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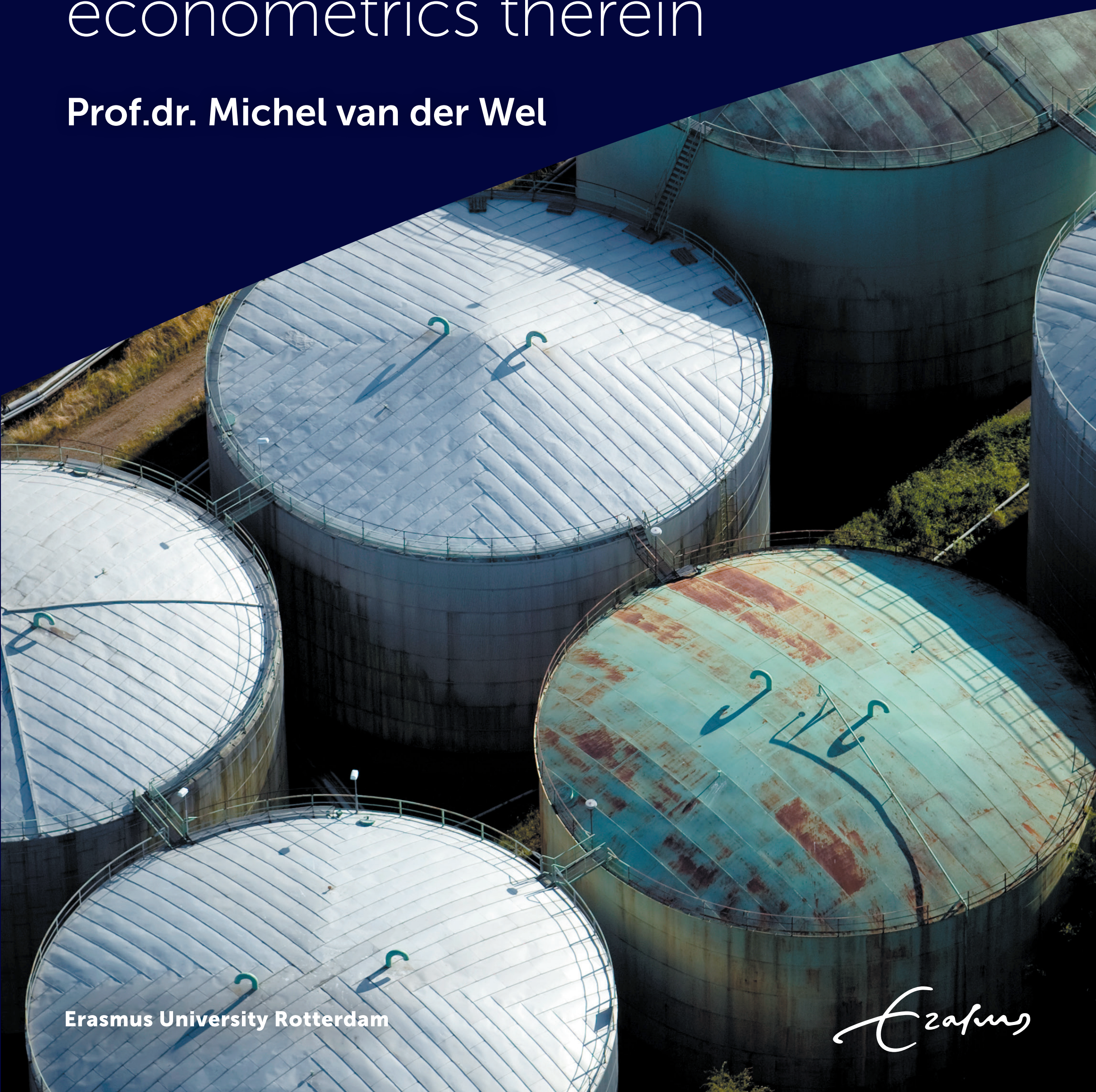
Connecting Silos

On linking macroeconomics and finance, and the role of econometrics therein

Prof.dr. Michel van der Wel



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Prof.dr. Michel van der Wel

Address delivered at the occasion of accepting the appointment as Professor of Econometrics of Macro-Finance at the Erasmus School of Economics, Erasmus University Rotterdam on Friday January 31, 2020.

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Connecting Silos
On linking macroeconomics and finance, and the role of econometrics therein

Abstract

The crises of this century have stressed how intertwined macroeconomics and finance are in practice. This intertwinement was absent in most economic models. This led to calls for economists to step out of their specialized silos. Since then, the literature of macro-finance, which studies the relationship between asset prices and economic fluctuations, has been developed. In this inaugural address, I argue for a prominent role of econometrics to study the macro-finance interaction. Key elements such as mixed frequencies and the selection of factors can be incorporated using recent econometric advances. I discuss some of the results, such as estimation of continuous-time equilibrium models for macroeconomic and financial series, as well as characteristics of trading on financial markets after macroeconomic news releases. Finally, I discuss the outstanding challenges, which include developing a yield curve model based on macroeconomic foundations, modeling how financial markets anticipate news releases, and developing a macro-finance model for European bond markets taking into account the large heterogeneity across the continent.

Connecting Silos
On linking macroeconomics and finance, and the role of econometrics therein

Samenvatting

De crises van deze eeuw hebben benadrukt hoe sterk de financiële en macro-economie in de praktijk met elkaar verbonden zijn. Deze verbondenheid was nagenoeg afwezig in economische modellen, wat leidde tot een oproep aan economen om uit hun gespecialiseerde silo's te treden. Sindsdien is de literatuur van macro-finance tot stand gekomen, waarin de samenhang bestudeerd wordt tussen macro-economische schommelingen en prijzen van financiële producten. In deze oratie beargumenteer ik dat er een prominente rol moet zijn voor econometrie binnen deze literatuur. Belangrijke elementen, zoals data die geobserveerd worden op verschillende frequenties en het selecteren van onderliggende factoren, kunnen worden bestudeerd door gebruik te maken van recente econometrische ontwikkelingen. Ik zal enkele resultaten in de literatuur bespreken, zoals het schatten van continue-tijd evenwichtsmodellen met macro-economische en financiële variabelen, en karakteristieken van handel op financiële markten nadat macro-economisch nieuws vrij is gekomen. Tot slot zal ik enkele openstaande uitdagingen geven, zoals het ontwikkelen van een model voor de rente-termijn structuur vanuit macro-economische evenwichtsbeginselen, het modeleren hoe financiële markten zich voorbereiden op nieuws, en het ontwikkelen van een macro-financieel model voor de Europese obligatiemarkt dat rekening houdt met de verschillende karakteristieken van de landen in het continent.

