Quantitative Studies in Irish Financial and Macroeconomic History

by

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This thesis is submitted to University College Dublin in fulfilment of the requirements for the degree of Doctor of Philosophy

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July 2016

In memory of my grandmother, Kathleen Stuart.

Acknowledgements

I would like to express my gratitude to my supervisors, Professor Morgan Kelly and Professor Cormac Ó Gráda, for taking me on as a student, for helping me to join the world of economic history, and for their generosity with their time and ideas throughout my PhD.

My thanks also to John Fitzgerald, who agreed to join my doctoral panel without hesitation, and whose enthusiasm and knowledge has been an inspiration.

The Central Bank of Ireland generously funded this PhD and accommodated me using annual leave to complete it. Particular thanks also to Dónal McSweeney and the Library team at the Bank for their patience and enthusiasm in dealing with my various requests.

Furthermore, I am grateful to various colleagues who have supported me as I have worked on this project. Richard Grossman, Peter Kugler and John Turner were always very kind in providing suggestions and comments when I sent them queries and papers. Ronan Lyons very generously provided me with a number of data series from his own work. Reamonn Lydon and Vincent O'Sullivan were always interested in, and supportive of, my PhD, even before I started it. Thomas Conefrey gave me some very helpful practical advice, at just the right moment. Many thanks also to Stefan Gerlach, who first suggested that I choose economic history as a PhD topic, and whose comments and ideas at various stages were invaluable.

Finally, I would like to thank my parents for all that they have done for me, and for being proud of me *every day*.

Contents

Summary

This thesis comprises four quantitative studies of Irish financial and macroeconomic history using long time span of data. The first Chapter examines the joint behaviour of monthly stock market returns in the UK, the US and Ireland in a multivariate DCC-GARCH framework. The results indicate that UK equity returns influence local (Irish) returns, but not global (US) returns. Estimated correlations between returns in the UK and Ireland and between returns in the UK and US converge over time, pointing to increasing financial integration.

The second Chapter provides a comparative study of stock price movements in Belgium, France, Germany, Ireland, the UK and US during the classical gold standard era. Principal component analysis is used to identify a global shock to equity returns, and the responses it elicits from national equity returns are studied in a VAR. The global shock had a significant effect on all markets, indicating that they were integrated. Greater exposure to the shock is compensated for by higher returns.

The third Chapter studies the effect of UK and Irish aggregate demand and supply shocks on Irish GDP and CPI over the period 1922-1979 in a VAR framework. Impulse responses show that UK aggregate demand and supply shocks have large and significant effects on Irish CPI, but smaller effects on real GDP. The important role of UK shocks in the evolution of CPI is illustrated by a historical decomposition, which also indicates that real GDP was driven by idiosyncratic domestic shocks.

The fourth Chapter compiles consumption and income data for Ireland from 1944 to 2014, and studies the relationship between the two series. Having established that the series are cointegrated, an error-correction model is estimated which is stable over the entire 70-year period. The model is extended to include financial and macroeconomic variables, and the results are discussed.

Declaration

I hereby certify that the submitted work is my own work, was completed while registered as a candidate for the degree stated on the Title Page, and I have not obtained a degree elsewhere on the basis of the research presented in this submitted work.

Rebecca Stuart

Collaborations

All chapters are my own work.

Chapter 1

Introduction

This thesis comprises four quantitative studies of Irish financial and macroeconomic history during the 19th and 20th century. The first two Chapters examine stock price developments from the 1870s through to the first half of the twentieth century. The third and fourth Chapters examine macroeconomic developments; the role of the UK in the Irish economy in the immediate post-independence period (1922-1979), and the evolution of consumption and income since 1944.

The thesis is distinguished by the use of long time spans of data and the application of time series econometric techniques. This is a surprisingly overlooked approach in Irish economic history. Many adopt a more narrative approach or microeconometric methods. By employing time series methods over long sample periods, the studies in this thesis identify the long-run determinants of the behaviour of the data, and downplay transient factors which may be present in shorter samples.

In so doing, this thesis addresses a number of questions, including: how did the Irish stock market returns move with those in other countries? Were they particularly strongly linked to those in the UK? How integrated was the Irish stock market with global markets? What was the role of UK economic developments in the evolution of the

economy in the newly-independent Irish state? What has been the relationship between domestic income and consumption in the post-World War II period?

The first of these questions are addressed in Chapters 2 and 3. These chapters examine Irish stock price movements in an international context during the period beginning in the 1870s which has been considered the first wave of globalisation. Chapter 2 examines the co-movement of stock returns in Ireland, the UK and the US over the period 1870-1939. This is a particularly interesting time for Ireland, which began the period as a part of the UK but became increasingly independent in the period after the Easter Rising of 1916. The Chapter first presents descriptive statistics for the three series of stock returns, including average returns and variances, and then estimates the joint behaviour of returns in a trivariate Dynamic Conditional Correlation (DCC) GARCH model (Engle 2002).

As two great financial centres, it may be expected that the UK and US stock markets were strongly linked. It may also be expected that the UK and Irish markets would be linked given the exceptionally close economic relationship between these two countries. This Chapter asks how these markets co-moved with the UK market, whether events in the UK market influenced those in global (US) and local (Irish) markets, and how this relationship evolved over time.

Chapter 3 also focusses on international stock price movements, examining the integration of stock markets in Belgium, France, Germany, Ireland, the US and the UK during the classical Gold Standard era, 1879-1913. Using an alternative framework to Chapter 2, this Chapter asks whether there were common shocks that affected indices in all countries, or in subsets of countries during the period, and whether exposure to such shocks was compensated for by higher returns.

To address these questions, the Chapter first studies returns and their correlations across countries over the sample period. The Chapter then uses principal component analysis to identify a global shock and estimates a VAR to determine whether this shock has a statistically significant impact on all markets. Furthermore, the Chapter discusses whether higher co-movement of equity returns in one country with this global shock component is associated with higher returns. As such, this Chapter fits into the literature examining modern international stock market integration while providing the most

comprehensive comparative study of stock prices co-movements during the gold standard that I have found.

In Chapters 4 and 5 the focus shifts to macroeconomic developments. Chapter 4 examines how external forces shaped the Irish economy in the immediate post-independence period, while Chapter 5 studies the role of domestic factors since the Second World War. In particular, Chapter 4 examines the ongoing influence of the UK on the Irish economic cycle over the period 1922-1979. Despite the establishment of separate administrative and economic functions in the Free State, the Irish and UK economies, which had been completely integrated up to this point, continued to be closely linked, largely as a result of international trade, free mobility of labour and a fixed exchange rate policy.

As such, this Chapter examines the role of UK macroeconomic shocks on developments in Ireland, using a SVAR model. The model includes Irish and UK real GDP growth and inflation and adopts a novel identification scheme based on an assumption on the price elasticity of aggregate demand schedule suggested by Ball *et al.*, (1988), to identify UK and Irish aggregate demand and supply shocks. It is possible to relate these shocks directly to global and local economic and political events, and to identify their impact on Irish output and inflation, and their role in the evolution of these variables. In so doing, the Chapter adds to the literature on the role of former colonizers in post-colonial economic developments which heretofore has focussed mainly on the legacy of colonial rule (i.e., the institutions or legal system put in place) rather than ongoing economic linkages.

Chapter 5 considers the role of domestic forces in shaping the Irish business cycle. Although Ireland is a small open economy, domestic factors still play an important role in the business cycle. This was evident during the recent financial crisis when real personal consumption, which currently accounts for approximately 60% of domestic demand, declined almost 6.5% in real terms, and real personal disposable income fell by over 17%. This chapter addresses such questions as whether this decline was unusual given the severity of the crisis; how did personal consumption develop during previous economic downturns in Irish history; and how has the relationship between personal disposable income and personal consumption evolved over time?

To answer these questions, this Chapter first compiles annual data on personal consumption and personal disposable income over the period 1944 to 2014. It then studies the relationship between the variables, examining to what extent movements in personal disposable income can explain the behaviour of personal consumption, estimating an error-correction model of the changes in the variables, and testing for stability in the relationship over the 70-year sample period. Finally, although there are a limited number of time series available for the entire sample period, the Chapter tests whether interest rates, credit, house prices and unemployment are significant drivers of consumption, and addresses the possibility of simultaneity bias. The Chapter is the first to examine these issues over such a long sample period.

This thesis presents a number of findings which are new to the literature. Chapter 6 summarises these results.

Chapter 2

UK equity returns and international stock price movements, 1871-1939

2.1. Introduction

This Chapter examines UK equity returns between 1871 and 1939, a period when international financial markets operated in a globalised manner.[1] Indeed, this period includes what has been described as the 'first era of globalization'[2] up to World War One, during which, it has been argued, capital flows and financial integration were similar, if not greater, than in more recent times.[3] However, the period includes significant variation; as noted by Obstfeld and Taylor (2005, p. 16), despite a revival in the aftermath of World War One, the market collapsed following the Great Depression.

In this Chapter I focus on the co-movements of UK equity returns with those in the US, which I consider a proxy for global markets, and in Ireland, the UK's much smaller, near neighbour. Following the completion of the transatlantic telegraph cable in 1866 and the subsequent improvements in communications, the US became a key player in the global

[1] See, for instance, Obstfeld and Taylor (2003).
[2] See Bordo and Meissner (2015).
[3] See discussion in Baldwin and Martin (1999).

financial system. As two great financial centres, it may be expected that the UK and US stock exchanges were strongly linked.

It may also be expected that the UK and Irish markets would be linked given the nature of the political and exceptionally close economic relationship between these two countries. Ireland was part of the UK at the start of the sample, although it became increasingly independent in the period after the Easter Rising of 1916. This Chapter asks how these markets co-moved with the UK market, whether events in the UK market influenced those in the global (US) market and/or in Ireland, and how these relationships evolved over time.

In addressing these questions, the Chapter first discusses how the means and variances of equity returns compare across the countries and over time. These statistics suggest that, although the volatility of all three markets increases over time, it is highest in the US and lowest in Ireland. It is possible that this is due to differences in the degree of market liquidity.[4] In particular, the narrative evidence suggests that the UK market may have been less liquid than that in the US, but more liquid than that in Ireland. The results are thus compatible with the findings in Goldstein (2015), Chakrabarty *et al.*, (2011) and Greenwald and Stein (1991) that less liquid markets tend to be less volatile.

Next, I employ a Dynamic Conditional Correlation GARCH model, which enables an examination of two aspects of the relationship between markets. First, the model allows us study whether events in the UK market led those in global and local markets. Second, it allows us to study whether and how correlations between the indices varied through time.

This Chapter is interesting for several reasons. First, while many studies of modern data examine international co-movements of data[5], most historical studies of stock prices focus on one, or at most two, markets.[6] Thus there is little evidence of the international behaviour of the level and volatility of returns during the period under review. This

[4] Another interpretation is that the US was an emerging market, experiencing high and volatile returns, at this time.

[5] See, for instance, Pukthuanthong and Roll (2006), Chambet and Gibson (2008) and Bekaert and Harvey (1995).

