Computational Macroeconomics for the Open Economy, by G.C. Lim and Paul D. McNelis (MIT Press, Cambridge, MA, 2008), pp. xiv + 231.

This noteworthy book attests the rapid advance in computational macroeconomics, which has become an indispensable analytical tool in macroeconomic policy research. Setting out their goals, the authors wanted to write a graduate textbook on computational macroeconomics, a research treatise that extends computational methods, and a policy-oriented book that is useful for researchers in central banks. These wide-ranging objectives give their book some unique features – it is more accessible than a research treatise or journal article and it is more focused analytically than a textbook. At the same time, the book demonstrates the power of numerical methods in macroeconomic policy analysis. Macroeconomists have turned to numerical methods because they make it possible to construct more realistic models for which closed-form solutions are unworkable. Ultimately, the goal is to build models that give quantitative answers to economic policy questions, or as the authors put it:

> Today quantitative policy-useful recommendations can come from a rigorous analysis of well-specified, internally coherent macroeconomic models, calibrated to capture key characteristics of particular real world situations. Good economic policy evaluation today is thus about providing quantitative, not simply qualitative, answers to pressing questions. (p. xi)

The two main contributions of this book are the application of artificial neural networks in macroeconomic modelling and a collection of increasingly sophisticated models that provide a coherent analytical framework for macroeconomic policy analysis in a small, open economy. Neural networks are used for the statistical analysis of financial data. This is the expertise of the second author, Paul D. McNelis (2005), who wrote *Neural Networks in Finance: Gaining Predictive Edge in the Market*. Kennedy (2008, pp. 349–357), who gives an introduction to neural networks, deplores the biological jargon that is common in this branch of econometrics. Indeed, the biological terms, which come from the numerical modelling of brain functions in artificial intelligence, are a distraction because mathematically a neural network is just a non-linear function. The inputs of the neural network are the explanatory variables and the output is the function value. In macroeconomics, neural networks can be used to represent complex models with non-linear behavioural equations for which there is no closed-form solution. Then, a neural network assigns points in the vector space of exogenous variables to points in the space of endogenous variables.

Modern macroeconomic models are based on the optimum conditions of economic agents. Usually, those non-linear equations are approximated with first- or second-order Taylor series around the steady state. Walsh (2010, chapter 2), for example, linearises the first-order conditions of the Sidrauski model around the steady state. As a consequence, the model simulations describe the behaviour of the economy close to the steady state. This has become a bigger handicap than had been imagined until only recently, for the global financial crisis has pushed the economies of many countries far away from the steady state. The non-linear structure of the economy accounts for the unprecedented policy responses by governments and central banks to the financial crisis. The fiscal deficit amounted to 9.0 per cent of gross domestic product in the United States in 2010, and after the latest extension of the tax cuts that had been introduced by George W. Bush, the deficit is bound to rise even further. The vast expansion in monetary aggregates may also be understood as a policy response by the Federal Reserve that was required by the non-linear nature of macroeconomic relationships, which matters far away from the steady state. The main advantage of a neural network is that it provides an approximation for an entire non-linear function and not – as in the case of a Taylor series approximation – only around some arbitrary point such as the steady state. For this reason, a non-linear macroeconomic model that is 'solved' or represented by a neural network can be used for economic policy evaluation in extreme situations far away from the steady state.

In Chapter 1, the use of neural networks in computational macroeconomics is reviewed. A neural network decomposes a non-linear function into a weighted sum of logistic functions

or some other sigmoid (S-shaped function). Starting with an initial set of weights for the sigmoids and their inputs, random shocks are applied and time series of the endogenous variables are generated, which are used to calculate the errors of the non-linear equations in the model. Then, the procedure is repeated in an iterative way until the weights are such that all equations hold tightly. One of the book's goals is 'to promote the reporting of accuracy statistics in computationally based research publications', which show that the numerical solution 'passes a minimum degree of computational accuracy' (p. 13).

The macroeconomic models that are presented in Chapters 2–11 roughly follow the evolution of computational macroeconomics since the 1980s. Considering a small, open economy, the basic market-clearing model is presented in Chapter 2 and a model with sticky domestic prices is given in Chapter 3. Afterwards, the sticky price model is extended step by step, introducing taxation (Chapter 4), endogenous exports and current account dynamics (Chapter 5), capital accumulation with adjustment costs (Chapter 6), natural resources (Chapter 7), financial frictions (Chapter 8), wage rigidities (Chapter 9) and habit persistence (Chapter 10). Shocks include productivity shocks, terms of trade shocks and shocks to government expenditure. The final model in Chapter 11 considers the effect of sudden reversals in international capital flows in a setup with sticky prices and wages, financial frictions, adjustment costs and habit formation. This model is relevant for the rapidly developing nations in South East Asia and Latin America, which are prone to disruptive changes in capital flows. The reader is encouraged to modify the various models to suit his or her own interests. To facilitate this, the MATLAB program of the basic market-clearing model is provided in the Appendix.