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1. Introduction

Dear Rector Magnificus,
Dear colleagues, friends, and family,
Dear distinguished guests,

With many things in life, there is not only one perspective to look at a problem. Multiple perspectives can be taken, each offering different insights that together paint the full picture. The same holds in the field of economics. A problem or topic is often not just about one thing, but touches upon many subjects that fall into one of the subfields of economics. A prominent example is the topic of interest rates, which macroeconomists often treat as a macroeconomic variable that policymakers affect, while financial economists think of interest rates as being derived from bonds traded on financial markets and thus as a financial variable.

In the past, the many ways to look at a problem and the many subfields in economics have existed fairly separately from each other. The common feature of economics is that it deals with supply and demand, but each of the subfields has different models, often used to study different topics. Macroeconomists work with macroeconomic models on topics related to the macroeconomy, and financial economists use financial models on topics concerning financial assets. Some of these developments have occurred so separately from each other, that it is argued that the developments took place in silos.

This silo-thinking was particularly problematic during the global financial crisis. Complicated financial products turned out to be too difficult to price and created a financial crisis. This became so big and spilled over to the real economy, leading to a macroeconomic crisis and a world-wide economic recession. This was the worst crisis since the great depression of the 1930s. Very soon into and after the crisis, it was clear we had to stop the silo-thinking, step out of our comfort zone, and come up with a unified approach, as illustrated by the below quote from The Economist.

"... economists need to reach out from their specialized silos: macroeconomists must understand finance, and finance professors need to think harder about the context within which markets work." The Economist, 16 July, 2009, 'What went wrong with economics?'

Shortly after the financial crisis, and not unrelated to it, was the European debt crisis, which further illustrated the relation between macroeconomics and finance. During this crisis, the macroeconomic situation in some European countries was so precarious that they were unable to pay back or refinance their debt, which led to a crisis on financial markets. These two crises thus illustrate that it is not just that financial markets impact the macroeconomy or that the macroeconomy affects financial markets. Instead, the link is bidirectional. To study this link, a coherent setting needed to be developed, using which something sensible can be said about both the macroeconomy and financial assets.

Fortunately, since then progress has been made, and such a unified approach has developed under the header of macro-finance. This inaugural address focuses on this development where the two silos of macroeconomics and finance are connected, and consists of four parts. In the first part, Section 2, I will explain the development of macro-finance and discuss why it is relevant. Next, in Section 3, I turn to the importance of a solid econometric approach for dealing with the challenges of macro-finance. Third, in Section 4, I will discuss some of the topics I have worked on so far, and in the final part, Section 5, I talk about the outstanding challenges and how I hope to contribute.

2. Macro-Finance

Macro-finance studies the relationship between asset prices and economic fluctuations.[1] The aforementioned crises motivated the development of this line of research, but was, of course, not constructed solely for such rare events, important as they may be.

To get more insights into the relationship between asset prices and macroeconomics, we can look at historical data. Figure 1 plots the return on the S&P500 stock index together with the change in the Industrial Production (IP) index, a key macroeconomic measure of the state of the economy. These variables are for the United States, and most of this inaugural address will focus on US results, though I will briefly discuss other countries later. Both variables are shown over a long horizon, almost seven decades, from 1950 to mid-2019. Because stock returns are a bit noisy, the plot shows the 12-month average of the stock index return, and, for fair comparison, the percentage change of the IP index is also based on the 12-month average. As stocks are generally more volatile than macroeconomic series, they are plotted on two axes. The blue line is the stock index and is on the left y-axis. The orange line is the IP series and is on the right y-axis. It is clear from the figure that there is a great co-movement between the two series, with a correlation of 31 percent. It is apparent there is some cyclicality, and this is present in both series. On top of this, the stock market crash in 1973-1974, the dot-com crash at the beginning of this century, and the financial crises are also present in both series.

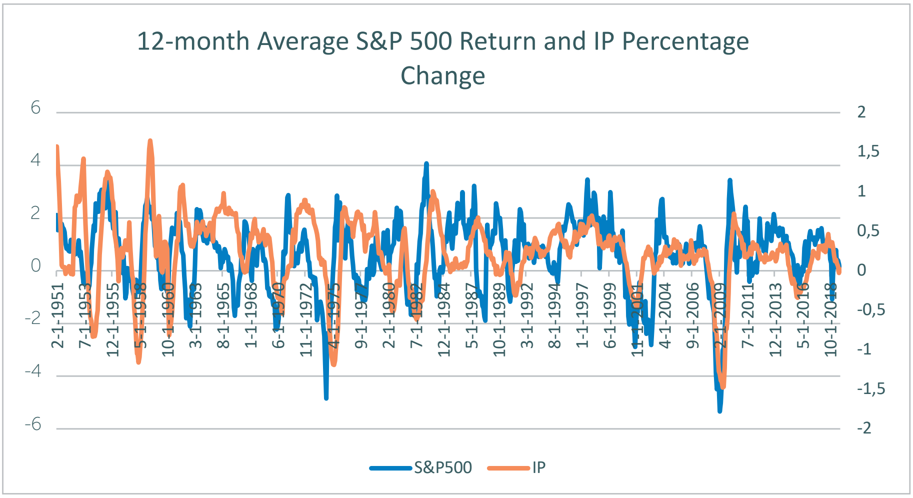

Figure 1: S&P500 12-month average return (in blue) and percentage change in Industrial Production in the US (in orange). Source: own calculations using Federal Reserve Economic Data (FRED).

1 Following, e.g., Cochrane's (2017) definition on page 945.

The link is there not only for the stock market, but also for other assets, such as the bond market. Figure 2 gives an example of the link between the bond market and the macroeconomy. The grey line is the yield spread. Governments don't just issue one bond, but offer a range of bonds with different repayment dates, or maturities, in order to attract different kinds of investors and distinguish short-term funding from long-term funding. The yield spread is defined as the yield on a bond with a long maturity minus the yield on a bond with a short maturity. Here, the spread is taken as the ten-year yield minus the three-month yield. This is plotted together with the so-called NBER recession indicator, which is the key measure used to judge whether the economy is in a state of recession. The orange shaded areas represent the months in which the country was in a recession. Also here a relation between the financial measure and the macroeconomic variable is present, be it a bit harder to find. The yield spread has predictive power for whether the economy will be in a recession or not.[2] Whenever the grey line drops below zero, a recession follows within a few months.