[6] There are exceptions, of course. See, for instance, Triner and Wandschneider (2005).

Chapter provides a first attempt to address this gap using data for the UK, US and Ireland.

Second, the results from the GARCH model indicate that the UK market is affecting the market in its small, nearby neighbour, Ireland. However, the UK market is not a global leader; returns in the US, which I view as a proxy for global developments, drive returns in the UK.

Third, the GARCH model implies that the correlation between the UK and Irish returns fell during the period, indicating the declining influence of the UK as Ireland became increasingly independent. In particular, this correlation declines in the period after the Easter Rising in Ireland, which ultimately led to the establishment of the Irish Free State and the separation of Irish administrative and economic functions from those of the UK.

At the same time, the correlation between UK and US returns increased, indicating an increasingly globalised market. I find that the exchange rate has little effect on this result. In addition, I discuss the effect of the weighting of individual stocks in the overall index on the estimated correlations, and provide evidence that the type of weighting used to construct the equity indices does not significantly affect the overall pattern of correlations, although differences in the absolute values of the estimates occur.

Furthermore, the findings in this Chapter suggest that, in terms of the broader literature and debate on market integration during the period under study, there is evidence that while large markets such as those in the US and UK may have been integrated globally, the Irish market was less integrated and tended to still be influenced by more local factors.

The Chapter is structured as follows: the next section discusses the channels through which the co-movement of stock returns could have occurred with reference to both theory and empirical evidence. The data are described in Section 2.3, with a particular focus on issues relating to the compilation of indices. The section also discusses some descriptive statistics. Section 2.4 presents the results of the GARCH analysis, including extensions, and Section 2.5 concludes.

2.2. Co-movements in stock returns

2.2.1 Why might there be international co-movements equity returns?

For simplicity, consider the Gordon (1959) dividend growth model, according to which the price of a stock is determined as follows:

$$p = \frac{D}{r - g}$$

Here, the price, p, is determined by the dividend today, D; the growth rate of dividends (which is assumed constant), g; and the required rate of return, r, which can be thought of as the sum of the risk-free rate and the risk premium required for holding equities. The model suggests that international co-movements in prices could occur if the risk free rate shifts in a number of countries at the same time. This could arise if there is a change in the perceived economic growth outlook across a number of countries. Alternatively, co-movements in economic growth across countries could lead the expected growth rate of dividends to be correlated across countries. Finally, risk premia could be reappraised across countries at the same time. These shifts could occur because of an event in one country, or in a number of countries.

The recent global financial crisis is an example of just such an event. A number of recent studies have considered the channels through which this shock was transmitted across countries. Studies by Hwang *et al.*, (2013), compare stock returns in emerging market economies with those of the US and find evidence of contagion and herding behaviour, whereby movements in one market affect sentiment in another, regardless of developments in fundamental factors. Similarly, Didier *et al.*, (2012) examine the co-movement of US stock returns with those in 83 other countries during the 2007-2008 crisis, finding that they were largely driven by financial linkages.

Certainly, a similar transmission of shocks was possible during the period studied here. Obstfeld and Taylor (2005, p. 25), argue that between 1870 to the First World War 'the first age of globalization sprang forth'. They point to the role of the gold standard in driving a convergence in interest rates across countries and the consequent increase in capital flows. Similarly, Baldwin and Martin (1999) present a number of measures of capital mobility and financial market integration and argue that capital mobility was perhaps

higher during parts of the sample period under review than in more recent decades. Nonetheless, such capital flows halted abruptly when the gold standard was abandoned first (temporarily) during the First World War, and then in 1931 in the wake of the Great Depression.

Furthermore, the time period in this study covers the first era of modern communications. When the Atlantic Telegraph Company completed the trans-Atlantic telegraph cable in 1866, it reduced amount of time it took to communicate across the Atlantic from over a week to just a few minutes. [7] The importance of this to stockbrokers is illustrated by Michie (1987, p. 46) who notes that by 1871 New York brokers were spending $0.8 million per annum on telegrams to London and that transatlantic cable companies deliberately located offices near to stock exchanges in order to provide express services to traders. Hoag (2006) uses an event study analysis on one security with a dual listing on the London and New York exchanges from the time that the cable became operational to show that the information lag decreased from 10 days to being instantaneous.

As a result of the developments in financial integration and communications, investors were able to respond quickly to news in other jurisdictions. For instance, Triner and Wandschneider (2005) examine the role of international markets in the Brazilian financial crisis of 1890/91, arguing that the behaviour of markets during that period is a precedent for the contagious financial crises that emerging markets faced at the end of the twentieth century.

Turning specifically to the UK, US and Ireland, it is clear that these markets were linked by trade and foreign direct investment throughout the sample period. In particular, the UK and Irish economies were fully integrated at the beginning of the period, and therefore a large degree of correlation could be expected between these two markets.[8] Even after independence, the UK continued to account for the overwhelming majority of Ireland's external trade.[9] Additionally, there were strong links between the UK and the

[7] By 1868, transmission speeds had increased to 8 words per minute. See Litton (1961) for a discussion of the development of telephone communication in Ireland.
[8] There was also a degree of co-listing of stocks. Some stocks were similarly co-listed on both the Irish and UK exchanges (this is discussed further in Section 2.3.1).
[9] Indeed, Barry and Daly (2011, p. 1) note that even following independence in 1922, Ireland traded 'almost exclusively with the UK'.

US: as late as 1939 the US accounted for the largest share of UK imports, and the third largest share of exports.[10]

In terms of foreign direct investment, it is clear that the UK and US markets benefitted from significant international capital flows. Sylla, *et al.,* (2006) note that as early as 1803 to 1804 almost half of US securities were owned by foreigners. Furthermore, Campbell and Rogers (2015) find that the UK and US markets were integrated over the period 1825-1925, although this is based on the inclusion of stocks of export-oriented companies, rather than just domestically-oriented companies. Similarly, Grossman (2014) argues that returns of industrials listed on the London Stock Exchange were more highly correlated with developing regions with which they had substantial colonial or trade connections than with non-industrials.

2.2.2 Measuring stock market co-movements

Having discussed how stock markets co-move, I next turn to the issue of measuring this joint behaviour. A variety of methods have been employed in (mostly recent) studies. One method is to consider the correlation of stock returns. For instance, Goetzmann *et al.*, (2005) calculate correlations of stock returns in Europe, Asia, the Americas, Africa and Australasia over long sample periods, generally beginning in the first half of the 20th century. They find that correlations were high in the pre-World War 1 era, even compared to more recent times, and interpret this as evidence of integration. Campbell and Rogers (2015), focus on the r-squared from a regression of two returns on each other since, in a bivariate regression, the r-squared equals the squared correlation coefficient for the two variables.[11]

Another strand of the literature seeks to identify common shocks and then estimate the co-movement of each stock market index with this shock. While many recent studies use such methods[12], few historical studies have employed them[13], possibly because common

[10] Data taken from Mitchell (1980).
[11] See Schotman and Zalewska (2006) for a similar study of the integration of emerging European economies and developed economies using modern data.
[12] See, for instance, Chambet and Gibson (2008), Pukthuanthong and Roll (2009), Bekaert and Harvey (1995) and Bekaert, Hodrick and Zhang (2009).
[13] Edelstein (1982) employed such methods to examine co-movements of rates of return across industries and countries over the period 1850 to 1914.

shocks can only be estimated in a comparative study including a number of indices. An exception is Stuart (2015) who uses principal component analysis to identify a common shock across six equity markets during the classical gold standard era, and then estimates the impact of this shock on the equities in a VAR.

Other studies of modern data estimate when market integration occurs. For instance, Bekaert and Harvey (1995) use a conditional regime-switching model in which periods of greater and lesser integration between modern capital markets are identified. Bekaert, Harvey and Lumsdaine (1998), test for breaks in reduced form financial and macroeconomic time series models for 20 emerging market countries, with identified breaks interpreted as reflecting increased integration.

An alternative approach uses generalized autoregressive conditional heteroscedasticity (GARCH) methods, which allow for the heteroscedasticity that is common in financial data, to estimate the co-movement of the returns and volatility across markets. In terms of historical studies, Choudhry (1994) estimates an integrated GARCH model of the persistence of stock return volatility of European indices in the 1920s and 1930s. The author shows that shocks to volatility are permanent for most of the indices studies. A similar GARCH approach is adopted in this Chapter.

2.3. The data

2.3.1 Data sources

This section outlines the data used in the analysis. There are a number of ways to construct a stock price index. An index can be a simple average of all stocks (referred to as 'equal weighted' or 'unweighted'[14]), or it can be weighted in a number of different ways, perhaps most commonly by market capitalization of the individual stocks. Since the method of construction can impact on the level of the index and therefore on returns, it is important to be clear about how the series are compiled.

[14] Although technically a simple averaging process results in all stocks being 'equally weighted', it is often referred to as 'unweighted'.

This Chapter uses two data series for the UK. The first is the monthly share price index compiled by Hills *et al.*, (2015), and available in the *Three Centuries of Data* spreadsheet on the Bank of England's website.[15] These data are themselves spliced together from a number of sources. From the start of the sample to June 1914, the data are from Smith and Horne (1934). These data are unweighted. In the subsequent period to November 1921, data are from Morgan (1952) and are weighted by market capitalisation. Thereafter data are market capitalization weighted variable dividend stocks taken from the Banker's Magazine.

Unweighted data such as the Smith and Horne (1934) index, bring with them some problems (see Grossman (2002) for a discussion). Furthermore, the Smith and Horne index focused primarily on industrials, and therefore does not include some of the largest companies at the time, and is subject to survivorship bias. Both of these issues are likely to lower the correlation between indices, and bias any econometric analysis towards finding insignificant results, although it is interesting to note that Campbell and Rogers (2015), find little role for firm size and industry in explaining co-movements in UK and US equities over the period 1825 to 1925.

Since market capitalisation weighted data from the Banker's magazine are available from December 1905, an alternative would be to use these data instead of the Smith and Horne index before 1914, reverting to the Hills *et al.*, series thereafter. However, these data have their own drawback since they include bonds/fixed income securities as well as equities. In addition, Grossman (2002) presents annual series of stock returns for the period 1871-1913 which is market capitalisation weighted. These data are based on end-year values, and can thus be compared with log changes in the December data from the Smith and Horne index. The correlation coefficient of these data is 0.64, and in 36 of the 43 years both indices change in the same direction (both series increase or both decrease). However, since monthly data are necessary for this study, I use the original Hills *et al.*, (2015) series for the main analysis, but use the Banker's magazine alternative series for the period 1906 to 1914 as a robustness check.

[15] See: http://www.bankofengland.co.uk/research/Pages/onebank/threecenturies.aspx.

