitivity to the business cycle. Given such a challenge to interpreting external ratings, the challenge is even greater with respect to internal ratings generated by banks themselves; see Treacy and Carey (2000) as well as Carey (2002) for further discussion. Supervisors might benefit from the credit risk insights provided by the GVAR modeling framework for assessing bank internal credit ratings systems qualitatively and perhaps quantitatively in the future.

With respect to refinements of the proposed Basel II capital requirements, the GVAR model has several potential applications, such as parameter calibration as per Lopez (2003). However, we focus here on its potential application to the issues of procyclicality and credit risk stress-testing. The term procyclicality refers to the possible alignment of regulatory capital requirements under the Basel II Accord with the business cycle in such a way that bank lending could exacerbate the cycle. The concern is that the proposed increase in the risk sensitivity of bank capital to business conditions would require banks to raise capital during a recession, when it is generally much costlier. In addition, this need to raise capital in a recession could diminish bank lending and hence postpone the recovery. Furthermore, during expansion, "excess" capital might accumulate as credit risks are perceived to have declined, and the concurrent reduction in regulatory capital requirements might fuel excessive bank lending that could accelerate and deepen the turn in the business cycle. See Borio et al. (2001) for a more complete formulation and discussion of procyclicality.

Although procyclicality is a reasonable public policy concern, the research on this topic to date has only been suggestive. Banks have seen their capital diminished during past recessions, but have raised new capital more or less successfully. The questions of whether the Basel II capital requirements would increase the correlation between bank lending and the business cycle and what the economic impact of such an increased correlation might be could be addressed within the context of the GVAR modeling framework. That is, for a given set of credit portfolios, capital requirements under differing regulatory guidelines could be determined, and the impact of a recession (or comparable economic events) could be used to examine what the impact on capital requirements might be. This type of analysis could complement the current policy discussion regarding procyclicality and be useful in future discussions.

Within the Basel II framework, credit stress-testing refers to a bank's methodology for analyzing the magnitude of credit losses that could arise under "stress" scenarios; i.e., economic downturns, such as the explicit example of two consecutive quarters of zero growth provided in the Basel II documentation, downturns in specific industries, or large financial market movements. The rationale for conducting such stress tests is that more formal modeling procedures may not be able to capture such events easily or at all, and prudent bank risk managers should take additional steps to account for that possibility.

The process by which banks establish stress-test scenarios and methodologies has to date been more of an art than a science, much in contrast to the great strides made in credit risk modeling as a whole. First, defining what the relevant stress scenarios are, both at the macroeconomic level and at the level of a specific bank portfolio, is a challenge that is generally difficult to address within the context of a standard credit risk model. Second, as highlighted by Berkowitz (2000), one of the main difficulties with stress-testing is that stress scenarios formulated outside of a formal model are never explicitly assigned probabilities. Hence, there is no guidance regarding the results of the stress tests with respect to the rest of the credit risk management framework.

The authors' proposed GVAR modeling framework could directly address both of these concerns. Regarding how scenarios are constructed, the authors have explained how readily their modeling procedure can be applied. By directly modeling many observable macroeconomic and financial market variables, their framework permits credit risk managers to craft scenarios that directly influence their specific credit exposures. Since the scenarios can be constructed within a modeling structure, their probabilities can be determined and directly incorporated into the overall credit risk management process. As outlined in their section on conditional loss distributions and in the companion PSTW paper, the authors provide a clear and consistent framework for generating scenarios and evaluating their impact on expected portfolio losses and the tail quantiles used for capital determinations and risk management. The scenarios in the paper are univariate and hence their probabilities are easily determined; i.e., the 2.33σ

shocks correspond to the 1% tail within their chosen Gaussian context. The probabilities of multivariate scenarios are obviously more complicated to calculate, but not impossible. Furthermore, the effects of a specific shock on other macroeconomic factors are clearly specified and hence can be consistently accounted for within the stress tests.