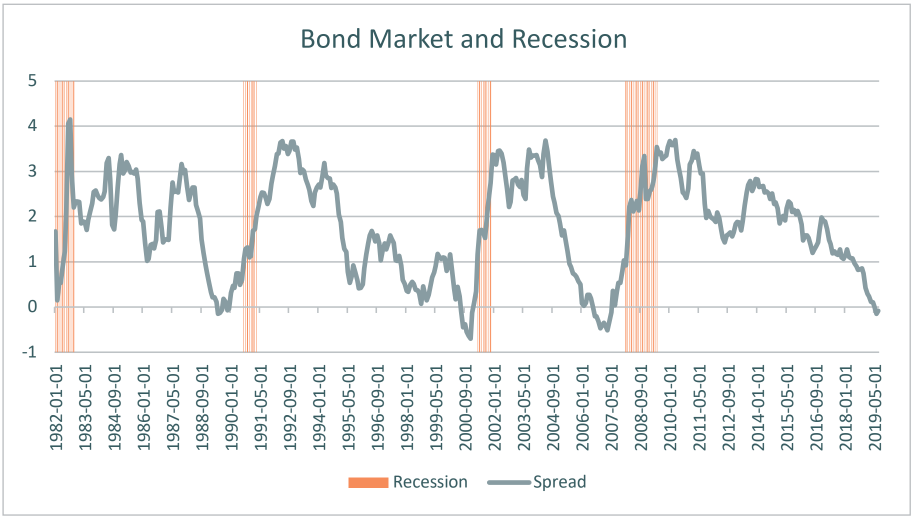

Figure 2: Yield spread (in grey), 10-year yield minus 3-month yield, with recession indicator (orange bars). Source: own calculations using Federal Reserve Economic Data (FRED).

I hope you are now convinced of the relationship between asset prices and the macroeconomy, and of the empirical justification for the study of macro-finance. The aim of this literature is that, with the models that have been developed so far and are currently being developed, it is possible to understand the link between finance and macroeconomics, and also to better comprehend the precise nature of the earlier-mentioned crises and to prevent future reoccurrences. These macro-finance models can also be used to help policymakers become more aware of the effect of policy interventions on macroeconomic variables, such as economic growth and

2 Literature on this link dates back to Estrella and Hardouvelis (1991).

unemployment, and their effect on financial variables such as stock and bond prices and interest rates, which in turn can significantly affect pension funds, for example. The models can also be used by investors, looking to incorporate macroeconomic information in their forecasts of financial variables, and by macroeconomists, hoping to benefit from the richness of real-time financial data.

3. Econometric Elements

There are a number of reasons why we cannot simply use off-the-shelf econometric techniques to study macro-finance, and we need to work on improving the current econometric tools and even develop new tools.

First, macroeconomic data are often available at lower frequency than financial data and often with a delay. For stock and bond markets, we can simply look at what is happening on financial markets to see what a certain asset is worth at any particular time. To researchers, data are available at a very high frequency, daily, but also intra-daily, at a second, or even millisecond level. However, the most important macroeconomic indicators are only available at the monthly frequency, or sometimes even at the quarterly frequency. The data are also not available instantaneously. For example, gross domestic product (GDP) is reported quarterly, and the GDP of a particular quarter is available as an advance estimate about one month after it ends, as a second estimate two months later, and the final figure is only available about three months after the quarter ends, and even that number is often revised later on. In the study of macro-finance, high-frequency financial data need to be combined with such lower-frequency macroeconomic data. This is a challenge. An easy thing to do would be to simply analyze the data at the lowest frequency, but then there is a risk that valuable information at the higher frequency is lost. Simply including the daily data as they are and interpolating the lower-frequency data is not fair either, as it implicitly assumes smoothness for the lower-frequency variable while the higher-frequency variable contains noise, which may be evened out when looking at a slightly longer horizon. So it may not be useful or necessary to immediately go to the highest frequency either.

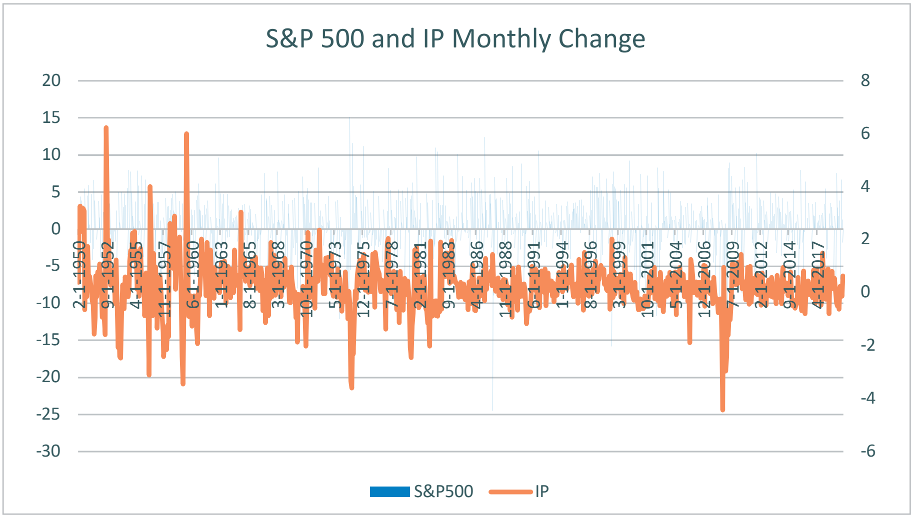

Figure 3: S&P500 1-month return (in blue) and percent change in Industrial Production in the US (in orange). Source: own calculations using Federal Reserve Economic Data (FRED).

To illustrate the frequency and measurement trade-off, Figure 3 is the same plot as Figure 1, but now both variables are simply the monthly number, not a rolling average. In this picture, it is a lot less clear whether there is a relation between the stock market and industrial production, and in fact the correlation is -1 percent when the series are measured in this way. Mixed-frequency modeling, as it is called, is a typical econometric element of macro-finance, as well as using variables as they are available in real-time.

To get clear guidance on the macro-finance link, we can also rely on economic models. However, these are complex, as they need to capture many elements. Ideally, the models start from an equilibrium framework from which dynamics are obtained for both macroeconomic and financial variables, in a unifying framework. Given the mixed frequency nature of the data, the models should explicitly allow for variables being available at different frequencies. To accurately describe the diversity of an economy, it should allow for a lot of heterogeneity. Fortunately, some of these elements are already in place in existing models, but not all. In any case, estimation techniques have not kept up with these developments in economic models. Parameters in such models are often not estimated but calibrated to match a select number of features in the data. The estimation we do is often based on Bayesian analysis, where tight priors might need to be imposed to derive some sensible output, which is also not desirable per se.

On top of the above aspects, are the more traditional econometric concepts that can be applied and have to be adjusted to the macro-finance setting. For example, news does not arrive continuously, but in batches. News about the macroeconomy often comes at fixed times that are known well in advance. The aforementioned releases of the GDP follow a strict release schedule announced months in advance, and both the date and the specific time of the release is set in advance, as is the case for other macroeconomic series. It is mostly the news, the unexpected part of it, which drives financial markets. So, to properly study the macro-finance interaction, we should distinguish macro information as the news flow and the resulting state, also referred to as the stock, and examine how these enter the models and analysis. Stock-flow analysis is another typical aspect of the econometrics of macro-finance, as is properly studying the effect of news events on economic and financial variables.