Irish data are taken from Grossman *et al.,* (2013) for the period 1871 to 1930 and from Grossman *et al.,* (2015) for the period thereafter. The data from Grossman *et al.,* (2013) are monthly, compiled using over 35,000 price-year observations from the *Investor's Monthly Manual*, and cover the period October 1864 to June 1930. The overall market index includes 118 equity securities issued by 94 companies over the entire sample period. For the period 1930 to 1939, Grossman *et al.,* (2015) take firm-level last-business-done prices from the records of the Dublin Stock Exchange for the 1930s. Both of these series are weighted by market capitalization.

The US data series are the Common Stock Price Index compiled by the Cowles Commission and Standard and Poor's Corporation, and obtained through the Federal Reserve Bank of St Louis Economic Data (FRED) website. The data from the Cowles Commission are used to the end of 1917 and are, in general, arithmetic averages of the highest and lowest prices of the month weighted by the number of shares outstanding at the end of the month. From 1918 to the end of the sample period, the index is an average of Standard and Poor's weekly composite stock price index, which was calculated using closing prices on Wednesdays. The index includes 198 stocks in 1918, increasing to 480 in 1957.[16] Notably, these series are not weighted by market capitalisation, as the Irish and UK (post-Smith and Horne) indices are. However, no market capitalisation weighted series is available for the US.

An alternative data source for the post-Cowles part of the sample, is the Dow-Jones Industrial Stock Price Index where the average price per share is calculated at an unweighted arithmetic mean of actual prices, and prices are calculated as the average of the high and low price for the daily closing indexes for the month. This series is available from 1897 to 1935. Overall, the correlation coefficient of the two Dow Jones and the Standard and Poor's indices is 0.90, indicating that there is not a great difference between the two series. In addition, Goetzmann *et al.,* (2000) calculate an index for the period up to 1925. This is a price-weighted index in which the monthly returns for each stock that is traded in two consecutive months is weighted by the price at the beginning of the two months. This series exhibits a lower correlation with the Standard and Poor's series up to

[16] For more information, see Moore (1961), p. 24.

1925. As such, I use the Standard and Poor's series, which is compiled for the entire sample period on FRED, and which is widely used in the literature.[17]

Since stock prices in the UK and Ireland are in pounds Sterling, but those in the US are in Dollars, the exchange rate must also be considered. Although the gold standard was in operation for much of the period, there were still periods of floating exchange rates. The dollar-sterling exchange rate is taken from Craighead (2010). Interestingly, the dollar-sterling exchange rate does not seem to have a large impact on returns: the correlation between US returns denominated in Dollars and US returns denominated in Sterling is 0.95. Since throughout the period Ireland was either ruled by Britain, or had a one-to-one exchange rate peg with Sterling, no exchange rate adjustment is needed for these indices.

An issue that arises in analysing the joint behaviour of these data is the extent to which companies are listed on more than one of the exchanges studied. Such dual listings would of course raise the correlation of the two indices. An analysis of the compilation of the Irish index from Grossman *et al.,* (2013) for the period 1871 to 1930 indicates that, of the 94 companies which constitute the index, seven are also listed in London, although never all at the same time.[18] However, it should be noted that dual listings are a feature of modern indices as well.[19]

2.3.2 Evolution of the series over the sample period

The final series are plotted in log levels and indexed to 100 in January 1871 in Figure 2.1.[20] UK stock prices decline through the mid-1870s during the Long Depression, before growing strongly in the late-1870s and early-1880s. The peace and stability of the Edwardian era saw a rise in stock prices in the early-1900s, and stability thereafter. The First World War led to a decline in the index, as did the depression of 1921-22 following the ending of war orders. The series rose markedly in the mid-1920s. Nonetheless, this has been seen as a period of market failure: although the stock market provided many

[17] See for instance Shiller (2000).
[18] For the purposes of this analysis, Guinness, the largest Irish company of the time which was also listed in London, is excluded from the Irish index.
[19] See Pagano *et al.,* (2001) and Fernandes and Ferreira (2008) for discussion on the motivations for, and benefits of, cross-listing in modern exchanges.
[20] Throughout this section, US prices are converted to Sterling, to ensure that they are comparable with the other series.

new companies with capital during this period, firms in new manufacturing industries, such as automobiles, airplanes, synthetic fibres and chemicals, did not raise as much equity finance as might have been expected.[21] Thereafter, the crash in 1929 is clearly in evidence. The Great Depression pointed to a lack of investor protection, which prompted the London Stock Exchange to improve the vetting of applications for new listings. This process, alongside the wider economic pick-up, meant that new listings increased strongly in the mid-1930s, and the index recovered in the final years of the sample.[22]

The impact of the Long Depression is also in evidence in the US series. Nonetheless, the US recovered more strongly in the 1880s than the UK, perhaps due to the effect of the Second Industrial Revolution. The stock market rose throughout much of the following period until the failure of the Knickerbocker Trust in 1907.[23] The index picked up again thereafter and, by 1921, 171 million shares were traded. This figure rose to over a billion in 1929, as prices rose sharply in the run-up to the 1929 crash. However, the crash which began in October 1929 was not short and sharp; the bottom of the market was reached only in 1932. In the aftermath of the crash, the Securities Act of 1933 was enacted with to two aims: to ensure full disclosure to investors and to prohibit fraud in the sale of securities. For most of the period thereafter, the market regained ground lost in the crash, although the market would not recover fully before the end of our sample period. Nonetheless, the series rose substantially over the course of the sample period.

While somewhat similar patterns are in evidence in the Irish series, it is much more stable than the other series.[24] The invention of the pneumatic tyre by Dunlop in Belfast in 1888 resulted in a 'bicycle boom' through much of the 1890s. The years thereafter were relatively quiet, with limited new company registrations in the pre-War period. This period is marked by a gradual decline in the series. Notably, there is no post-War increase in stock prices, perhaps since the Irish independence struggle led to uncertainty and economic disruption. Through the 1920s the index generally rose, as stockbrokers

[21] See Chambers (2010) for a discussion.
[22] See Smith (1929) and Michie (2001) for a discussion of the early years of the London Stock Exchange.
[23] See Library of Congress business reference service and NYSE.com for a chronology of the exchange.
[24] See Thomas (1986) for a discussion of the development of the Irish exchanges.

increasingly focused on debt and equity requirements of domestic companies. Having declined in the wake of the Great Depression, the index picked up again in the 1930s. This may be due to efforts to increase funding available to domestic firms, which included tax incentives in the 1932 Finance Act to encourage investment in stocks and shares. However, there is disagreement about the impact of these measures on the stock exchange[25], which was likely tempered by other initiatives such as the establishment of the Industrial Credit Company in 1933. By the end of the sample period, the Irish index was only marginally higher than in 1871.

2.3.3 Descriptive statistics

The three panels in Figure 2.2 show the monthly percentage changes, measured by the differences in log levels, of these series (note the panels have different vertical scales). These data can be interpreted as capital gains, exclusive of dividends, and hereafter referred to as returns. The figure shows that both the UK and US series record a small number of monthly returns in the region of +/-10%.[26] However, exclusive of these outliers, the US series is more volatile throughout the period, with most month's returns in the region of +/-5%, compared to +/-3% in the UK. Returns in Ireland appear less volatile than those in both the UK and the US, with most monthly figures in the region of +/-2%, and never exceeding +/-6%.

Average monthly returns and their variances are presented in Table 2.1. These are calculated for the entire sample period as well as four 17-year sub-periods. The average return in the US was substantially higher than in the UK or Irish markets. Indeed, the average monthly return in the US was just less than 0.115% over the entire sample period, compared to an average monthly return of 0.025% in the UK and 0.062% in Ireland. This result is not surprising and is compatible with, for instance, findings in Jorion and Goetzmann (1999) that US equity returns were higher than those in other developed economies in the twentieth century.[27] Interestingly, even in the final subperiod US returns

[25] Thomas (1986, p. 185) notes that Stock Exchange witnesses at the 1938 Banking Commission were divided on the impact of the measure.
[26] Grossman (2002) notes that the unweighted Smith and Horne index might underestimate capital appreciation.
[27] Jorion and Goetzman (1999) use real data, while the data here is nominal.

exceed those elsewhere, recording a positive average monthly return despite the 1929 crash, compared to a negative return in the UK.

The variance of US equity returns is over three times that of the UK return which, in turn is almost three times that of Irish returns over the entire sample period. While this indicates a higher level of risk in the US market, it is also the one with the highest return, and it is therefore interesting to consider the risk-return trade-off in each market. Calculated as the standard deviation divided by the mean, a lower 'coefficient of variation' implies a more attractive trade-off of risk and return. Interestingly, the coefficient of return is lower in the US market than in the UK market (39.3 and 97.6, respectively), indicating that the greater return in the US market more than offsets the risk associated with higher volatility.[28] The coefficient of variation is lowest in the Irish market.

Interestingly, the US returns have the highest variance in every sub-period. Similarly, the variance of UK returns is higher than those of Irish returns in every subperiod. It is possible that the US market was more volatile because it was an 'emerging' market experiencing high economic growth at this time. Another hypothesis starts from the assumption that the US market is more liquid than that in the UK, which in turn is more liquid than that in Ireland. In the current sample, it seems reasonable to assume that the Irish market was the least liquid, being the smallest and least developed. Furthermore, Campbell and Rogers (2015) note that the market capitalization of equities on the NYSE was much larger than any other exchange at this time, but that it had fewer stocks listed than some other exchanges, since it only accepted for listing very large firms which 'were likely to be heavily traded'[29].

Given this hierarchy of liquidity across markets, it may be that that more liquid markets are more volatile. For instance, theoretical models such as Greenwald and Stein's (1991) indicate that reductions in market liquidity can reduce volatility by allowing informed traders to enter the market and provide liquidity. This is in line with Goldstein (2015) who finds that trading halts of individual stocks on the New York Stock Exchange

[28] The coefficient of variation is not included in Table 2.1 since average returns are often negative in individual sub-periods, making it difficult to interpret.
[29] See Campbell and Rogers (2015, p. 2).

(NYSE) result in a small but statistically significant decline in volatility, while Chakrabarty *et al.*, (2011) show that when the NYSE is closed, volatility increases in other exchanges as trading moves to them. In addition, the general pattern of increasing variance over time which is evidence from the sub-period analysis, such that variance approximately doubled in the UK and Ireland over the sample period and quintupled in the US, is also compatible with this hypothesis since liquidity was most likely increasing in all markets over time.

2.4. Estimating the role of UK equities in other markets

I next estimate formally the role of UK markets during the sample period. Considering the US index as a proxy for global markets, I examine the role of the UK market in Irish and global developments each. Since financial data such as those used here often display heteroskedastic volatility that is predictable through time, I first test for autoregressive conditionally heteroskedastic (ARCH) effects using the Engle's Lagrange Multiplier (LM) test.

2.4.1 Testing for ARCH effects

Testing for ARCH effects requires regressing each return series on its own lags and lags of the other returns series and retrieving the residuals series. The residuals series is squared, and then regressed on its own squared lags. The null hypothesis is that ARCH effects are not present, and therefore that the parameters on the squared lagged terms are equal to zero. The LM test indicates that the null of no ARCH effects can be rejected for all three series (all have p-values of 0.00).