Although the advantages of stress testing within the GVAR modeling framework are obvious for credit risk managers, supervisors might also benefit from working within this framework. First, within the Basel II framework, national supervisors might use the framework to assist in writing guidance on how their banks' stress scenarios could be designed. In addition, supervisors may have concerns regarding specific national, industry or financial factors that they may wish banks to address. The GVAR framework could assist supervisors in formalizing their own analysis on these issues before addressing the affected banks. The modeling framework could also allow supervisors to refine and change this list of concerns over time.

Second, supervisors must review and in some way validate the stress scenarios and testing procedures at several banks. How to do so is not immediately obvious, but the GVAR modeling framework again could provide supervisors with a consistent framework within which to do this. For example, supervisors might be able to analyze a bank's stress scenarios within the context of the GVAR model or relative to supervisory baseline scenarios. Such comparisons might provide a foundation on which to conduct conversations with banks on this aspect of their credit risk management systems.

III. Macroeconomic and monetary policy applications

Although the principal application in this paper is to quantify how macroeconomic shocks affect the value of bank loan portfolios, it is worthwhile to consider whether the GVAR model could be useful more broadly. In particular, it is interesting to consider whether central banks, who are some of the main consumers of macroeconomic models, might find it useful for policy formulation. There is no doubt that increased globalization and freer capital markets have greatly increased the exposures of national economies to global economic factors. It follows that to assess the impact of these factors and the risks they present to national economies, central banks and other policymakers need to think about shocks and their propagation from a global perspective, which requires a global model.

With this point in mind, it is interesting to note that most central banks, even central banks in small open economies that are highly exposed to external shocks, do not use global models for policy formulation. Central banks tend to concentrate their efforts on using models for macroeconomic forecasting, and rather than forecast foreign GDP growth themselves, they might use the Blue Chip forecasts of U.S. growth as a proxy for world growth. Certainly, it is clear that for policy simulations and scenario analysis, quantifying and understanding the effects of global shocks requires a global model, but building such a model is a nontrivial task. Three well-known examples of global models are NiGEM, from the National Institute of Economic and Social Research in the U.K., Multimod III, from the IMF, and MSG2 developed by McKibbin and Sachs (1991). Could one of these models be used for monetary policy analysis and for credit risk management?

The key difficulty with using these models for risk management is that they are large and computationally demanding. Multimod III (Laxton *et al.*, 1998) is designed to examine policy scenarios not to generate forecasts per se. MSG2 does not incorporate stock prices, which prove to be important for describing the returns on firm assets, although it does model the consumption value of a country's capital stock. NiGEM models stock prices, but contains over 3,000 equations and requires sophisticated solution software. While these models could be used or adapted for risk management purposes, their focus is on modeling and forecasting macroeconomic variables. There is clearly a need for a global model designed specifically for risk management that can also generate global forecasts for key macroeconomic variables.

The approach taken within the GVAR model is novel. First, the authors keep the size of the model "small" by placing tight limits on the number of variables that enter the models for each individual country/region. Hence, they resist the temptation to disaggregate, a feature of many macroeconometric models built during the 1980s and 1990s. The model's small size allows it to be solved quickly without using specialized software. Second, they keep the model relatively theory free, placing more emphasis on the integration/cointegration properties of the data than on economic theorizing. An economics-based dichotomy does exist in that the foreign variables entering each country/region are treated very differently during estimation than domestic variables (a version of the small country assumption supported by tests for weak exogeneity). More generally, though, the estimation is free to determine the number and nature of any cointegrating relationships, and these cointegrating relationships, while normalized on particular variables, are not given an economic interpretation. Of course, the particular normalization does not affect the model's forecasts or impulse response functions.

Third, the model is kept in first-order form by modeling each country/region as a VAR(1) process conditional upon foreign variables, with the foreign variables determined by trade-weighting the individual variables for each country/region. Generalized impulse response analysis, which enables unique identification of shocks independent of the variable ordering, allows the model's structure and dynamic properties to be analyzed. The result is a relatively small, atheoretic global model whose structure is cleanly partitioned into permanent and transitory components and is in the form of a VAR(1) process, making simulation and stability analysis straightforward. The model's compact size coupled with the fact that it can forecast and generate impulse responses for key macroeconomic aggregates make it convenient for generating macroeconomic forecasts and for performing the simulations needed to stress test global asset portfolios.