Another traditional econometric subject applicable in the context of macro-finance is how to properly measure and summarize the state of the economy. The macroeconomy is rich, with many variables capturing different elements of the macroeconomy. Even when considering macroeconomic variables that are available over a longer horizon, over 100 variables can be used, and this is even only for one particular country. When studying the macro-finance interaction, one could simply choose a few key variables and take these to represent the economy as a whole. However, this is fairly subjective and one could always argue that a particular variable, or even a small set of particular variables, misses key elements of the economy. An alternative approach to deal with the subjectivity is to let the data speak in determining which variables to include, but even then one can still argue that key elements of the economy are missed. An alternative approach is factor modeling. In this case, the information in all available variables is combined and the key driving factors of these variables are extracted. Factor modeling and variable selection are also key elements in the econometric implementation of macro-finance.

Finally, there is a role for the traditional econometric topic of testing. Of course, without proper estimation there can hardly be a role for testing, so this is the first hurdle to overcome, as mentioned earlier. Various tests would be of use, of course, including the traditional tests of significance of parameters representing certain economic effects. However, additional and adapted tests for the macro-finance setting should also be included. Examples are testing whether financial variables add value to macroeconomic models, whether macro variables can be of use and possibly replace financial variables for modeling asset prices, and whether model-implied dynamics still satisfy fundamental finance theory.

4. Results So Far

It sounds like there is a lot of work to be done, and there is. Fortunately some elements are already in place. I will now highlight a few things achieved so far, based on my own research in this area. In my own work, I generally study the market for government bonds, also known as treasuries. I do so for a number of reasons. First, the bond market is an incredibly important market. By many measures it is even bigger than the stock market. The outstanding bond debt in the US is $42 trillion, compared to a stock market size of $34 trillion.[3] Second, the bond market is of importance to many different parties. For individuals, it provides a lower bound on the interest rate they earn on their savings account, the rate they pay on their mortgage, and in their pension holding it determines both the return on investment and the discount rate. For policymakers, the bond market decides market interest rates after they set typically short-term policy interest rates. For investors, the bond market determines the return on a large part of their investment as they do not only invest in risky stocks, but also for a large part in much safer bonds. For the government, the bond market decides how expensive it is to fund its operations. Third, as government bonds are issued by governments, they are a very natural starting point to examine the macro-finance interaction. While macro-finance is much broader than this, the idea is that important implications obtained for the bond market will apply to other assets as well.

One of the papers that reflects my way of thinking of macro-finance, is my joint work with Bent Jesper Christensen, from Aarhus University, and Olaf Posch, from Hamburg University.[4] The paper develops a small-scale equilibrium model. It starts from a simple economy with a single consumer that maximizes expected life-time utility, and where output is produced following a particular production function. The model is intentionally small-scale and similar to many of the existing traditional models. What is special about it, is that the model is cast in continuous time. This is a departure from the great majority of the current literature, which studies a discrete-time setting.[5] However, there are many good reasons to study the continuous-time setting. The first is that it is a very natural way to think about data observed at mixed frequencies. In a discrete-time setting, one would need to make a statement on the model's frequency ex ante, and thus the length of the time step. In continuous time, one can think of just a continuous time-line for different variables, such as economic output, consumption, and interest rates. These variables all evolve in continuous time, but are simply sampled at different frequencies. This easily allows the macroeconomic variables to be measured at different frequencies from the more financial variables, and even the macroeconomic

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3 Source: https://www.bis.org/statistics/secstats.htm and https://www.nasdaq.com/articles/us-stock-market-biggest-most-expensive-world-us-economy-not-most-productive-2018-04-02.

4 See Christensen, Posch, and Van der Wel (2016).

5 Existing literature on continuous-time equilibrium models dates back to Bergstrom (1966), Sims (1971), Phillips (1972, 1991), Cox, Ingersoll, and Ross (1985a), Hansen and Sargent (1991) and Hansen and Scheinkman (1995). Since then, literature mostly moved to a discrete-time setting.

variables to be sampled at different frequencies. We do not need to develop a new model for each frequency or translate a variable from one frequency to another one.

A second reason for the continuous-time approach is that because of the different framework, different methods are used to solve the model. In the often-used discrete-time framework methods such as log-linearization to approximate a solution are used, as well as all kinds of perturbation methods to make that approximation more precise. In continuous time, models are solved using Ito's Lemma, which is more commonly used in financial settings. The interesting thing is that because of this, different models can be solved in continuous time than in discrete time. And, when a model can be solved in continuous time, the solution is exact and not based on linearization or approximation. The full range of models that can be solved in continuous time is something explored right now in the literature, and one promising example of a large continuous-time setting is actually used to examine the effect of financial frictions on business cycles.[6] What makes the alternative, exact, solution approach so appealing, is that no linearization or approximation about some steady state is necessary. This is not only a matter of mathematical elegance, but in some cases approximations are not good enough. The current period, with interest rates near, at, or even below zero is a good example. A setting with zero interest rates is a challenge to many models as it is essentially a corner-solution, and the quality of an approximation will often deteriorate rapidly when a model solution is studied in deviation from such a special point.

A third and final reason for this renewed interest in a continuous-time setting, is that it is a convenient way to bridge the gap between macroeconomics and finance. While current macroeconomic models are mostly in discrete time, most financial models are in continuous time, and to make the connection it is convenient to have a macro model in the same setting. This will be particularly helpful to, as the quote shown earlier mentioned, help macroeconomists understand finance and let financial researchers see the economy in which markets operate.

The main contribution of our paper is however not the model itself, but the estimation approach. In the end, the model solution states dynamics for each of the variables, and the next aim is to estimate the underlying deep parameters which describe preferences, uncertainty and average growth, etc. The econometric problem at hand is to estimate these parameters by looking at a vector time series, thus a multivariate setting, taking into account the continuous-time nature and mixed frequencies. To illustrate this, let us take as a given that the model describes economic growth, consumption, and the level of a representative interest rate to characterize the bond market, without going into too much detail about what the equations look like. Some approaches exist, but only after bringing all variables to one and the same frequency, and translating the system to discrete time. After having done this, you could use some of the estimation methods that we teach our students here in our bachelor program. When having these three economic series, an

6 See Brunnermeier and Sannikov (2014).

approach is to find the parameters that make the model-predicted value of these variables as close as possible to the observed ones. Doing this in a multivariate setting requires choosing how much relative weight to put on each of the economic variables. A simple approach is to give the same weight to each of these variables. Then, a mistake you make in describing the interest rate is equally important and gets the same weight as a mistake you make for consumption. This may be fair, but sometimes not desirable, for subjective reasons such as a preference to describe one of the series better than the others, and also when the different series are not equally predictable and volatile. A second approach is to take the volatility of the series into account, and weigh by it. A mistake in a series that is more volatile and where bigger shocks are thus expected, is weighted less than the same size of mistake in a series that is less volatile. This is essentially what the estimation method GMM does in the commonly used two-step approach. In our paper, we develop a new way to estimate the parameters in this system. We also weigh growth, consumption, and the interest rate differently based on data, but we additionally allow the model to determine the weights. The model predicts the level of uncertainty, and often this uncertainty is also a function of the deep underlying parameters of the system. By deriving weights based on the model, the parameters do not only appear in the predictions you make, but also in the weights of these predictions, thereby increasing estimation precision. Our approach, which is labeled the martingale estimation function approach, was developed for the purpose of estimating deep parameters in continuous-time structural models where there may be mixed frequencies.[7] This new tool will be very useful for the exploration of more elaborate models, describing more elements of the economy.