2.4.2 The GARCH framework

Since ARCH effects are present, a natural question is how the volatility of returns interacted across countries, particularly, how does the volatility of UK returns interact with those in global and local markets. To explore this further, I estimate the joint behaviour of stock returns in a dynamic conditional correlation (DCC) multivariate

GARCH model framework as set out in Engle (2002).[30] Unlike other specifications, such as constant conditional correlation models, DCC models assume that the correlations between series vary through time, which seems reasonable when looking at 70 years of data. In addition, this feature of the model allows us to see how the correlation of the UK market with global and local markets varied through time.

The conditional covariance matrix in the DCC-GARCH model is given as $H_t = D_t R_t D_t$ and is composed of a diagonal matrix of conditional standard deviations, D_t, and a correlation matrix, R_t. The elements in D_t are standard deviations from univariate GARCH models. The correlation matrix, R_t, must be both positive definite and must have each element less than or equal to one. To ensure this, and in the simple case of a GARCH(1,1) specification, Engle (2000) specified R_t as:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha(\epsilon_{t-1}\epsilon'_{t-1}) + \beta Q_{t-1}$$

Where $\bar{Q} = Cov[\epsilon_t \epsilon'_t]$ is the unconditional covariance matrix of the standardized errors from univariate GARCH models.

The scalars α and β are referred to as adjustment parameters. For H_t to be positive definite, α and β must be such that $\alpha + \beta < 1$. Furthermore, it must be that $\alpha \geq 0$ and $\beta \geq 0$ or else Q_t collapses to $\bar{Q}$ and there is no time variation in the correlations.

Finally, Q_t^* is composed of the square root of the diagonal elements of Q_t. Q_t^* therefore ensures that each element of R_t is less than 1.

In estimating the model, the missing data during the first five months of the First World War is treated as a gap during which the unconditional expectations are substituted for the dynamic components that cannot be computed. This method is appropriate when T/g goes to zero as T goes to infinity, where T is the sample size, and g is the number of missing observations; a reasonable assumption in this instance.

[30] The data in Figure 2.1 raise the question of whether the UK and Irish data are cointegrated. However, a Johansen test using either the Trace statistic or the Maximum Eigenvalue test, suggests that this is not the case.

2.4.3 Results of the mean equations

I first estimate a trivariate GARCH model of UK, Irish and Sterling-denominated US (referred to as US) returns. The results are presented in Table 2.2. Two lags of Irish, UK and US returns are included in the mean equation. Of the nine twice-lagged terms in the model, only two are significant at the 5% level. This raises the question of whether second lagged term is necessary. A joint test of the nine coefficients on the twice lagged term indicates that they are jointly significant at the 2.5% level (p-value = 0.02), while a Likelihood ratio test comparing the model with two lags to a more parsimonious model with just one lag, also indicates that these lags should be included (p-value = 0.02). I therefore proceed with two lags.

All of the ARCH and GARCH terms are significant implying (in addition to the results of the ARCH test) that a GARCH specification is appropriate.[31] Furthermore, a Wald test rejects the hypothesis that the adjustment parameters, α and β, are both equal to zero, indicating that the dynamic correlation specification of the GARCH model is appropriate (p-value = 0.00).[32]

Turning to the mean equations, it appears that both the first and second lags of UK returns impact on Irish returns, but neither lag impacts on US returns. Interestingly, lagged US returns have a predictive value for current UK returns. Indeed, even twice lagged US returns are significant at the 10% level. The implication of this is twofold: the UK market, rather than leading global markets, is subject to global shocks, but on a local level, the UK market still leads returns in its smaller neighbour, Ireland.

The, US equation is the only case in which own lagged returns are significant, although the coefficient on the second lag is negative. Furthermore, lagged Irish returns are also significant in this equation, with a negative sign. This is an unexpected finding which

[31] In some instances, it appears that the ARCH and GARCH terms might sum to 1, implying integrated GARCH processes. A Wald test that the terms sum to 1 gives p-values of 0.001, 0.062 and 0.005 for the UK, Ireland and the US, respectively. Although the test just fails to reject the null for the Irish equation, the result is marginal, and I proceed on the basis of no integration.

[32] If the adjustment variables are both equal to zero the DCC model collapses to a constant conditional correlation model, implying that the underlying assumption that there are dynamics in the correlation is incorrect.

may, for instance, arise from methodological issues such as whether the indices are calculated as prices at the start of end of the month, or as monthly averages.

2.4.4 Estimated variances and correlations

The estimated variances are presented in Figure 2.3. The series of high returns in the UK in 1880 as growth returned after the Long Depression impacts the estimates of variance around this time, as does the tumultuous post-1929 period. However, aside from this, the variances in the UK and Irish markets are much lower than in the US. For the US market, there are two particularly marked periods of higher turbulence: during the second industrial revolution between 1900 and 1910, and around the Great Depression. The variance of Irish returns is much lower, with only the period of the early 1920s marked as by higher variance.

The estimated correlation coefficients for the different return series implied by the model are shown in Figure 2.4. The correlation between UK returns and Irish returns is generally higher than the correlation between any of the other series. However, on average, it appears that the correlation of UK and Irish returns declined over time. At the same time, it is noticeable that the correlation of UK and US returns increased during this period. Indeed, it appears that these correlations converge over time: by the end of the sample, the two correlations appear to move together and be of similar magnitude.

At no point do these two correlations turn negative. However, the correlation of Irish and US returns is negative on four occasions, and is generally much lower, on average, than the other correlations. Nonetheless, by the end of the sample, a co-movement in this and the other correlations is also apparent.

What might account for the changing patterns in these correlations? In the case of UK and Irish returns, the decline is particularly noticeable in the period after the First World War; however, the explanation may lie more in the strengthening independence movement in Ireland at the time. The Irish Easter Rising in 1916 was followed by a struggle for independence which ultimately led to the founding of the Irish Free State in 1922. The turmoil of this struggle, alongside the (albeit slow) decoupling of the economies following Irish independence, may account for the lower correlation in that period. Furthermore, the increasing correlation of the US and UK returns could reflect an increasingly

globalised financial market characterised by ever-improving communications and more integrated macroeconomic activity.

2.4.5 The role of the exchange rate

So far, US stock prices have been measured in Sterling to make them comparable to the UK and Irish prices. However, this assumes that a change in the exchange rate has the same effect on UK and Irish returns as a change in the US equity market, which need not be the case. Furthermore, it is possible that the stability provided by the gold standard resulted in greater capital flows and a higher correlation of returns in UK and US markets, than those periods when the dollar-sterling exchange rate was floating, as it was at the start of the sample until the US joined the gold standard in 1879, for short periods during the 1910s and 1920s, and following the breakdown of the gold standard in 1931. It is interesting, therefore, to include the exchange rate as a separate variable in the mean equation, while including US returns in dollars.[33] The results are reported in the Table 2.3.

Interestingly, in the UK equation the coefficient on the first lag of the exchange rate is significant while the second lag of dollar-denominated US returns becomes insignificant. In contrast, the exchange rate is not significant in the US or Irish equations.

Overall, this suggests that the exchange rate is having an effect on UK returns that is independent of developments in the US stock market, but that there is no similar effect in the US or Ireland. Nonetheless (and perhaps unsurprisingly given the high correlation between the dollar and sterling-denominated US returns series reported earlier), including the exchange rate in this manner has little effect on the correlations, which are therefore not reported here.

2.4.6 Weighting of indices

The importance of the construction of series has already been discussed. The early part of the UK series is unweighted, which may have an impact on the results. Here I use the alternative market capitalisation weighted series that splices data from the Banker's

[33] Alternatively, a dummy can be defined that takes the value of 1 when the exchange rate is floating and 0 otherwise. This gives very similar results to those in Table 2.3 in terms of coefficient size and significance, and the dummy is only significant in the UK equation. Since this method does not include information on the variation in the exchange rate when it is floating, the method report above is preferred, and the results using the dummy are not reported here.

magazine (which includes bonds/fixed income securities) into the series instead of the Smith and Horne (1934) data. The Banker's magazine data are only available from 1906 onwards, shortening the sample period.[34]

The results are presented in Table 2.4; including these data does not change the significance of the coefficient estimates in either the mean or ARCH equations. In terms of the correlations, however, while the general pattern is similar, the estimates using these data indicate a much higher correlation of returns in the UK and in Ireland in much of the period up to the First World War (Figure 2.5). There is a similar effect on the correlation of the UK and US returns in the period, and also, a higher correlation in the period leading up to 1929, although again, the overall pattern of the correlation is similar to when weighted data are used (Figure 2.6).

2.5. Conclusions

This Chapter has analysed the role of UK stock markets in the international transmission of equity returns and volatility over the period 1871-1939. The degree of market integration at this time has been discussed in previous literature. Here, the increasing influence of US stock markets at this time proxies for the greater global forces at work, while the paper also considers the influence of the UK market on its smaller, near neighbour in Ireland.

As such this Chapter has presented a first and preliminary analysis of the behaviour of UK, Irish and US stock prices, with the aim of understanding the joint behaviour of returns. The Chapter first analysed some descriptive statistics of the series, which suggested that volatility was highest in the US and lowest in Ireland. Combined with narrative evidence, and findings in studies such as Goldstein (2015), Chakrabarty *et al.*, (2011) and Greenwald and Stein (1991), this suggests that the UK market may have been less liquid than that in the US, but more liquid than that in Ireland.

The Chapter then analysed the joint behaviour of the returns in a multivariate DCC-

[34] There is an additional gap in this index, in July 1906, which leads to two missing data points in July and August of that year in the returns series. This is dealt with in the same manner as the gap for the First World War, discussed in Section 2.4.2.

GARCH model. The results from the model indicate that global shocks, proxied by US returns, impact on UK returns, but not *vice versa*. This result suggests that the UK was subject to global shocks, rather than a driver of global equity prices. The result is robust to changes in the exchange rate.

However, there is clear evidence that UK stock returns impact on Irish stock returns. Since there is little evidence that events in the US play an important role in determining Irish stock returns, it appears there is a structural relationship between Ireland and the UK, reflecting close political and economic links.

Furthermore, while developments in the UK market continued to have a role in Ireland throughout the period, the correlation between the UK and Irish returns declined through the period. This decline in influence coincides after the Easter Rising in 1916, during which Irish independence was increasingly asserted, and the Irish economy became less integrated with that of the UK.

Conversely, UK returns became increasingly correlated with global factors, evidenced by increasing correlation with the US returns. The result is that the correlations converge over time, suggesting that perhaps markets became more integrated through time. Finally, since historical stock market data is subject to a number of methodological differences, I discuss the effect of this as it relates to the weighting of individual stocks in the index. It appears that the overall pattern of the estimated correlations is not changed by the weighting of the stocks although differences do occur, particularly in periods of heightened activity or uncertainty.

In terms of the broader literature which discusses the degree of integration that was present in financial markets during this period, these results suggest that while large markets (the US and UK) may have been integrated at the global level, Ireland was less integrated and tended to still be influenced by the UK.

