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Chapter two evaluates the size and power of some nonlinear tests for panel unit roots in the presence of cross-sectional dependency and spatial dependency. Based on the simulated results some robust tests for nonlinear panel unit roots have been found.

Chapter three applies robust linear and nonlinear tests for panel unit roots in order to investigate the purchasing power parity theory in developing regions. The main finding is that nonlinearities is an important phenomenon in the real effective exchange rates in developing regions and that support for several regions may be found by applying the nonlinear panel unit root test.

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Chapter five investigates the causal relations between exchange rates and interest rate differentials using wavelets. Also the sign of the relationship between the two variables is studied using impulse response functions. The data used is for seven country pairs in which Sweden is included in all of the different combinations. In this chapter one key empirical finding is that the causal relationship between the two variables becomes stronger as the time scale increases. The other key empirical finding is that more evidence of negative relationships is found at the shorter time scales and more positive relationships at the longer time scales.
Essays on Nonlinearities and Time Scales in Macroeconomics and Finance

KRISTOFER MÅNSSON

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Essays on Nonlinearities and Time Scales in Macroeconomics and Finance

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Abstract

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Introduction and summary of the thesis

I Introduction

This thesis consists of four different essays regarding the issue of nonlinearities and time scales in economics and finance. The special focus is on market frictions and price rigidities that may cause nonlinearities and different relationships between economic variables over time. Furthermore, the focus is on the use of appropriate and robust econometrical techniques when evaluating economic theory using econometrical methods.

In chapter two different tests for nonlinear panel unit root are considered and evaluated using simulated experimental data. These tests have been developed because the standard linear unit root tests lack statistical power, which may lead to problems when evaluating economic theories when the true data generating process is, in fact, nonlinear. The economic theory suggests a number of sources of nonlinearity in macroeconomic and financial data. One of the most frequently cited reasons for nonlinear adjustment is the presence of market frictions such as transaction costs. In the presence of market frictions the adjustment process towards equilibrium takes place only when the deviations from the equilibrium price are large, and thus arbitrage activities are profitable. This type of nonlinear process that may be modelled using an exponential smooth transition autoregressive (ESTAR) model has been frequently considered in the previous literature by, for example, Granger and Teräsvirta, (1993) and Kapetanios et al. (2003). In chapter three these methods are then applied to the purchasing power parity (PPP) theory, which states that the equilibrium exchange rate of two currencies is the rate that equalizes the currencies’ purchasing power. PPP is based on the law of one price (LOP) which holds for a good in a group of countries if its price, when expressed in a common currency, is the same for all countries. The notion PPP is commonly used when moving from a single good to a basket of goods and applying price indices instead of prices of individual goods. In the presence of no transaction costs the linear panel unit root tests may be applied. However, when assuming that transaction costs exists, the data generating process becomes nonlinear and therefore nonlinear unit root tests should be used instead. In that situation using linear methods instead of nonlinear methods may lead to a substantial loss of power and therefore rejection of the PPP theory.

Then in chapter four another type of nonlinear model is used in order to test for asymmetric price transmission (APT) effects in the Swedish interest rate market. Here the possible tendency for the Swedish bank SEB to change its
customers' mortgage interest rates more in magnitude in response to borrowing costs increases than in response to borrowing cost decreases in order to evaluate if positive APT exists. Arguments for the existence of APT effects is put forward by, for example, Stiglitz and Weiss (1981) where rigidity of interest rates can be related to adjustment costs and information asymmetry in the analyzed market. Other arguments for positive APT effects are dominating market-power effects, asymmetric information, non-competitive markets, adjustment costs, or menu costs originally which may cause positive APT effects.

Finally, in chapter five another issue is considered when using econometrics in order to evaluate economic theory which is the one of time scales. By applying the relatively new method denoted wavelet analysis, one may decompose a time series into different time scales. This is an important feature in economic and financial systems where variables may operate on different time scales simultaneously so that the relationship between variables may differ across different time scales. By only looking at the aggregate time series one may reject economic theory due to a lack of power when aggregating the time series over different time scales. It may also lead to less knowledge regarding the relationship between variables when only looking at, for example, the short run relationship using vector autoregressive models, or the long-run relationship using cointegration techniques instead of investigating the relationship from the short run up to the long run. In open-economy macroeconomics the different theoretical models offer different conclusions regarding the relationships between economic variables. The assumptions behind the conclusions provided by the theoretical models have frequently been associated with time scale. Firstly we have the long-run, in which product prices are perfectly flexible, and secondly, we have the short-run in which this is not the case. In chapter five wavelet analysis is applied to investigate the relationship between the spot exchange rate and interest rate differentials where such a situation (different predicted relationship on different time scales) exists.

