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Accounting for Time-Varying and Nonlinear Relationships in Macroeconomic Models
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Chapter 8

Summary

This dissertation, entitled "Accounting for time-varying and nonlinear relationships in macroeconomic models," consists of (i) methodological papers introducing new ways to deal with time variation and nonlinearities in macroeconomic models and (ii) applied papers on various macroeconomic topics in which time variation and nonlinearities are key elements of the analysis. Below, I summarize the main contributions and findings of the various chapters of this dissertation.

Chapter 2, which is joint work with Luca Gambetti, is a methodological contribution regarding vector autoregressions (VARs) with time-varying parameters. We have shown that the standard time-varying VAR workhorse suffers from overparameterization, which is a serious problem as it limits the number of variables and lags that can be incorporated in the model. As a solution for the overparameterization problem, we have proposed a new, more parsimonious time-varying VAR model setup with which we can reliably estimate larger systems including more variables and/or more lags than was possible hitherto. The key distinctive feature of the new model setup is the covariance matrix of the innovations to the time-varying parameters which is now assumed to be of reduced rank instead of full rank. The rank reduction implies cross-equation restrictions that amount to a reduction in the number of underlying factors driving the time-varying parameters. The applications presented in Chapter 2 and Chapter 4 suggest that the number of underlying factors included in the "reduced-rank model" can be chosen to be much smaller than the number of time-varying parameters, which is very good news for the parsimony of the model. In addition to the empirical support, the rank reduction also has important practical advantages over the standard model setup in that the Bayesian estimation procedure is much faster due to the much smaller dimension of the underlying factor structure. Moreover, the Markov chain Monte Carlo procedure converges much faster so that much shorter Markov chains are needed, cutting computing times even further. Finally, in addition to the empirical support of the rank reduction and the associated practical advantages, we have argued that the implied cross-equation restrictions are theoretically appealing.

Chapter 3 is about the influence of the prior on the amount of time variation when estimating VARs

with time-varying parameters. I have demonstrated that the prior on the covariance matrix of the shocks driving the time-varying parameters has much influence on the amount of time variation in the VAR coefficients, at least in the application of Cogley and Sargent (2001), which I have used for my analysis. In addition, I have demonstrated that also the incorporation of stochastic volatility has much influence on the amount of time variation in the VAR coefficients. For this purpose, I have extended the model of Cogley and Sargent (2001) with stochastic volatility, just like Cogley and Sargent (2005). The estimated amount of time variation in the VAR coefficients is much smaller in the model setup with stochastic volatility than in the model setup without stochastic volatility, at least when the prior on the covariance matrix of the shocks driving the time-varying parameters is left unchanged.

Chapter 4 is an application on the time variation in the dynamic effects of unanticipated changes in tax policy. I have used the reduced-rank time-varying VAR model setup that was developed in Chapter 2 to analyze to what extent the dynamic effects of unanticipated changes in tax policy have changed structurally over the post World War II period in the United States. For the identification of the structural tax shock, I have followed the identification strategy of Mertens and Ravn (2013b), which exploits the informational content of a narrative series of unanticipated tax changes. The distinctive difference with their paper is that I have used a time-varying VAR, whereas they have used a time-invariant VAR. The time variation estimated in Chapter 4 points to a permanent decline in the tax multiplier as well as a faster response of the economy. Despite the permanent decline, the estimated tax multiplier is still at the higher end of the range of existing empirical estimates, which is consistent with Mertens and Ravn (2013b). I have also analyzed to what extent fiscal policy has become more countercyclical over time. The results indicate that spending policy used to be procyclical and has become countercyclical after the beginning of the 1990s, whereas tax policy already used to be countercyclical and has become even more countercyclical over time.