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Table 2.1: Descriptive statistics, monthly returns, 1871-1939

	Average return			Variances		
	UK	Ireland	US	UK	Ireland	US
Full sample	0.025	0.062	0.115	5.955	1.810	20.510
1871-1888	-0.040	0.140	0.076	5.155	1.222	9.082
1889-1905	0.206	0.082	0.313	4.208	0.760	11.281
1906-1922	0.015	-0.109	-0.023	5.092	2.978	12.552
1923-1939	-0.082	0.092	0.125	9.515	2.351	50.590

Table 2.2: Trivariate results for monthly returns denominated in Sterling, 1871M2-1939M8

	Dependent variable		
	UK returns	**Irish returns**	**US returns**
Lagged IE returns	0.066	0.046	-0.352***
Lagged UK returns	0.063	0.037*	-0.019
Lagged US returns	0.068***	0.014	0.390***
Twice lagged IE returns	0.048	-0.014	0.051
Twice lagged UK returns	0.066	0.038*	0.029
Twice lagged US returns	-0.030	-0.012	-0.123***
Constant	0.059	0.067	0.266**
Variance Equations			
Lagged residual squared	0.127***	0.468***	0.163***
Lagged GARCH term	0.846***	0.340***	0.779***
Constant	0.053***	1.227***	0.941***
Adjustment			
Alpha	0.015***		
Beta	0.974***		

Notes: ***, ** and * indicate significance at the 1%, 2.5% and 5% levels respectively.

Table 2.3: GARCH Results, Dollar denominated US returns, 1871M2-1939M8

Variables	UK returns	Irish returns	US returns
Lagged IE returns	0.040	0.039	-0.327***
Lagged UK returns	0.067	0.038*	-0.009
Lagged US returns	0.066***	0.012	0.377***
Lagged exchange rate	0.165***	0.079	0.154
Twice lagged IE returns	0.022	-0.022	-0.003
Twice lagged UK returns	0.061	0.038*	0.035
Twice lagged US returns	-0.019	-0.008	-0.118***
Twice lagged exchange rate	0.044	0.025*	0.041
Constant	0.072	0.067	0.282**
Variance Equations			
Lagged residual squared	0.470***	0.124***	0.182***
Lagged GARCH term	0.350***	0.849***	0.761***
Constant	1.159***	0.052***	0.989***
Adjustment			
Alpha		0.015***	
Beta		0.975***	

Notes: ***, ** and * indicate significance at the 1%, 2.5% and 5% levels respectively.

Table 2.4: GARCH Results, Weighted Banker's Magazine data, 1906M2-1939M8

Variables	UK returns	Irish returns	US returns
Lagged IE returns	0.023	-0.019	-0.363***
Lagged UK returns	-0.044	0.132***	-0.111
Lagged US returns	0.113***	-0.006	0.452***
Twice lagged IE returns	0.007	-0.057	0.121
Twice lagged UK returns	0.092	0.081**	0.139
Twice lagged US returns	-0.047	-0.022	-0.139**
Constant	0.003	0.026	0.214
Variance Equations			
Lagged residual squared	0.166***	0.096***	0.163***
Lagged GARCH term	0.825***	0.888***	0.823***
Constant	0.082	0.047	0.513*
Adjustment			
Alpha		0.038	
Beta		0.896****	

Notes: ***, ** and * indicate significance at the 1%, 2.5% and 5% levels respectively.

Figure 2.1: Stock prices in log levels, January 1871=100

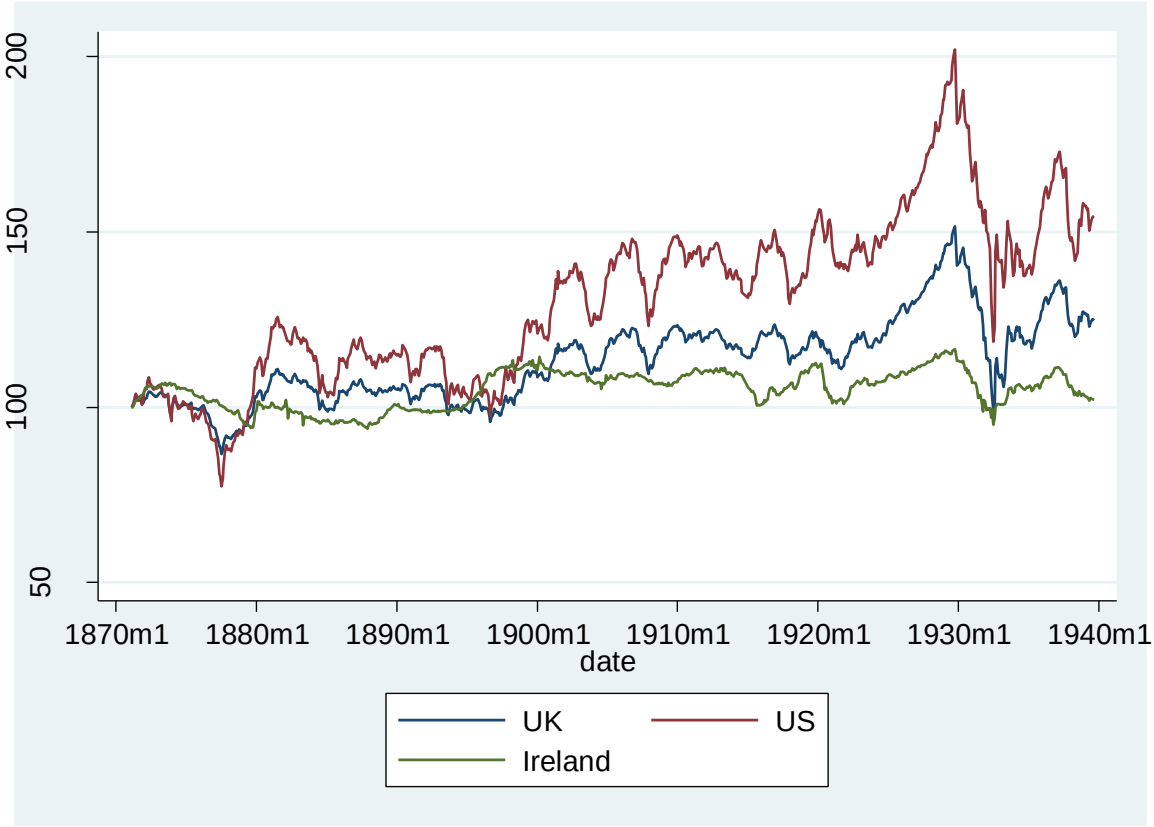
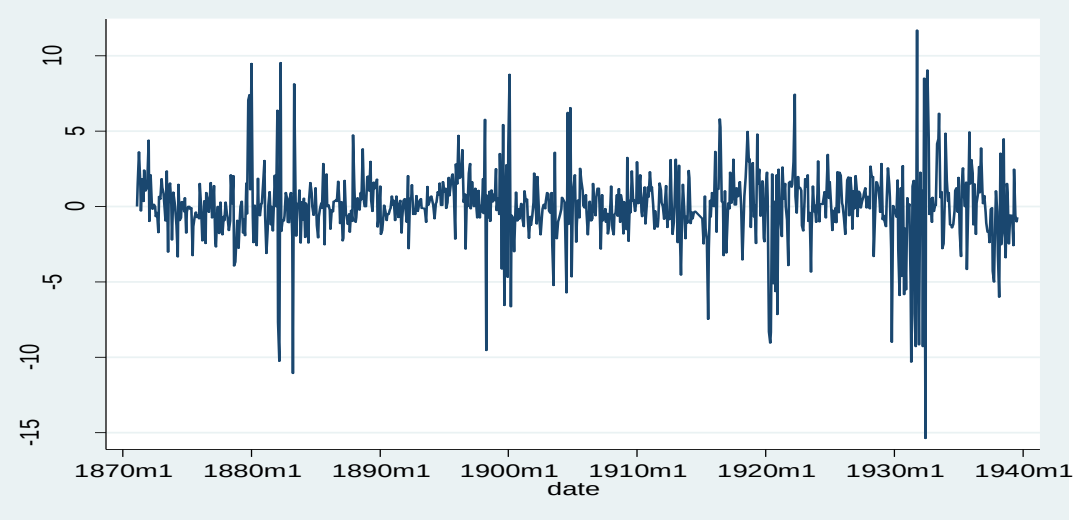
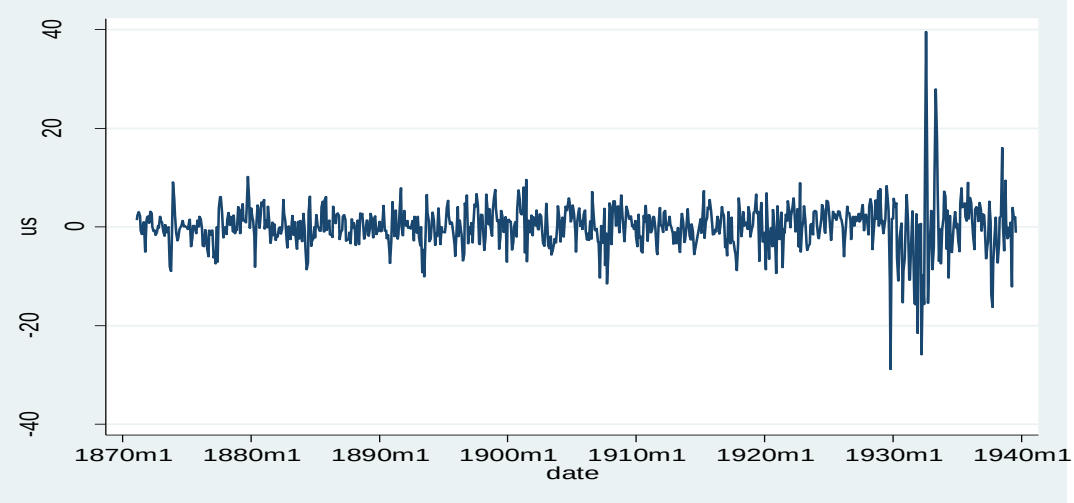