This research was very structural and involved setting up a model and thinking about the most appropriate way to estimate the parameters. In my research, I have also looked for the link between macroeconomics and finance in a more flexible way. In another line of work, I studied the link between macroeconomics and finance, again represented by the bond market, by focusing on very special times of the day, which are the times when news, such as the GDP release that I mentioned earlier, arrives on financial markets. As discussed earlier, although the time of the news is known, the content in the news release is not. It is interesting to examine what happens on financial markets around these releases as it also tells us the effect macroeconomic figures have on financial markets. In two papers on the topic, one joint with Albert Menkveld from the VU University Amsterdam and Asani Sarkar from the Federal Reserve Bank of New York,[8] and another one joint with my colleague Dick van Dijk from the Econometric Institute, Anne Opschoor from the VU University Amsterdam, who was at the time a PhD student here, and Nick Taylor from the University of Bristol,[9] we study trading on financial markets around news releases. These studies

7 Alternative estimation approaches for estimating general continuous-time processes exist, such as Ait-Sahalia (1999, 2002), but these methods are not designed for mixed-frequency equilibrium models.

8 See Menkveld, Sarkar, and Van der Wel (2012).

9 See Opschoor, Taylor, Van der Wel, and Van Dijk (2014).

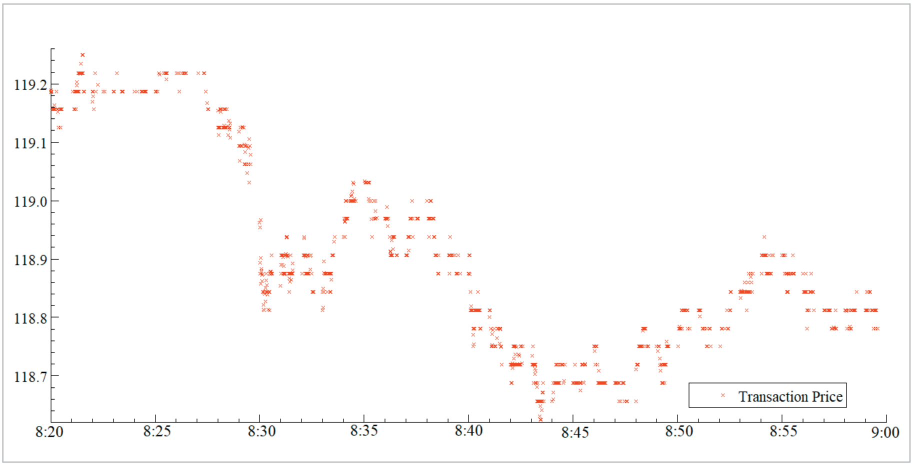

Figure 4: Price of 30-year treasury bond futures on October 15, 2009. Source: Figure 1B of Menkveld, Sarkar, and Van der Wel (2012).

focus on whether trading merely reflects the news, or whether new information is actually released in the trading. In both papers, we benefit from detailed high-frequency data, which allow for tracking precisely what happens on financial markets.

Figure 4 shows an example of such a day when news is released. Plotted here is the price of the 30-year T-bond futures. This is a futures contract, a derivative, for which the price is closely related to the price of the 30-year treasury bond. This derivative contract is often used as a substitute for the bond itself because somehow trading for that maturity is more concentrated on the derivative market than on the underlying market. The figure shows that there were two releases at 8:30 in the morning of October 15, 2009. These announcements were about the Consumer Price Index (CPI), so inflation of the preceding month, and the weekly unemployment rate. The figure nicely illustrates some properties that hold more generally around the news announcements.[10] First, trading is a bit mute before the news is released as most market participants do not want to take on risky positions in case there is a price jump. Second, after the news there is an immediate price response, and there is not much trading necessary to move the market. Third, after this initial price reaction, the market is relatively volatile as it digests the full impact of the numbers that were just released, and analysts and traders read the corresponding statement with the numbers as well.

In the papers, there are a number of findings. First, we confirm that the news announcement itself is of key importance. The market expectation of the news, often measured empirically by surveys among analysts before the announcement, is already incorporated in prices, and thus the response is purely due to the news that is released, the unexpected part, often also called the surprise. If this significantly deviates from what was expected, the price response is large, and if expectations were more or less

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10 Literature on this dates back to Ederington and Lee (1993) and Fleming and Remolona (1999).

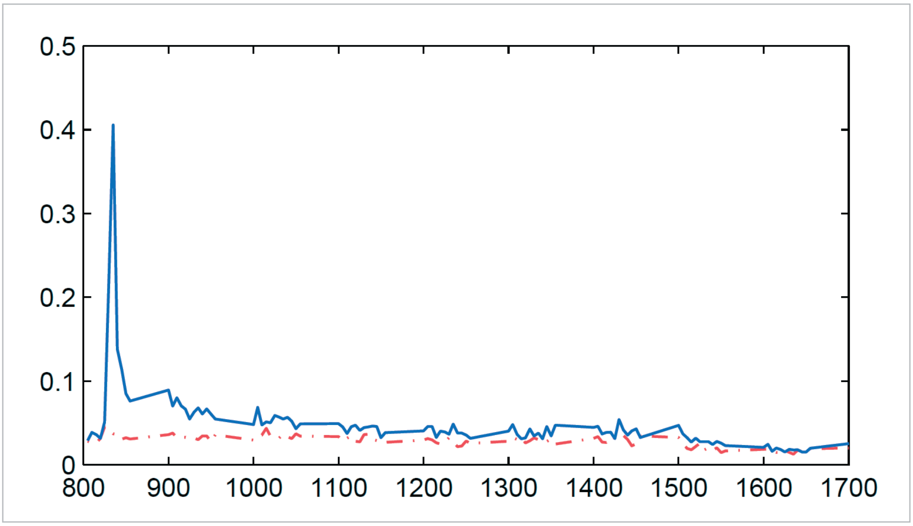

Figure 5: This figure shows volatility of 30-year treasury bond futures on announcement (blue) and nonannouncement days (red). Each series is obtained by the average over 69 trading days where an 8:30 non-farm payroll announcement was made, and 69 trading days where no announcements were made, respectively, from 2004 through 2009. Source: Figure 1A of Opschoor, Taylor, Van der Wel, and Van Dijk (2014).

right, the price response is quite small. Second, and interestingly, trading is very intense after the news release. It turns out that trading is informative, which is quite surprising as the news is public and has just been published, so it seems there is not much additional information that trading can uncover. This is however not true, because even though the numbers have been released, trading reflects differences in interpretation of the news releases and its consequences, and also how market participants' risk preferences and endowments may have shifted as a result of the new information.[11] The results of our detailed transaction-level dataset show that particularly the trading by end-users in the economy carry information, and not necessarily the trading between intermediaries in financial markets.