Chapter 5, which is joint work with Wouter den Haan, is a methodological contribution in the field of nonlinear numerical solution techniques. We have proposed a new numerical solution technique to solve Dynamic Stochastic General Equilibrium (DSGE) models with nontrivial nonlinearities. The idea is to solve for today's behavior from the exact nonlinear equilibrium conditions under the assumption that tomorrow's behavior follows from the first-order perturbation approximation and where the expectation is numerically approximated with a very accurate numerical integration routine. We have called our numerical solution technique the "perturbation-plus" procedure, though it is possible to use *any* numerical approximation for tomorrow's behavior (or last period's behavior for the multi-step ahead version). The key advantage of the perturbation-plus procedure is that it is easy to program and therefore we have compared the accuracy of the perturbation-plus procedure with other procedures that are also easy to program. We have demonstrated that regular higher-order perturbation approximations, for which standard, user-friendly software is available, are not guaranteed to generate non-explosive time paths and are not shape-preserving due to the unavoidable oscillations of polynomials. An alternative is the pruning perturbation procedure, proposed by Kim, Kim, Schaumburg, and Sims (2008), which deals with the problem of exploding simulated data but does not alleviate the problem of undesirable odd shapes. We have compared the accuracy of the various perturbation-based approximations on the basis of three models with nontrivial nonlinearities. The regular perturbation procedure produces very inaccurate results due to the problems highlighted before. The perturbation-plus procedure as well as the pruning procedure give a good qualitative insight in the nonlinear aspects of the true solution, but can differ from the true solution in some quantitative aspects, especially during severe peaks and throughs.

Chapter 6, which is joint work with Eric Bartelsman and Pieter Gautier, is an applied paper about the effects of employment protection legislation (EPL) on the sectoral allocation of firms and workers. We have provided empirical evidence that high-risk sectors, which contribute strongly to aggregate productivity growth, are relatively small and have relatively low productivity growth in countries with strict EPL. To understand these findings, we have developed a two-sector matching model where firms endogenously choose between a safe technology and a risky technology. Strict EPL makes the risky technology less attractive as it raises the costs of shedding workers in case of a low productivity draw. So a higher level of firing costs decreases the relative size and average productivity of the risky sector. In addition to the effects of EPL, we have analyzed the effects of an increase in the variance of risky-sector productivity, which is of interest as the arrival of new information and communication technologies (ICT) since the mid-1990s is shown to be associated with an increase in riskiness. An increase in the variance is good for aggregate productivity and is appealing to individual firms as there is no bound on positive shocks while firms have the option to close a job if a sufficiently large negative shock occurs. Interestingly, the effects of the observed time variation in the variance of risky-sector productivity have proven to be very different depending on the level of EPL. In fact, the model predicts that high-EPL countries can take much less advantage of the arrival of new risky technological opportunities than low-EPL countries. This prediction is confirmed by our empirical analysis, which reveals a strong and robust interaction effect of EPL and riskiness on the relative size and productivity of risky sectors. The described interaction mechanism can explain a considerable portion of the slowdown in productivity in Europe relative to the United States since the mid-1990s.

Chapter 7, which is joint work with Pierre Lafourcade, is a methodological contribution in the field of DSGE models. We have constructed a large new-Keynesian DSGE model with a more careful stochastic specification than is standard in the literature. We have emphasized the gains of including stochastic trends within the theoretical framework of the DSGE model and jointly estimating them with the cycles. We have paid particular attention to common trends (or lack thereof) and have built our DSGE model around the co-integrating relationships we have found in the data (for the Dutch economy). The resulting trend-cycle decomposition has a structural interpretation, which is very valuable from a policy perspective and produces interesting econometric results. First, the trend-cycle decomposition captures the co-integrating properties of the data without which medium to long-run analyses would likely be misspecified. Second, our setup produces better-behaved posteriors for parameters along decision margins where traditional modeling imposes highly persistent but temporary shocks. Third, the co-existence of permanent and temporary disturbances along the same margin broadens the scope for counterfactuals, as it allows agents to respond differently to permanent and temporary shocks. For clarification, we do not want to give the impression that the Dutch economy is a special case; in fact, the philosophy of our approach and the methodology are general.