Figure 2.2: Stock returns in the US, UK and Ireland

(a) UK



(b) US



(c) Ireland

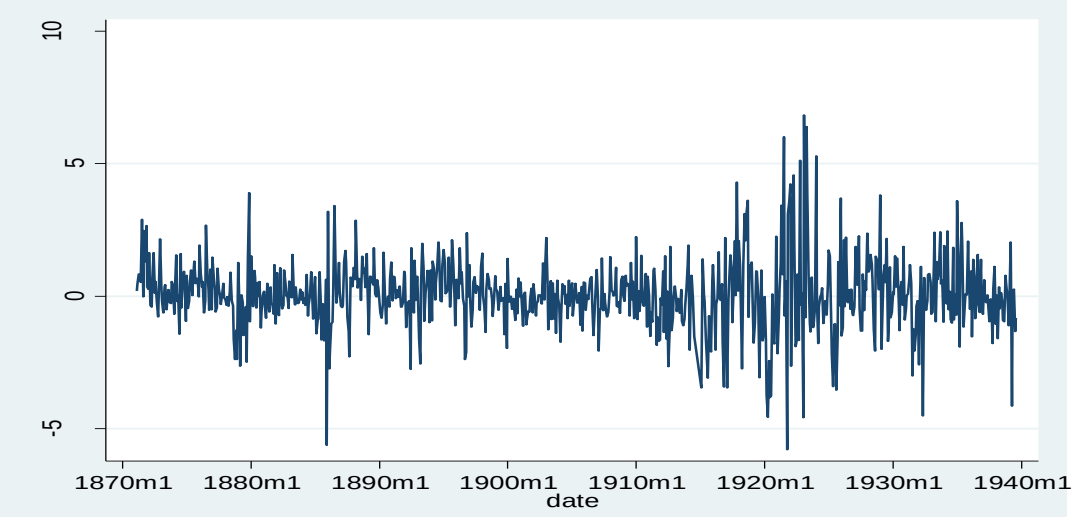


Figure 2.3: Variances estimated from trivariate GARCH

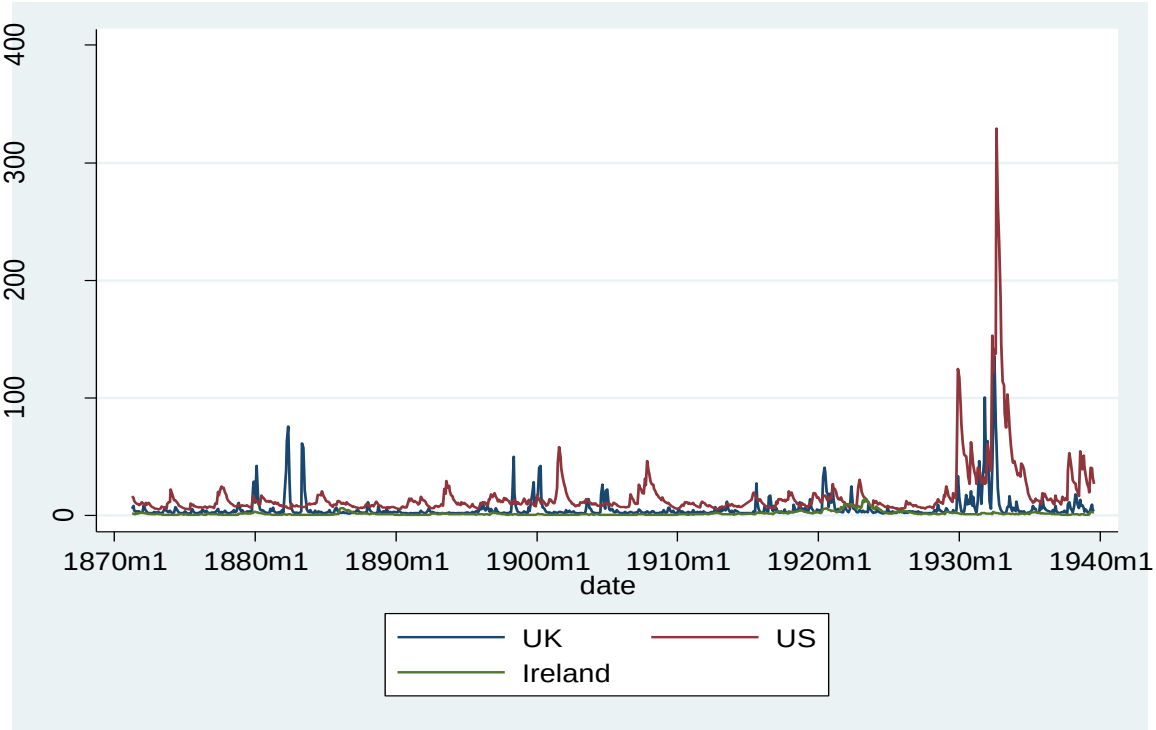


Figure 2.4: Estimated correlations estimated from trivariate GARCH

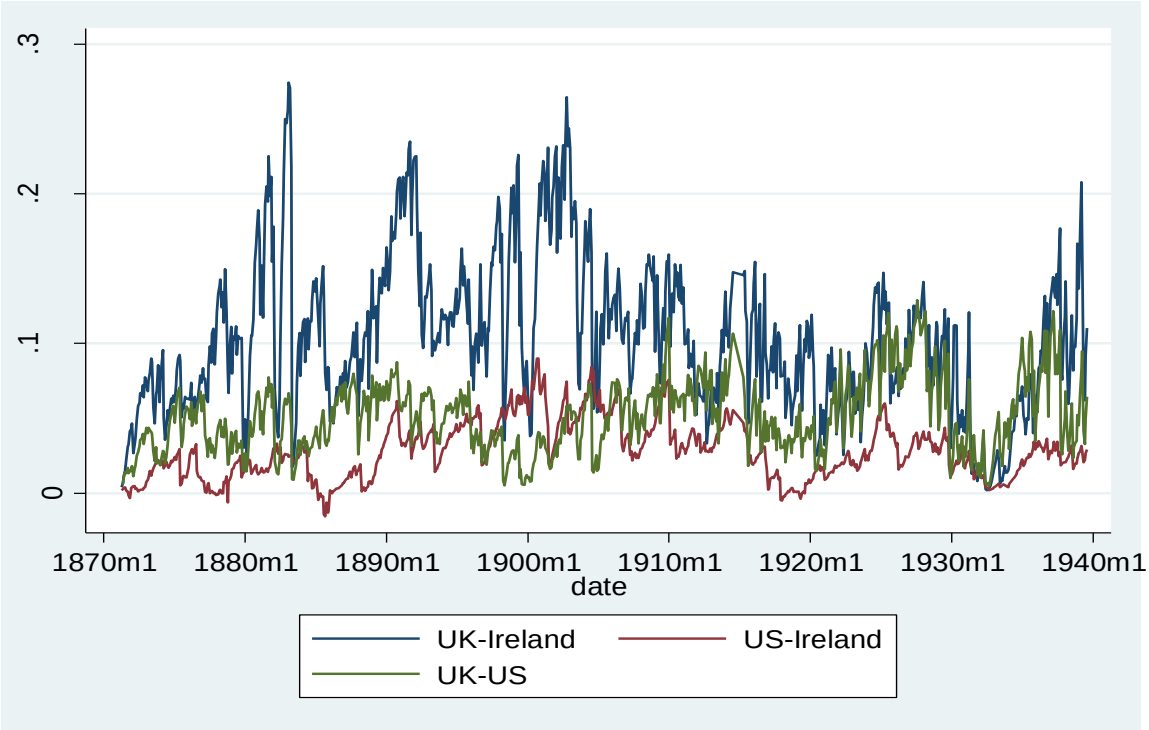


Figure 2.5: Estimated correlations with weighted UK data, UK-Ireland

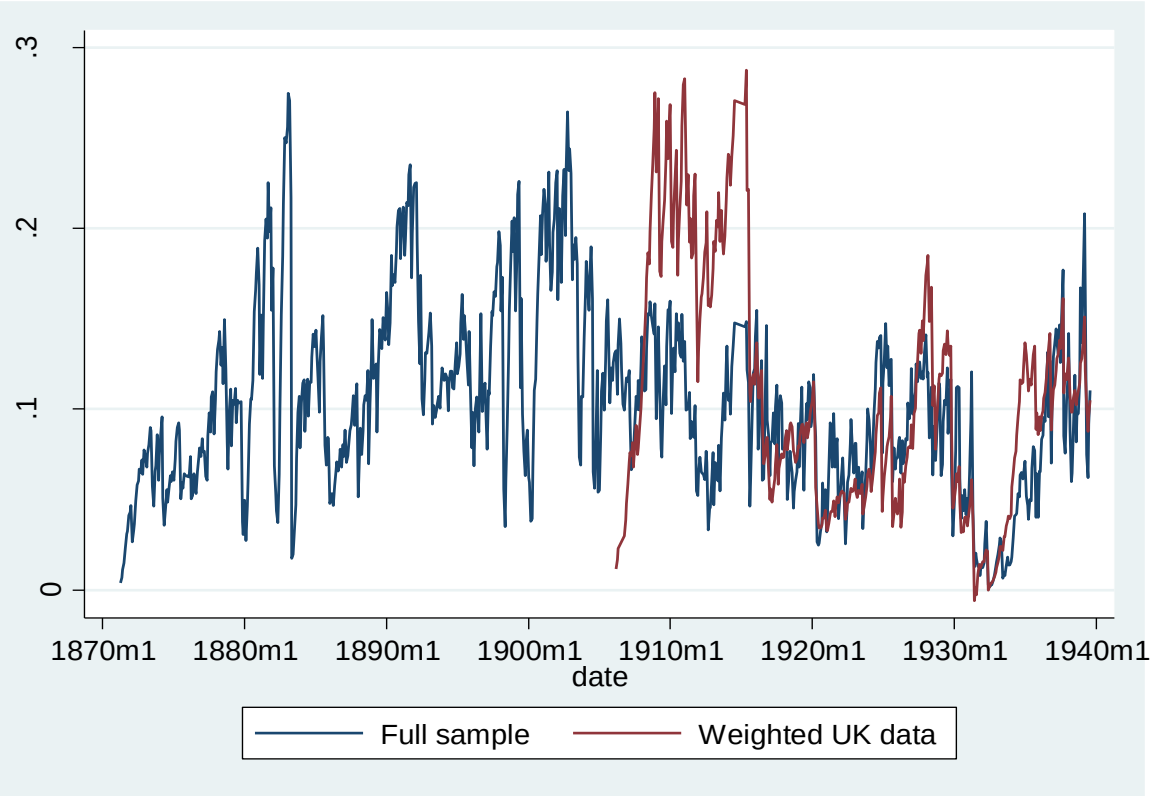
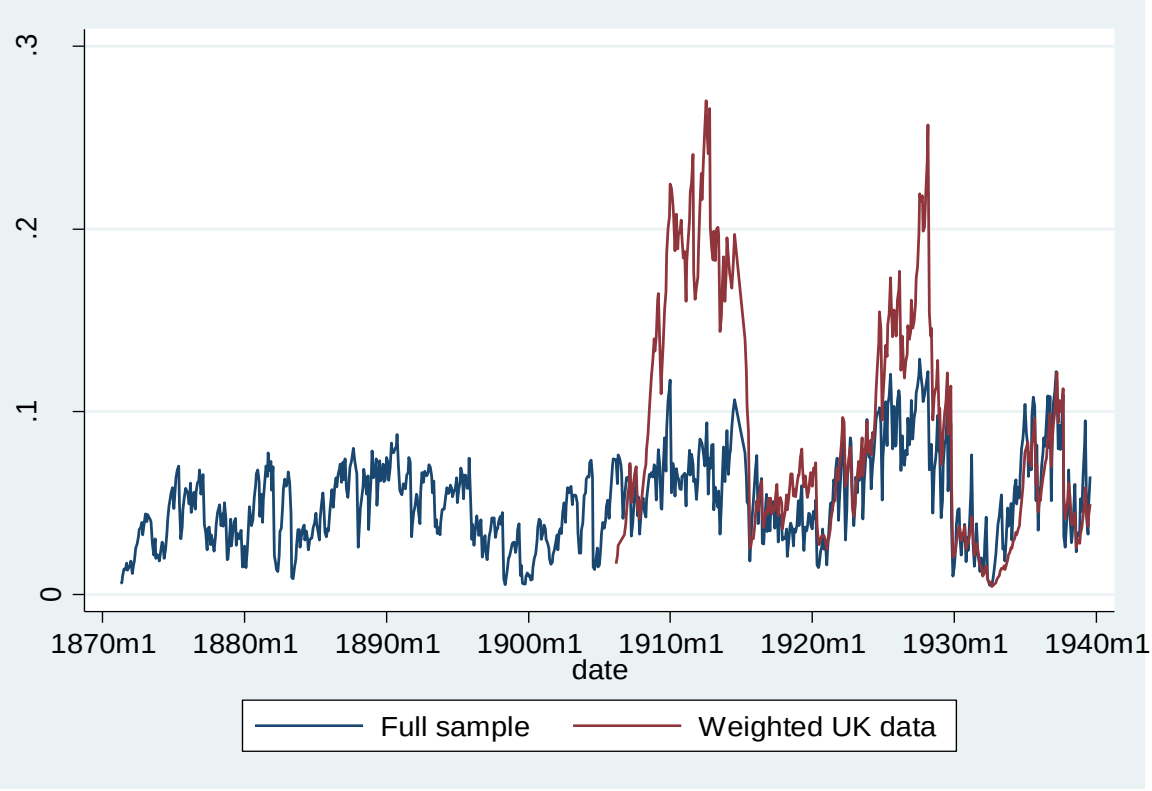