Chapter 7, in which the one-sector model is expanded to a two-sector model, is of particular interest to the Australian reader. The model is suitable to investigate the effect of terms of trade shocks in a small, open economy that exports natural resources. Surprisingly, the impulse response function of the exchange rate does not support the phenomenon of Dutch disease, which is discussed at the beginning of the chapter. Actually, the opposite effect occurs; that is, a terms of trade boom produces a depreciation of the exchange rate that would benefit the export of manufactured goods. Chapter 8 is of special interest because the modelling of the financial sector in computational macroeconomics is still in its infancy. The simulations suggest that the adoption of inflation targeting by central banks accounted for macroeconomic stability in the 1980s and 1990s. This raises the question of why inflation targeting did not prevent the global financial crisis, and whether, in fact, monetary policy was a contributing factor by creating an asset price bubble before the crisis. Given the role of banks in the global financial crisis, computational macroeconomic models with a financial sector that mitigates financial frictions are an urgent and promising field of research.

Another goal of the book is 'to promote more widely the use of welfare distributions for assessing the payoff of different policy rules' (p. 14). Economic shocks render consumer welfare uncertain. The market-clearing model provides the benchmark, for 'the best that the economy can achieve, in terms of welfare, comes under fully flexible prices and perfect market-clearing conditions. The aim of optimal monetary policy, and other forms of government intervention, then, is to bring the welfare distributions of the economy operating under the distortions of price stickiness as close as possible to the welfare distributions under perfect price flexibility' (pp. 37–8). Yet it turns out that the welfare loss because of sticky prices is negligible. An increase of consumption by 0.0249 per cent would be sufficient to compensate the consumer for the economic inefficiency arising from sticky prices (p. 61). Similarly, including the output gap in the monetary policy rule produces a welfare gain in terms of consumption of only 0.0019 per cent (p. 64), and the welfare implications of other policy experiments are also trivial. Naturally, the welfare gains of macroeconomic policy must be small if, as found by Lucas (1987, p. 27), an increase in consumption of 'something less than 0.1 per cent' would be enough to compensate consumers for the welfare costs due to business cycles.

The ultimate goal of numerical macroeconomic research, to give quantitative policy advice, remains elusive. The main problem is that the available computational models underestimate the welfare cost of unemployment. A temporary spell of unemployment has only a

minor effect on consumer welfare because lifetime income and consumption do not change much. In the standard analysis, the unemployed smooth consumption by borrowing and they compensate for the temporary loss in income by working more in the future. Basically, welfare declines only because the pattern of work over the consumers' life becomes less efficient. There is, however, no doubt that both the Great Depression in the 1930s and the recent global financial crisis seriously affected welfare. The reason is that many households lost access to the credit market after defaulting on their family homes. Welfare fell substantially for a large portion of the population because people became unemployed and, without access to the credit market, current income determines consumption. Certainly, the use of computational macroeconomic models for quantitative economic policy advice requires models that generate realistic welfare effects.

Despite that, this book is highly recommended to researchers in central banks and graduate students who are interested in macroeconomic policy research in a small, open economy. It fills a gap as a textbook on the use of neural networks in computational macroeconomics and it provides an up-to-date manual for macroeconomic modelling in a small, open economy. At this stage, the quantitative results still need to be viewed with caution. Yet the meticulous presentation of intricate models that is given in this book demonstrates that computational macroeconomic models that are based on the non-linear first-order conditions of economic agents provide a transparent way of macroeconomic modelling and policy analysis.

Ernst Juerg Weber
University of Western Australia

REFERENCES

Kennedy, P. (2008), *A Guide to Econometrics*, 6th edn. Wiley-Blackwell, Malden, MA.
Lucas, R.E. (1987), *Models of Business Cycles*. Basil Blackwell, New York.
McNelis, P.D. (2005), *Neural Networks in Finance: Gaining Predictive Edge in the Market*. Elsevier Academic Press, Burlington, MA.
Walsh, C.E. (2010), *Monetary Theory and Policy*, 3rd edn. The MIT Press, Cambridge, MA.

Information and Learning in Markets: The Impact of Market Microstructure, Xavier Vives (ed.) (Princeton University Press, Princeton, NJ, 2010), pp. 424.

Information lies at the core of the modern economy, in general, and of financial markets, in particular. Understanding how information disseminates among market participants, to what extent material information is reflected in asset prices, whether and how the speed of adjustment to new information depends on market microstructure – these issues are of crucial importance to market participants as well as legislators.

In his new book, Xavier Vives provides a thorough and rigorous analysis of the existing studies to address these questions. More specifically, the author bridges a gap between two views of financial markets – informational efficiency and herding. While the informational efficiency paradigm suggests that agents act rationally by efficiently updating their beliefs based on new information available, previous financial turmoils, such as 'Black October' in 1987, the Mexican crisis in 1994, and the Russian default in 1998, have shown how market participants can 'follow the crowd', or herd, causing the crisis to spread across different markets, leading to so-called 'contagion'.

Xavier Vives suggests a unified treatment of these questions. In contrast to behavioural finance studies, which introduce systemic behavioural biases to explain contagion and other market anomalies, an author addresses these phenomena within the standard framework of Bayesian rational agents. By relying on simple mathematical tools, Xavier Vives offers a reader a lucid view of how information aggregates among rational market participants, and how various types of market microstructure affect investors' learning.

Besides linking market microstructure and agents' learning, Xavier Vives offers a reader a very simple and intuitive way of understanding the problems associated with information asymmetry in financial markets. Although an agent updates his/her trading strategies based on private information, they still do not take into account the informational benefit that other market participants derive from his action. By introducing the concept of information externality, the author clearly shows how severe potential welfare implications of the information asymmetry problem may be.