So would this model be suitable for analyzing other issues, such as those pertaining to monetary policy? Would using a global model like this one improve policy formulation? Unfortunately, the answers to these questions are likely to be no, largely because the model is too atheoretic for policy simulations, but also because the limited dynamic structure used to describe each country/region makes it difficult for the model to properly capture the mechanisms at play in actual economies.

The importance of the latter point is made abundantly clear in Pagan (2003). Pagan uses the FPS model, a small open economy model of the New Zealand economy operated by the Reserve Bank of New Zealand, to show that VAR processes cannot easily represent the complex interactions at work in standard structural macroeconomic models accurately. The heart of the problem is that economic outcomes reflect the interactions of a large number of variables and markets. But to approximate accurately the impulse responses from a system that contains a large number of variables using a VAR containing the five or six variables that are of interest typically requires a long lag structure. The simulations that Pagan (2003) performs show that a VAR(10) in six variables is generally needed to approximate the dynamics of a model like FPS, and that even longer lags are needed to capture the dynamic responses of some shocks, such as foreign GDP shocks, for which even a VAR(15) was inadequate.

With these ideas of system approximation in mind, if a VAR model allows for six shocks, but the economy is subject to ten shocks (say), then there is no reason to think or to assume that the VAR shocks will be orthogonal. In this respect, it makes sense to focus on generalized impulse response functions (as the authors do), which examine individual shocks while integrating out the effects of the remaining shocks, rather than to impose orthogonality erroneously. The usefulness of generalized impulse response functions turns on whether the resulting shocks have a natural interpretation and on whether the historical distribution of the errors is stable over time. In the case of oil price shocks (which are important in the GVAR model because they significantly affect company returns), imposing orthogonality is unlikely to be problematic, since oil price shocks are often the consequence of political events not caused by macroeconomic shocks. For this reason, one might expect that the dynamic consequences of oil price shocks will be similar in the GVAR model to those from an orthogonalized VAR. More generally, however, whether the distribution of the errors has been stable over the estimation period (1979.Q1 – 1999.Q1) remains an open question. Note that for the United States, Sims and Zha (2002) develop a VAR that allows for stochastic volatility, documenting a changing distribution for the errors.

Aside from macroeconomic forecasting, central banks are highly interested in policy simulation and stabilization issues, hence the enormous literature on optimal monetary policy rules. Critical to policy stabilization is the view that inflation stabilization requires a nominal anchor and that inflation will follow a random walk without it. The latter property is usually achieved by imposing dynamic and/or static homogeneity on prices, often through a markup equation or a Phillips curve equation. Models in which dynamic and static homogeneity are present also have the important property that the long-run Classical dichotomy holds; i.e., nominal variables do not affect real variables in the long-run, preventing a permanent tradeoff between real and nominal variables. Models in which the Classical dichotomy does not hold will often imply expansionary monetary policies as central banks are directed to raise inflation in the vain hope of permanently raising output or of permanently lowering the unemployment rate. Related to this point, for policy simulations it is desirable to keep track of stocks and to model stock/flow relationships formally so that wealth, indebtedness, and capital stocks can affect current outcomes and so that intertemporal budget constraints are respected. This is particularly important for policy simulations involving optimal control where the absence of stock/flow relationships and intertemporal budget constraints can appear to offer policymakers a free lunch.

The GVAR model does not formally impose either the dynamic/static homogeneity condition or an accounting for stock/flow relationships, but neither do many commonly used models. In fact, many New Keynesian models, widely used to examine monetary policy issues, also ignore stock/flow relationships, implicitly assuming that the capital stock is constant; see Clarida *et al.* (1999) as an example. Thus, the GVAR model has limited use for stabilization issues, although perhaps not more so than many other models.