Figure 2.6: Estimated correlations with weighted UK data, UK-US



Chapter 3

International stock market co-movements during the Gold Standard

3.1. Introduction

This Chapter examines global stock market co-movements in Belgium, France, Germany, Ireland, the UK and the US during the classical gold standard, 1879-1913. This period has been referred to as the 'first era of globalization'[35], during which the stability and convertibility of the gold standard enabled large sums of capital to flow across borders.[36] Indeed, it has been argued that capital flows and financial integration were similar, if not greater, during this period than more recent times.[37] Since countries at this time were linked through international trade, capital flows, foreign direct investment and through the fixed exchange rate regime imposed by the gold standard, it is interesting to consider whether the co-movements of their stock markets ted at this time.

Stock price co-movements can arise from a variety of sources, including common shocks such as oil price movements, trading in the same, or closely-related securities across

[35] See Bordo and Meissner (2015).
[36] See Obstfeld and Taylor (2005).
[37] See discussion in Baldwin and Martin (1999).

different markets and the existence of international investors operating in two or more markets. A number of studies have attempted to measure stock market co-movements using various methods on modern data, including Pukthuanthong and Roll (2006), Chambet and Gibson (2008) and Bekaert and Harvey (1995). However, although studies have shown that some financial markets have been integrated on a bilateral basis from at least as far back as the first half of 18th century[38], with some exceptions,[39] few studies have examined integration in historical stock market data across a number of countries.

As a result, a number of questions are unanswered, including: How does the correlation between stock price indices vary through time? Were there common shocks that affected indices in all countries, or in subsets of countries? Was exposure to such shocks compensated for by higher returns? Using stock price data for the Belgium, France, Germany, Ireland, the UK and the US, this Chapter first studies returns and their correlations across countries.

These correlations indicate that the geographical proximity and common languages of stock exchanges does not predict the correlation of indices. Furthermore, average correlations are growing over time. Together, these point towards the existence of an increasingly integrated globalised financial market.

However, the pair-wise correlation of returns is just one way of looking at the co-movement of markets. The Chapter next presents principal component analysis to determine whether indices were subject to a global shock. This analysis indicates that the first principal component, which explains almost a third of the variance in stock returns, moves all indices in the same direction. As such, I consider this a global shock, and discuss the exposure of the different countries to it. Moreover, the second principal component appears to be a 'Continental European' shock, which moves equity returns for Belgium, Germany and France relative to those in Ireland, the UK and the US.

The strong co-movements of equity returns can be interpreted in two ways. They can be seen as *transmission* or *contagion* of a shock from one country to the others, perhaps

[38] Neal (1987) studies the capital market between London and Amsterdam in the early eighteenth century and concludes that they were efficient and integrated from the second quarter of that century onwards.

[39] See, for instance, Triner and Wandschneider (2005).

through economic fundamentals such as trade linkages. Alternatively, they can be thought of as reflecting *common shocks* that affect returns in all countries at the same time. Unfortunately, it is not entirely clear which of these two interpretations is driving the observed correlations. In this sense, the analysis here documents empirical regularities in the data without proposing a structural explanation for them.

I next turn to the issue of whether markets that are more vulnerable to the global shock offer less diversification benefits and are therefore riskier. I therefore consider the returns on indices in light of exposure to the shock. I find that higher co-movement of equity returns in a country with this global return component is associated with higher returns. This indicates that investors required greater return in exchange for reduced diversification, as theory would suggest.

Finally, I conduct a VAR analysis which indicates that the global shock has significant effects on returns in all economies, and that the second, 'Continental European' shock has a significant effect on returns in five of the six economies.

As such, this Chapter fits into the literature examining stock price co-movements and market integration and provides a comprehensive comparative study of the integration of stock markets during the gold standard. Furthermore, in showing that a global shock existed, the Chapter adds to the literature which suggests that financial markets were well integrated during the gold standard era.

The Chapter is structured as follows: The next section first discusses how market integration might arise, focussing on theory and the transmission channels that were present during the period of this study. It then discusses how financial market integration has been measured in the literature. Section 3.3 outlines the historical background of the indices used in this study, and discusses the data and some descriptive statistics, including correlations. Section 3.4 sets out the principal component analysis, discussing the identification of the global shock, looks at the risk-return trade-off with specific reference to exposure to this shock, and presents the VAR analysis. Section 3.5 concludes.

3.2. Co-movements of stock returns

3.2.1 Dividend discount model

Next I turn to the question of why equity returns co-move across countries. The price of a stock, P_t, is equal to:

$$P_t = \frac{D_t}{1+r} + \frac{E_t P_{t+1}}{1+r}$$

Where D_t is the dividend at the end of the current period, $E_t P_{t+1}$ is the expected price next period, and r is the required return, which is given by the sum of a risk free interest rate and a risk premium.

Repeatedly substituting for $E_t P_{t+1}$ gives us:

$$P_t = \sum_{k=0}^{\infty} \left(\frac{1}{1+r}\right)^{k+1} E_t D_{t+k}$$

The stock price today thus depends on three things: the risk free interest rate, the risk premium, and the expected future stream of dividends.

This simple expression shows that stock returns might co-move across countries for several reasons. First, the risk free rate could shift across a number of countries at the same time. For instance, this could arise if there is a change in the perceived economic growth outlook across a number of countries.

Second, stock prices could co-move if there is a reappraisal of risk premia across countries. This could occur because of an adverse event in one country, such as a bank failure, or in a number of countries that raised investors' risk perceptions.

The third possibility is correlations in the expected path of future dividend payments. Since corporate profits, and therefore dividend payments, are likely to be positively correlated with general economic activity, business co-movements may lead stock returns to be correlated across countries.

3.2.2 Causes of co-movements in stocks

A number of studies of modern data have examined the determinants of co-movements in stock prices and identified a number of transmission channels, including economic fundamentals, financial market integration, policy uncertainty and contagion. For instance, Becker, *et al.*, (1995) demonstrate that US macroeconomic news spills over in to the UK market.[40] Didier *et al.*, (2012) examine the co-movement of US stock returns with those in 83 other countries during the 2007-2008 financial crisis, concluding that it was largely driven by financial linkages. Ko and Lee (2015) find that stock price movements and economic policy uncertainty generally exhibit a negative relationship. Hwang *et al.*, (2013), compare stock returns in emerging market economies with those of the US during the recent financial crisis, and provide evidence of contagion and herding behaviour.[41]

These effects are predicated on the free flow of capital across borders. Obstfeld and Taylor (2005, p. 25), argue that between 1870 to the First World War 'the first age of globalization sprang forth'. They point to the role of the gold standard in driving a convergence in interest rates across countries and the consequent increase in capital flows. Furthermore, Baldwin and Martin (1999) present a number of measures of capital mobility and financial market integration and argue that capital mobility was perhaps higher during this period than in recent decades.

Indeed, Sylla, *et al.*, (2006) note that as early as 1803 to 1804 almost half of US securities were owned by foreigners. Furthermore, as one of the earliest participants in the Industrial Revolution, Belgium had many heavy industries which were funded by the financial sector. The reputational effect of this led to large capital flows into Brussels, which in turn enabled further large investments abroad with the result that, by the First World War, Belgium was one of the biggest foreign direct investors per capita (Chlepner, 1930).

[40] On the other hand, other studies such as King, *et al.*, (1994) find that observable economic data do not explain much of the co-movement across 16 national stock markets.

[41] Similarly, Grammatikos and Vermeulen (2012), analyse the stock market returns in the EMU from 2003 to 2010. They find that financial stocks became significantly more dependent on changes in the spread between the Greek and German CDS during the heightened uncertainty in the wake of the collapse of Lehman Brothers in September 2008.

In terms of trade links, Campbell and Rogers (2015) find that market integration between the US and UK was weak during the period 1825-1925 when stocks of domestically-oriented firms are examined, but that integration increases when stocks of export-oriented companies are examined. Similarly, Grossman (2014) presents data on quantity, capital gains, dividends, and total returns for domestic and overseas equities listed on the London Stock Exchange during 1869-1928, and finds that the returns of firms in more industrial markets were more correlated with each other and with developing regions with which they had substantial colonial or trade connections.

Furthermore, trade links between the countries in this sample were strong during this period. For instance, throughout the sample period, Ireland was part of the UK with the result that the UK accounted for the overwhelming majority of Irish exports.[42] Similarly, despite geographic distance, the US was the UK's main trading partner throughout much of the period: Campbell and Rogers (2015) cite data from Mitchell's European Historical Statistics when noting that from 1854, when the first data was reported, to at least 1925, the UK imported more from the US than from any other country. The same source[43] indicates that there were strong trade links between Belgium, France, Germany and the UK throughout this period, although none so one-sided as that between the UK and US and the UK and Ireland.