Third, we show that the informativeness of trading is there not only for the returns themselves, but also for the volatility. Figure 5 is similar to Figure 4, but covers a full day, and not just at one day but an average over many days. The blue line depicts the average volatility of the 69 days in the period from 2004 through 2009 after an unemployment announcement was made, and the red line shows the average on regular days, when no announcements were made. A considerable jump is visible at announcement time, and the effect persists for almost the entire morning.[12] Figure 6 shows that the order flow is much higher on days with announcements compared to

11 See, e.g., Evans and Lyons (2002) and Kim and Verrecchia (1994, 1997).

12 Modeling approaches for news impact on volatility include Andersen, Bollerslev, Diebold, and Vega (2003, 2007).

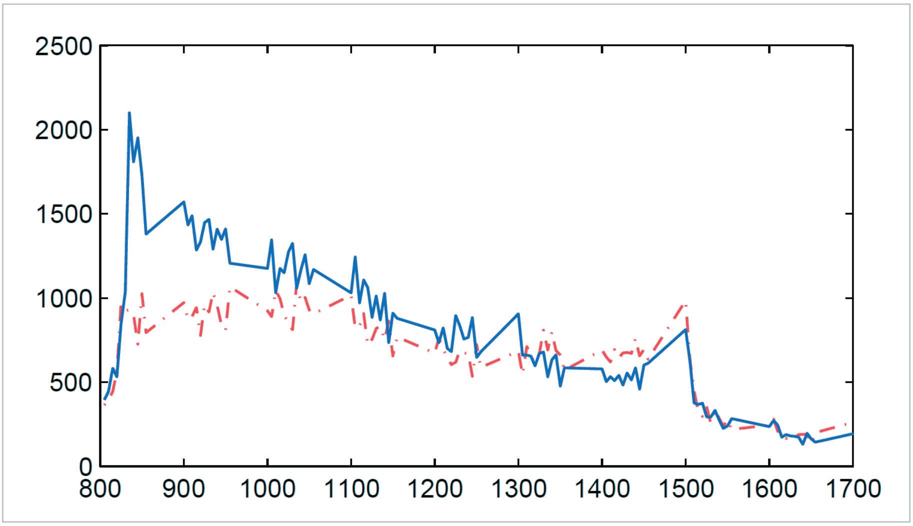

Figure 6: This figure shows absolute order flow of 30-year treasury bond futures on announcement (blue) and nonannouncement days (red). Each series is obtained by the average over 69 trading days where an 8:30 non-farm payroll announcement was made, and 69 trading days where no announcements were made, respectively, during 2004 through 2009. Source: Figure 1B of Opschoor, Taylor, Van der Wel, and Van Dijk (2014).

non-announcements days. In the paper, we document that the order flow is very significant for describing volatility. Taken together, these findings document how important macro news is for financial markets, but also the importance of looking at financial markets for finding more information about macroeconomic news releases.[13]

A final line of research, with Bent Jesper Christensen from Aarhus University,[14] studies to what extent macroeconomic variables can replace the typical factors in a financial model for the yield curve. Such yield curve models, also known as term structure models, study the relation between prices, or yields, of bonds with different maturities. Many of these term structure models describe the evolution of interest rates as a function of a number of factors, and so-called arbitrage restrictions then describe the shape of the yield curve.[15] Traditionally these factors are latent, and almost all papers document that these factors represent the shape of the yield curve and can be interpreted as the level, slope, and curvature. In this solely finance approach, these are thus the financial factors driving the yield curve, but as they are latent they may also represent macroeconomic effects. We study to what extent they do so, by carefully

13 See also Evans and Lyons (2008); Berger, Chaboud, and Hjalmarsson (2009), and He, Lin, Wang, and Wu (2009).

14 See Christensen and Van der Wel (2019).

15 Traditional contributions are Vasicek (1977) and Cox, Ingersoll, and Ross (1985b). Recent contributions include Joslin, Singleton, and Zhu (2011); Joslin, Le, and Singleton (2013); Adrian, Crump, and Moench (2013); Hamilton and Wu (2012, 2014), and Bauer and Rudebusch (2019).

replacing these latent factors with observed macroeconomic factors. This is a tricky econometric issue, as the latent factors are designed to optimize the fit and descriptive power. More or less by construction we would not expect the observed factors to do better than latent factors, as the latter can take on any value, and thus also the value of the observed factor. To examine whether observed factors can replace latent factors, we look at the restrictions that the fundamental economic theory of no-arbitrage imposes on the yield curve. We do this in a very general model setting and adopt Heath, Jarrow, and Morton's (1992) approach, which nests the great majority of existing term structure models. The results show that with too few factors and only latent factors, no-arbitrage is actually rejected, which is unlikely to be the case in practice, and thus provides evidence against the model. However, when adding macroeconomic variables, the output from the test improves. The best model structure that we find is a four-factor model, of which two factors are latent. The macro factors that matter most are an aggregate measure describing inflation and changes in industrial production.

5. Outstanding Challenges

I have given you some examples of my prior work, which illustrates that a lot of work has already been conducted on the macro-finance link and on combining the silos in which macroeconomics and finance exist. We have a continuous-time framework to deal with the mixed frequencies, know how news affects financial markets and how financial markets convey information about macroeconomic variables, and we have no-arbitrage tests to see to what extent macro variables replace more traditional latent variables in financial models. Of course we are not there yet, and many challenges remain. Let me highlight a few challenges that I plan to take on as part of the chair position.

First, the final step is to have an encompassing framework, where from basic economic foundations, equilibrium dynamics are found for macroeconomic quantities, and at the same time a so-called asset pricing kernel is developed using which assets can be priced.[16] Currently, joint with Olaf Posch from Hamburg University, I am developing such a setting. We again start from a small economy, and based on this derive the pricing kernel. We combine this pricing kernel with inflation dynamics to price assets that promise sure pay-offs in the future, which is what bonds offer. Interestingly, early results indicate that the model behaves similarly to existing popular term structure models but is extended with macroeconomic variables.