2 Non-Stationarity and nonlinearities

In econometrics, when deriving asymptotic distributions in order to test different hypothesis regarding parameters, a necessary assumption is that the time-series variables of concern are stationary. A consequence of applying the commonly used econometric techniques when evaluating econometric theories using non-stationary variables is that one may obtain misleading conclusions. Therefore the presence of non-stationary data induces the potential risk of falsely detecting spurious (non-existing) regression relationships. A simple definition of non-stationarity is that the mean and the variance of a time series cannot drift too far away from a constant equilibrium or a trend (trend-stationarity) in the long run. If a variables mean or variance systematically
increases/decreases over time, the variable is a function of time and hence non-stationary. Furthermore, the covariance should be unaffected by a change in the time origin. A formal definition of stationarity is the following:

\[
E(y_t) = E(y_{t-s}) = \mu,
E(y_t - \mu)^2 = E(y_{t-s} - \mu)^2 = \sigma^2_y,
E(y_t - \mu)(y_{t-s} - \mu) = E(y_{t-s} - \mu)(y_{t-s} - \mu) = \gamma,
\]

where \(\mu\), \(\sigma^2_y\) and \(\gamma\) are all constants. The concept of a stochastic non-stationary process may be explained by considering the following simple DGP:

\[
y_t = \gamma y_{t-1} + u_t.
\]

This process is stationary as long as \(|\gamma| < 1\) since in that case the effect of a shock to the system will gradually die away. The situation where \(|\gamma| > 1\) is often not the relevant case in economics since such a case implies that the effect of shocks increases over time and the process becomes explosive. However, a commonly encountered DGP in economics when analyzing time series is when \(|\gamma| = 1\) which corresponds to a non-stationary processes usually denoted a unit root process. The unit root process is common in macroeconomics and finance and it makes it impossible to predict future outcomes since the variance of \(y_t\) limits infinity as the number of time periods goes to infinity. Therefore another name for a unit root process is a random walk.

In the past it was common practice to estimate equations involving non-stationary variables using standard regression models. However, when Granger and Newbold (1974) in a seminal paper introduced the term, spurious regression, the research community became aware of the potential problems caused by non-stationary variables. By applying Monte Carlo simulations where unit root process that are totally unrelated were generated the authors reached their conclusion. In the design of the experiment they chose to generate the simplest random walk which corresponds to the above DGP with \(\gamma = 1\) and then they regressed them on each other. Despite the fact that the variables were totally unrelated, the authors found that the null hypothesis of a zero coefficient was rejected more often than standard econometric theory predicts. This may lead to erroneous claim that empirical support for economic theory has been found and due to this a lot of research started regarding tests for non-stationarity. The most utilized test is the classical Dickey-Fuller (1979) test which is a one-tailed test since for most economic time series the situation \(\gamma = 1\) is the only relevant random walk process while \(\gamma = -1\) almost never exists. This test is firstly used as a diagnostic test in order to determine whether
economic time series are stationary. Secondly it may be applied to test economic theories such as PPP and the efficient market hypothesis (EMH). However, a general problem with the Dickey-Fuller test is the lack of power to distinguish between a unit root process from a near unit root process. Another problem noted by Kapetanios et al. (2003) is the issue of potential nonlinear stationary processes. In this paper the authors suggested that time series follows a stationary ESTAR process which looks as follows:

\[ y_t = \gamma y_{t-1} \left(1 - \exp\left(-\theta y_{t-1}^2\right)\right) + u_t. \]

For this process the convergence towards an equilibrium point is quicker the further away from the mean value that the time series is. The process may be motivated by, for example, transaction costs, government interventions and trade barriers. It is therefore nowadays common practice to consider the ESTAR model when testing for unit roots in order to increase the power of the statistical tests. This nonlinear DGP has been frequently considered when testing, for example, the PPP theory (see Taylor, 2009).

3 PPP and nonlinear PPP

The classical PPP theory is based on the LOP which simply states that in the presence of a competitive market structure, identical products which are sold in different markets should be sold at the same price when expressed in terms of a common currency. The PPP theory has a long history in economics, dating back several centuries, but the specific terminology of PPP traces its origin to the writings of the Swedish economist Gustav Cassel (1918, p 1) where the author wrote the following:

“According to the theory of international exchanges which I have tried to develop during the course of the war, the rate of exchange between two countries is primarily determined by the quotient between the internal purchasing power against goods of the money of each country.. At every moment the real parity between two countries is represented by this quotient between the purchasing power of the money in the one country and the other. I propose to call this parity "the purchasing power parity."

This fundamental macro theory was introduced in the years after World War I during the international policy debate concerning the appropriate level for nominal exchange rates among the major industrialized countries after the large-scale inflations during and after the war (Cassel, 1918).