Another theme that permeates the monetary policy rules literature is that expectations matter -- especially inflation expectations -- and that “managing” private sector expectations through statements, increased transparency, and formal policy targets is helpful -- indeed important -- for macro-stabilization. Of course, once expectations are added to a model, issues of time-consistency become important. The economy responds differently to shocks depending on whether the central bank can or cannot commit. Because the GVAR model does not contain forward-looking expectations, it is perhaps better viewed as the reduced-form equilibrium of the model's rational expectations equilibrium. For policy design, something more structural is desirable if the Lucas (1976) critique is to be avoided.

IV. Conclusion

The authors' proposed GVAR modeling framework should have many empirical and policy applications because of its compact nature and its great degree of flexibility. The authors correctly identify its usefulness in the area of credit risk measurement and management, and thus their work has immediate application to many public policy questions regarding bank supervision and regulation. However, given the differing concerns of monetary policy, we are less certain the GVAR model would be as useful for this purpose. Aside from the fact that most central banks do not currently model global economic factors directly, their current emphasis on policy simulations limits the GVAR model's usefulness, mainly due to its atheoretic nature. Furthermore, while the model's limited dynamic structure should not overly hamper its usefulness with respect to credit risk concerns, it probably would limit its usefulness for macroeconomic analysis and policy.

References

Allen, L. and Saunders, A. (2003), "A Survey of Cyclical Effects in Credit Risk Measurement Models," BIS Working Paper #126, Bank for International Settlements.

Amato, J.D. and Furfine, C.H. (2003), "Are Credit Ratings Procyclical?," BIS Working Paper #129, Bank for International Settlements.

Basel Committee on Banking Supervision (2003), "The New Basel Capital Accord," Manuscript, Bank for International Settlements.

Berkowitz, J. (2000), "A Coherent Framework for Stress Testing," Journal of Risk, Winter, **.

Blume, M.E., Lim, F. and MacKinlay, A.C. (1998), "The Declining Credit Quality of U.S. Corporate Debt: Myth or Reality?," *Journal of Finance*, 53, 1389-1413.

Borio, C., Furfine, C. and Lowe, P. (2001), "Procyclicality of the Financial System and Financial Stability: Issues and Policy Options," BIS Paper #1, Bank for International Settlements.

Carey, M. (2002), "Some Evidence on the Consistency of Banks' Internal Credit Ratings," Manuscript, Board of Governors of the Federal Reserve System.

Clarida, R., Gali, J., and M. Gertler (1999), "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature*, 37, 1661-1707.

Laxton, D., Isard, P., Faruqee, H., Prasad, E., and Turtleboom, B. (1998), "MULTIMOD Mark III: The Core Dynamic and Steady-State Models," International Monetary Fund Occasional Paper #164.

Lopez, J.A. (2003), "The Empirical Relationship between Average Asset Correlation, Firm Probability of Default and Asset Size," *Journal of Financial Intermediation*, forthcoming.

Lucas, R. (1976), "Econometric Policy Evaluation: A Critique," in Brunner, K. and Meltzer, A., eds., *The Phillips Curve and Labor Markets*. North Holland, Amsterdam.

McKibbin, W., and Sachs, J. (1991), *Global Linkages: Macroeconomic Interdependence and Cooperation in the World Economy.* The Brookings Institution, Washington.

Pagan, A. (2003), "Reflections on Some Aspects of Macro-Econometric Modelling," Invited lecture to the African Econometrics Conference, Stellenbosch.

Pesaran, M.H., Schuermann, T., Treutler, B.-J., and Weiner, S.M. (2003), "Macroeconomic Dynamics and Credit Risk: A Global Perspective," Manuscript, University of Cambridge.

Sims, C., and Zha, T. (2002), “Macroeconomic Switching,” Manuscript, Princeton University.

Treacy, W.F. and Carey, M. (2000), “Credit Risk Rating Systems at Large U.S. Banks,” *Journal of Banking and Finance*, 24, 167-201.

Wagster, J.D. (1996), “Impact of the 1988 Basel Accord on International Banking,” *Journal of Finance*, 51, 1321-1346.