However, the model implies that the macroeconomic variables affect the bond prices in a peculiar way. They can affect the dynamics of the financial variables, but do not necessarily determine how different bond prices relate to each other at a point in time. This sounds a bit complicated, and it actually is. The idea is that the relation of bond prices at a point in time is determined by the economic mechanism of no-arbitrage, that was also mentioned earlier. What this roughly means is that financial markets price instruments to ensure that there is no free lunch, thus no money left on the table. Because financial markets are so massive with an incredible array of financial instruments, it is often possible to replicate the pay-off of a given asset by setting up a smart strategy in which other assets are combined in a portfolio. The price of the given asset must be the same as the price of the portfolio because if that were not the case, there would be money left on the table. Suppose, for example, that the price of the asset is lower than that of the replicating portfolio. You could earn money for sure by buying the asset, selling the portfolio, and thus generating a positive pay-off when you make these trades. Then, when the assets pay out, the pay-offs cancel out, so the net effect is zero. Thus, in this case, there was free money left on the table, and the trades

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16 Only elements of such approach exist, such as models that simply include macro variables in a financial model [see, e.g., Ang and Piazzesi (2003) and Diebold, Rudebusch, and Aruoba (2006)], approximations [such as the discrete-time model of Van Binsbergen, Fernandez-Villaverde, Koijen, and Rubio-Ramirez (2012)] and approaches that only capture select features of the term structure [see, e.g., Wachter (2006); Piazzesi and Schneider (2007); Doh (2011), and Rudebusch and Swanson (2008, 2012)].

are referred to as an arbitrage opportunity. Of course, this cannot be the case, and the mechanism of no-arbitrage brings prices in line to ensure no such arbitrage opportunities are possible.

The no-arbitrage mechanism in the context of bond pricing determines the relation of similar bonds at a point of time. For a long time, it was thought that this relation was dominated by the same factors as those that determine how bond prices evolve over time. These driving factors could be recovered by looking at bond prices at a point in time, and then used to describe the evolution of the prices, and even forecast them. Recent empirical evidence however documents that this is not the case, and that there can be factors that are useful for forecasting bond prices, which do not appear by looking at the no-arbitrage relation.[17] In the terminology, there are factors which are not spanned by the yield curve and thus cannot simply be replaced by yield factors.[18] There is empirical evidence and an intuition for such a way of macro factors affecting the yield curve, but a solid model that brings about this kind of relation is lacking. We are developing a model that does precisely that and documents, based on an equilibrium framework, that macroeconomic factors are actually unspanned. Currently we are setting up the right estimation framework for the model, and we also hope to extend the model, by including a financial sector and adding frictions.

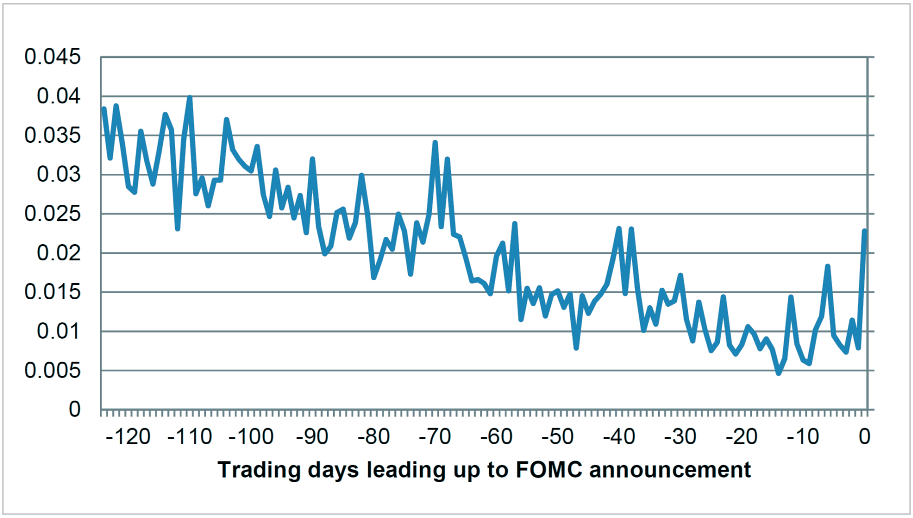

Figure 7: Average absolute change in the market-based target rate in event-time for the period of 124 trading days prior to an FOMC announcement day (excluding weekends and holidays). Source: Figure 3B from Van Dijk, Lumsdaine, and Van der Wel (2016).

17 See, e.g., Cooper and Priestley (2009); Ludvigson and Ng (2009); Greenwood and Vayanos (2014); Cieslak and Povala (2015).

18 This terminology is from Joslin, Priebsch, and Singleton (2014).

Second, I hope to further develop the modeling of how macroeconomic news releases affect financial markets. We currently know a lot about what happens after an announcement. What happens in advance is much more of an open question. In work with colleagues Dick van Dijk and Robin Lumsdaine, both from the Econometric Institute, we have documented that markets set up well in advance of decisions from the Federal Open Market Committee (FOMC), essentially the central bank committee in the US. The FOMC meets eight times in the year and makes decisions on how high or low the benchmark interest rate should be. Changes to this interest rate have a significant impact on markets. Market participants however do not just sit and wait, but anticipate the announcement. In our research, we document that they anticipate up to 124 trading days, which is the furthest our data allows us to go back, and is roughly half a year. Figure 7 shows the average absolute change in the market-based expected target rate, when looking at a financial derivative related to the benchmark rate. A key finding is that both speeches and testimonies of the members of the FOMC play a role, and that there is an equally important role for macroeconomic news releases.

If investors set up so well in advance of the FOMC release, we can expect them to also anticipate macroeconomic news. Figure 4 documents trading was relatively calm just before a news announcement, but it is likely this anticipation is stronger a bit longer before the announcement. In new joint work with Deniz Erdemlioglu, from IESEG in Lille, we study how what is known before an announcement influences what happens after the announcement. Of course, before an announcement the value of the news to be released itself is yet unknown. However, many things are known beforehand, such as measures of expectations of the value to be released, how dispersed these expectations are, and how much the expectations deviate from the previous month's value. Of course, it is unrealistic that any of this information can be used to predict returns. If information is available that matters for pricing, it should already be incorporated in prices. However, we also know there is a volatility effect after the announcement, and there is no theoretical prediction on whether or not this can be forecast with information beforehand. Our preliminary results indicate that indeed there is no predictability for returns, but the volatility after the announcement can be predicted using variables known ex ante. This paper is a starting point, which I hope to take further in the coming years. Particularly, I aim to combine these more traditional approaches and measures of news expectations with more recent methods using detailed datasets on news messages analyzed by language processing tools. These can serve as additional or alternative measures of expectations, dispersion, and add value because they can also give insights into attention being given to news.