Nowadays the PPP theory is mainly looked upon as a long-run relationship, which implies that the nominal exchange rate and relative prices should be
cointegrated, or equivalently, that the real exchange rates should be stationary and mean reverting. This has in the previous research firstly been tested by applying, for example, the Dickey-Fuller test where little evidence supporting the PPP in the long-run was found. An example of such a study is Taylor (1988) where the author concluded that he found extremely unfavorable results for the PPP as a long-run equilibrium condition. A potential explanation for this may be found in Michael et al. (1997) where it was argued that when the assumptions of no transaction costs and no trade barriers were relaxed, a plausible process for the real exchange rate is an ESTAR process. The potential distortion of the PPP theory caused by transaction costs may however, be traced back as far as Cassel (1918) where tariff rates, transport costs, and similar hindrances to trade were discussed as potential problems causing short run deviations from PPP. When Kapetanios et al. (2003) found a simple test for stationary ESTAR process this became frequently applied and a larger support for the fundamental macroeconomic theory, especially in developing countries was found (see for example Bahmani-Oskooee et al., 2008).

4 Nonlinearities caused by asymmetric price transmission

Economic theory suggests that a number of important time series exhibit nonlinear behavior. For example in Romer (2012) it is explained that the downward rigidity of wages is a key feature in many macroeconomic models. Furthermore, it is established that downturns in the business cycle are sharper than recoveries in some key macroeconomic variables such as output and employment. Therefore, many different nonlinear models have been introduced. These may be applied to test different types of economic theories where a nonlinear process is suggested. Some of the most simple and useful nonlinear models have been suggested in order to investigate potential arbitrage price transmission (APT) effects. The following very simple model with a threshold may estimate APT effects:

\[ y_t = \alpha_0 + \beta_1 x_t + \beta_2 I_t x_t + u_t \]

where \( I_t = \begin{cases} 1 & \text{if } x_t > 0 \\ 0 & \text{otherwise} \end{cases} \)

Here the threshold is at the value zero and one may measure if there is pattern of positive APT inefficiencies by testing if \( \beta_2 \) is significant and positive. In the literature, there are several diverse reasons offered for the existence of APT effects. Common explanations for (positive) APT are: dominating market-power effects; asymmetric information; non-competitive markets; adjustment costs; or menu costs originally suggested by Barro (1972). However, it is also
argued in Stiglitz and Weiss (1981) that rigidity of interest rates can be related to adjustment costs and information asymmetry in the analyzed market. These adjustment costs may stem from the search for information, the menu costs of adjusting rates, the costs associated with adverse selection and moral hazard as well as consumer inertia and switching costs (Vajanne, 2009). Hence, there are several reasons in the previous literature for why the market efficiency may not hold and positive APT effects may be present.

5 Wavelet analysis and theories of exchange rate determination

Wavelets are, by definition, small waves. This means that they begin at a finite point in time and then they die out at a later finite point in time. Therefore they must, whatever their shape, have a defined number of oscillations and last through a certain period of time or space. These small wavelike functions are ideally suited to locally approximating variables in time or space as they have the ability to be manipulated by being either "stretched" or "squeezed" so as to mimic the series under investigation. Wavelet analysis is used extensively in many different disciplines such as signal processing, engineering, medical sciences, physics and astronomy. However, it has not fully entered the economics literature even though wavelets possess many desirable properties, some of which are useful in economics and finance. Ramsey (2000) suggested different ways that wavelet analysis may be used in economics and econometrics such as constructing robust econometrical methods, time-scale decomposition and forecasting. In this thesis we focus on the ability of wavelets to handle time-scales. In this situation the wavelet decomposition provides a multi-scale analysis which Schleicher (2002) compared with the activity of a camera-lens. The author noted that zooming out the lens brings a broad landscape, while zooming in the lens allows the researcher to find details which were not observable in the landscape portrait. In mathematical terms, Schleicher (2002) defined wavelets as local orthonormal bases consisting of small waves that dissect a function into layers of different scales. This ability of wavelets to dissect time series into different layers makes this type of analysis very useful in economics because most economic time series consist of different layers. This may for example be caused by economic agents that make decisions with different time horizons. For instance, in the currency market there are intraday traders, day traders and long-term traders. The exchange rate is in this example generated by the activities of all traders with different time horizons. By using wavelet analysis one can decompose the time-series (in this example the spot exchange rate) into the different layers and thus zoom in on the activity of the traders at different time scales. We are also able to zoom out
and obtain the broad landscapes which corresponds to longer-term trends of the time series.

In this thesis wavelets are used to investigate the causal relations between exchange rates and interest rate differentials. In the different theoretical models in open-economy macroeconomics different conclusions regarding relationships between economic variables have been reached. The legitimacy of the relevant assumptions has frequently been associated with time scale. Firstly there is the long-run, in which product prices are perfectly flexible and secondly there is the short-run in which this is not the case. Hence, wavelet analysis is a natural tool when investigating this type of relationship.

Asset-approach exchange rate determination models that assume product prices are perfectly flexible and bonds of different countries are perfectly substitutable are referred to as flexible-price monetary models. In dealing with exchange rate determination, these models rely heavily upon purchasing power parity in combination with some additional assumptions or theoretical results indicating a positive relationship between a country’s nominal interest rate and its prices or inflation level (as in Fisher, 1930). As a result, they tend to indicate a positive relationship between the interest rate differential and the exchange rate or the change in that exchange rate.

In contrast, in the short-run, sticky-price models as in the Keynesian tradition rely heavily upon the exchange rate as an equilibrating variable to maintain either (i) a zero balance of payments in the face of incipient capital flows between countries arising from changes in interest rate differentials or (ii) the uncovered interest rate parity condition. As a result, these models tend to indicate a negative relationship between the interest rate differential and exchange rate. Due to different predictions regarding the link between the interest rate differential and the nominal exchange rate of the Keynesian and Asset-approach at different time-scales, wavelet analysis may be a very useful tool when investigating this relationship.

6 Outline and summary of the dissertation

This thesis consists of four chapters. This section describes briefly the different chapters and the main contribution.

6.1 Testing for nonlinear panel unit roots in the presence of cross-sectional and spatial dependency

In this paper the effects of exogenous and endogenous cross-sectional and spatial dependency is investigated on the size and power properties of the nonlinear versions of the Im, Pesaran and Shin (IPS), common factor IPS (CIPS), Wald (W), Likelihood Ratio (LR) and Lagrange Multiplier (LM) tests.
Simulated data is applied to evaluate the tests and the main conclusion from this paper is that the nonlinear versions of the IPS and CIPS tests are often oversized in the presence of endogenous cross-sectional dependency and spatial dependency. The optimal test based on the simulated results when the number of cross-sectional units are small compared to the amount of time periods is the W test, while the LR test is preferable when $T$ and $N$ are close to each other.

6.2 Nonlinear behavior in real effective exchange rates for developing regions

In this paper it is investigated whether the purchasing power parity (PPP) theory holds for different developing regions located in Africa, Asia and Latin America. We use the linear and nonlinear version of the W test that was found in the previous chapter to be optimal when the number of cross-sectional units are small compared to the amount of time periods in the presence of various type of cross-sectional and spatial dependency. In summary, the results show that nonlinear reversion towards the equilibrium point is an important phenomenon for developing regions, and that strong support for the PPP theory is found in Northeast and Southeast Asia, Central and South America and Sub-Saharan Africa.

6.3 Asymmetric quantile analysis of the Swedish mortgage price discovery process

In this paper we investigate if positive asymmetric price transmission (APT) exists by using Swedish banking data. We apply the robust quantile regression and we may find significant and positive APT effects over all analyzed regression quantiles of the mortgage interest rates. Hence, the main contribution is that there is a higher propensity for the bank to rapidly increase its mortgage interest rates for customers following an increase in its borrowing costs, compared with the propensity for the bank to decrease its customers' mortgage rates subsequent to a corresponding borrowing cost decrease.

6.4 An investigation of the causal relations between exchange rates and interest rate differentials using wavelets

In this chapter wavelet analysis is used to investigate the causality in a Granger (1969) sense between the spot exchange rate and the nominal interest rate differential for seven countries pairs, each of which includes Sweden. In order to determine the sign of the relationship at different time scales impulse response functions is utilized. One of the main empirical findings in this paper
is that the causal relationship between the two variables becomes stronger as the time scale increases. When studying the sign of the relationship using impulse response functions we may find more evidence of negative relationships at the shorter time scales (i.e. an increase in the Swedish interest rate compared to that of another country is associated with a lower Swedish krona price of the other country’s currency) and more positive relationships at the longer time scales.

References


Collection of Articles or Papers

Paper 1
Testing for Nonlinear Panel Unit Roots in the Presence of Cross-Sectional and Spatial Dependency
Kristofer Månsson

Paper 2
Nonlinear Behavior in Real Effective Exchange Rates for Developing Regions
Kristofer Månsson

Paper 3
Asymmetric Quantile Analysis of the Swedish Mortgage Price Discovery Process
Kristofer Månsson, Ghazi Shukur & Pär Sjölander

Paper 4
An Investigation of the Causal Relations between Exchange Rates and Interest Rate Differentials Using Wavelets
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