Finally, so far I have studied the US bond market in all of my work. This is for a number of reasons. First, it is simply one of the biggest financial markets in the world. Its importance goes much beyond the US, and it is also a crucially important market for Dutch taxpayers. A lot of Dutch pension fund investment is in US treasuries, and whatever happens in the US market affects other markets including ours. Second, in the US good-quality data exist for both financial markets and macroeconomics. Third, US data are well-studied and thus new approaches can be easily compared with existing methods.

However, I think it is very important to look beyond the US and also study the European case. There are a number of reasons why this is a lot more challenging. First, the market is very fragmented. European government bonds do not exist, only bonds issued by the various European governments. Unlike in the US, these do not only vary by maturity, but also by country characteristics. Moreover, the risk of default may become a factor as we witnessed during the European debt crisis. A second challenge is data uniformity. Data would need to be collected on the macroeconomic situation for all European countries. Fortunately, Eurostat, the statistical office of the European Union, provides relative uniformity. However, for sound statistical analysis a long time series is needed and, while the definitions may be the same, not all measures may be of equal importance in each country when considering small but possibly important characteristics of employment figures (e.g., should they be nonfarm payrolls, include short-term work?). Third, the model for the European case needs to take into account these idiosyncrasies but also the strong relationships among EU members. These can be complicated. They may be reinforcing spillovers (as all members are subject to ECB policy), such that if one country is performing poorly, the entire continent may be affected. On the other hand, there may also be more counter-effects, such that if one country is performing poorly, other countries may benefit and serve as a safe haven. As a first study in this direction, my colleague Martina Zaharieva from the Econometric Institute and I are now developing a factor-like term structure model for the European case, with as first goal to study varying levels of integration of the European bond markets benefitting from full term structure data.[19]

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19 Pozzi and Wolswijk (2012) study Euro area integration using an asset pricing model for risk premiums. We will study the full term-structure, thus benefitting from a rich cross-sectional dimension as well, and will develop the corresponding econometric techniques.

6. Conclusion

To conclude, I hope that you now have an overview of how the silos of macroeconomics and financial economics are becoming more and more connected. Macro-finance sets out to study the relation between asset prices and economic fluctuations. I argue that there should be a prominent role for econometrics. This is mainly due to saliently different characteristics in macroeconomic and financial data. For example, data for these two subfields are observed at very different frequencies. Macroeconomic variables are only released at specific times, and the macroeconomy is broad such that factor modeling techniques should be used to summarize the information. An important mission of my chair is to take on the challenge of developing the right econometric techniques for macro-finance and to offer empirical insights.

I have shown a few examples of my work on this topic. This includes the development of an estimation technique specifically designed for continuous-time equilibrium models, which can deal with a lot of the characteristics mentioned earlier. It also includes studies on the relationship between macroeconomic news releases and trading on financial markets, with perhaps a surprising finding that trading on financial markets reveals information about the macroeconomy.

Finally, I discussed the outstanding challenges, such as building a model for macroeconomic series and obtaining closed-form expressions for the term structure from simple shared economic foundations, how information before news releases impact markets, and how to apply the state-of-the-art techniques to the more complicated European case. I look forward to contributing to these challenges.

Word of Thanks

As we approach the end of my inaugural address, I would like to take the opportunity to thank a number of people. Some of these ‘word of thanks’ will be in Dutch.

First, I would like to express my great gratitude to my colleagues here in Rotterdam, particularly at the Econometric Institute. From day one you made me feel incredibly welcome, even though I am from the city that is usually only mentioned by its area-code and not by name. I really enjoy everything here, from joint research, teaching in our Bachelor and Master programs, supervision of PhD students, academic discussions, thinking how to improve the way we do things, even to discussing interesting political developments and the weekend’s football matches. It is always a risk to mention specific names because there are many other names that you leave out, but I would particularly like to thank Dick and Richard. Dick, you were an incredible coach early on in my career, and a much-valued co-author on many joint papers. I really enjoy the pleasant chats we have and working with you on our shared research interests, and hope we can continue doing this for many years to come. Richard, you are an excellent guide to all things Rotterdam, including the Econometric Institute and even the local dialect. You are an incredible source of knowledge not only on econometrics, but on many things official and more off-the-record, and always provide a fresh perspective. I really enjoy our interactions.

A second word of thanks goes to the Erasmus University Rotterdam. I would like to thank the Rector Magnificus, Members of the Board, and the Dean of the School of Economics for your trust in me and for my appointment as professor. I would like to thank the Trustfonds for supporting me during the brief period as endowed professor. Rotterdam really is the city where the shirts are sold with the sleeves rolled up, something that I really saw in practice when we worked on the MOOC in Econometrics. Also a word of thanks to our students, who are often also hard-working, definitely ambitious, and critical in a good way.

My academic career started in Amsterdam. I started studying just before the bachelor-master system was introduced and did my ‘doctoraal’ at the VU University Amsterdam. The program really came to life in the second year, when we moved away from general basic subjects and started studying real econometrics. Siem Jan, you were instrumental in shaping my interest in econometrics. Your enthusiasm, down-to-earth but also ‘let’s do it’ approach is a great inspiration. I am very fortunate that we are still in touch and enjoy our lunches over the summer. Later on during my study, I met Albert, who interested me in finance generally and market microstructure specifically. He hired me as research assistant, my first ever academic job, where I also met Andre Lucas. I am extremely happy and grateful that the three of you took me on as PhD student. I learned so much from the three of you!

It is a cliché, but I could never have done it alone. I like to work in teams, and learn and benefit from my co-authors, as they hopefully learn and benefit from me as well. I am happy that many of you are here today. Thank you so much for all the time we spent together. The same holds for the PhD students that I have had the pleasure of supervising and those who I am currently supervising.

Dan in het Nederlands. Een groot woord van dank voor mijn ouders Ans en Roel en zus Ingrid. Als geen ander zien jullie hoe ik met het werk bezig ben en hoe het me bezig houdt. Jullie aanmoediging, maar soms ook ontmoediging, heeft me enorm geholpen om hier nu te staan. Marco en Julia, enorm bedankt allereerst dat jullie hier 45 minuten aan jullie Engels hebben gewerkt. Ik hoop dat jullie trots zijn, maar dat maakt me niet heel veel uit, ik ben namelijk enorm trots op jullie en het maakt me enorm blij om jullie vader te zijn.

Finally, back to English, I would like to thank my wife, Pan Lei. We met almost two decades ago, when we were both pursuing our PhD at the Tinbergen Institute. By chance, the office secretary Norah pointed me to the empty desk just across from you as the place where I should sit. The small-probability event of us meeting has been the most-consequential and greatest thing to happen in my life.

I have said. Ik heb gezegd.

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Macro-finance studies the relationship between asset prices and economic fluctuations. This inaugural address argues for a prominent role of econometrics in this topic, as it allows for dealing with key characteristics such as mixed frequencies and factor selection. The address also highlights opportunities for further research in this area.

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