Finally, the period under review is marked by the first era of modern communications, with the telegraph in widespread use. Transatlantic communication was possible following the completion of the first cable by the Atlantic Telegraph Company in 1866, making almost real time communication possible with even the most remote of the countries in this study, the US. Hoag (2006) uses an event study analysis on one security with a dual listing on the London and New York exchanges from the time that the cable became operational to show that the information lag decreased from 10 days to zero. Michie (1987) notes that the overlap in the daily range of prices of two railway stocks listed on both the London and New York stock exchanges overlapped just 8.5 per cent of the time in 1860, and that the average differential in prices when there was no overlap

[42] Indeed, following independence in 1922, this relationship continued. Barry and Daly (2011, p.1) report that at this time Ireland traded 'almost exclusively with the UK'.
[43] Specifically, Mitchell (1980).

was 4.8 per cent of the average price. By 1870, this time using US government bonds, the daily price range of the two exchanges overlapped 73.6 per cent, and the average differential when they did not overlap was 0.52 per cent of the average price.

By reducing information asymmetries, these innovations in communications will have aided international market price co-movement. This is illustrated in a study by Triner and Wandschneider (2005), who examine the role of international markets in the Brazilian financial crisis of 1890/91. They argue that the behaviour of markets during that period is a precedent for the contagious financial crises that emerging markets faced at the end of the 20th century.

3.2.3 How can stock market co-movements be measured?

Next, I turn to the issue of measuring such co-movements, for which a variety of methods have been used. One method is to consider the correlation of stock returns, thus capturing the co-movements in them. For instance, Goetzmann *et al.*, (2005) use data on stock markets from around the world, generally beginning in the first half of the 20th century or later, to calculate correlations in stock price movements. They show that correlations were relatively high in the pre-World War 1 era and interpret this as evidence of integration. Campbell and Rogers (2015), focus on the r-squared from a regression of two indices on each other, arguing that this indicates how much of the movement one index is 'explained' by the other.[44]

An alternative approach uses generalized autoregressive conditional heteroscedasticity (GARCH) methods, which allow for the heteroscedasticity which is common in financial data, to estimate the co-movement of returns and volatility across markets. For instance, Stuart (2015) uses a multivariate GARCH framework to study the co-movements of the UK, US and Irish stock markets during the period 1870 to 1939. Similarly, Choudry (1994) employs an integrated GARCH model to study the persistence of stock return volatility of European indices during the 1920s and 1930s, finding that shocks to volatility are permanent for most indices.

[44] See also Schotman and Zalewska (2006) for a similar study of the integration of emerging European economies and developed economies using modern data.

Other studies of modern data seek to establish when market integration occurs. For instance, Lahrech and Sylwester (2011), estimate smooth transition GARCH models to identify the increase in integration between Latin American markets over the period 1988 to 2004, finding that increased integration is associated with economic liberalisation and trade. Bekaert, Harvey and Lumsdaine (1998), apply break point tests on reduced form financial and macroeconomic time series models using data for 20 emerging economies to determine when financial markets become more integrated. Bekaert and Harvey (1995) use a conditional regime-switching model to study periods of integration among capital markets using data on 21 developed and 12 emerging economies since the late-1960s and early-1970s.

Other methods consider whether there are common shocks driving returns across indices. In this framework, a common shock is identified and then the co-movement of each index with this shock is interpreted as indicating its level of market integration. A particularly relevant study in this context is that of Pukthuanthong and Roll (2009). Using data on a large sample of countries from the 1970s to the 2000s, the authors use principal component analysis to identify global shocks. They then estimate the vulnerability of each index to the identified shocks. A similar approach is taken in this Chapter. While a large number of modern studies use such methods[45], few historical studies have employed them[46], possibly because factors can only be estimated in a comparative study including a number of indices.

3.3. The data

3.3.1 Background

This Chapter uses stock market data from six countries: Belgium, France, Germany, Ireland, the UK and the US. I first briefly discuss the origins of each exchange in turn.

[45] See, for instance, Chambet and Gibson (2008), Bekaert and Harvey (1995) and Bekaert, Hodrick and Zhang (2005).

[46] Edelstein (1982) employed such methods in a cross-country and cross-industry study of company returns.

The Brussels stock exchange developed relatively early by international comparison, as a result of Belgium's participation in the industrial revolution.[47] Initially, the government played a central role in determining access to the exchange: it authorized which firms gained limited liability, and it could ban a company from trading on the stock exchange. However, these rules were relaxed in 1873, when the Company Reform Act removed the requirement for government authorization in the limited liability process, leading to an increase in the number of firms listed.

The French data pertain largely from the Paris exchange.[48] From the second half of the 19th century, official stock markets in Paris were highly regulated and were operated by the 'Compagnie des agents de change' (CAC). The number of official stockbrokers, or 'agents de change', was limited to around 60, and each had to be approved by the Minister of Finance and appointed by decree of the President of the Republic.

It was not until 1896, and the passing of *The Stock Exchange Act*, that exchanges were regulated at a national level in Germany.[49] Nonetheless, the Frankfurt stock exchange had its origins in the 11th century, with a bourse founded in 1585. Similarly, the Berlin exchange had been in existence since a decree from 1796, while there was also the small but growing exchange in Hamburg.

Despite being a part of the UK throughout this period, Ireland had a number of stock exchanges.[50] Primary among them was the stock exchange in Dublin which was established in 1793 and legally recognised through the *Act for the Better Regulation of Stockbrokers*, 1799. Other, smaller exchanges were subsequently established in Belfast and Cork.

In the UK, the London Stock Exchange has its origins in London coffee houses of the 17th century.[51] In 1773 brokers erected their own building in Sweeting's Alley, with a dealing room on the ground floor and a coffee room above. However, it wasn't until 1801 that a

[47] See Annaert, Buelens and Deloof, (2012) for a detailed discussion of the development of the Belgian exchange.
[48] See Hautcouer and Riva (2012) for a discussion of the details of the Paris stock exchanges.
[49] See Bersch and Kaminsky (2008) for a discussion.
[50] See Thomas (1986) for a discussion of the Irish stock exchanges.
[51] See Smith (1929) and Michie (2001) for a discussion of the early years of the London Stock Exchange.

formal membership subscription was required and the first regulated exchange, the Stock Exchange, was established.

The first stock exchange in the US was established in Philadelphia in 1790, however, this was later surpassed by the New York Stock Exchange, which was established in 1792 under the Buttonwood Agreement which was signed by 24 stockbrokers, and it began trading five securities. [52]

3.3.2 Data sources

In this section, the data used in the analysis are described. All countries for which monthly stock price indices could be located over the 35-year period 1879-1914 are used in this study. In total, I have found six countries for which data are available for the entire sample period.[53]

Belgian data are from Annaert, Buelens and Ceuster, (2012), and are price weighted, nominal returns without dividends for each month. French data are available from Le Bris and Hautcoeur (2010), and are a market capitalization weighted index of the top 40 stocks rated by market capitalization on French exchanges each year. The German data are taken from the NBER macrohistory database, and is composed of two separate series spliced together. These series are described as: an unweighted index of representative stocks for the period 1871-1889 and a weighted index of a larger number of stock for the period 1890-1913. Irish data are taken from Grossman *et al.*, (2013), and are market capitalization weighted. Data for the UK are from Smith and Horne (1934).[54] This is a monthly, unweighted share price index. For the US, the data are the Common Stock Price Index compiled by the Cowles Commission obtained through the St Louis Federal Reserve Economic Data (FRED) website. The data are, in general, arithmetic averages of

[52] See Michie (1987) for an in-depth account of the New York Stock Exchange up to the First World War, and Rappoport and White (1994) for a discussion of the 1920s and 1930s. The Library of Congress business reference service and NYSE.com provide a chronology of the exchange.
[53] Data for a seventh, Sweden, is available from 1906 on.
[54] Taken from Hills *et al.*, (2015) *Three Centuries of Data* spreadsheet on the Bank of England's website: http://www.bankofengland.co.uk/research/Pages/onebank/threecenturies.aspx

the highest and lowest prices of the month weighted by the number of shares outstanding at the end of the month.[55]

As historical data series, the indices used here are taken from a number of different sources, with construction often differing accordingly. One issue is that of the weighting of indices: an index can be a simple average of all stocks (referred to as 'unweighted average', or simply 'unweighted'[56]), or it can be weighted in a number of different ways, most commonly by market capitalization of the individual stocks.[57] An interesting example of the impact of weighting can be taken on the Irish data series, since both a weighted and unweighted series are available for exactly the same sample of stocks over the entire period. The correlation coefficient on the two indices over the period 1879 to 1914 is 0.82. Moreover, the correlation coefficient on the month-on-month changes in the two indices is 0.55. It is useful to consider how often the two series move in the same direction: in 70% of months both series either rise or fall.

In addition, the selection of companies included in the indices may differ. Of course, this can reflect differences in the predominant industries in different countries. However, when indices are compiled, they often include only a sample of companies. For instance, the Smith and Horne index focuses on industrials, and therefore does not include some of the largest companies at the time. In addition, the French index used here is a blue chip index, which the others are not. Similarly, stocks included in an index may be chosen because a time series of data is available for them. This can lead to survivorship bias whereby failed firms are under-represented in the index. The Smith and Horne index is subject to this bias. Both of these issues are likely to lower the correlation between indices, and bias any econometric analysis towards finding insignificant results, although it is interesting to note that Campbell and Rogers (2015), find little role for firm size and industry in explaining co-movements in UK and US equities over the period to 1925.

When analysing shocks across countries to stock prices, the level of co-movement can be exacerbated by dual listing of companies on a number of exchanges. Campbell and

[55] For more information, see Moore (1961, p.24). This series is widely used in the literature, see for instance, Shiller (2005).
[56] Although in principle a simple average implies that the stocks are 'equally weighted', this method is generally referred to 'unweighted' in the literature.
[57] See Grossman (2002) for a discussion of some issues that may arise with unweighted data.

Rogers (2015) find strong co-movement between stocks co-listed in New York and London. While this feature is likely to raise the correlation of the series, it is important to note that dual listings are a feature of modern indices as well.[58] Furthermore, it is not possible to obtain the underlying stocks for all the series in this sample in order to remove cross-listings.

Finally, exchange rate movements can affect stock prices in different countries. However, the countries analysed here were all on the gold standard during the period covered in this study. The US was the last of these countries to join the gold standard, doing so in 1879. Prior to this, France and Belgium joined in 1878, Germany joined in 1871, and the UK was on the gold standard continuously from 1821.[59] As such, the exchange rate does not play a role during the sample period.

3.3.3 Descriptive statistics

Figure 3.1 shows the series in log levels indexed to 100 in January 1879. The figure shows that the indices often moved differently across countries. Some indices displayed strong growth at certain points in the sample period, while others had sluggish growth throughout. For instance, Germany and the US indices grew rapidly at the start of the sample period. The UK and US indices grew quickly in the late-1890s and Belgian in the early-1900s. By contrast, the Irish and French indices barely grew over the sample period.

These periods of large increases in the levels of the series are naturally also visible in the growth rates of the series, displayed in the six panels of Figure 3.2, which shows the returns on the indices.[60] The volatility of the series is also readily apparent in Figure 3.2 (note that the vertical axes differ in the panels). Interestingly, with the exception of some outliers, while the series for Belgium, France and Germany generally move within a range of +/-5%, the Irish and UK series are less volatility, with most monthly returns in the

[58] See Pagano *et al.,* (2001) and Fernandes and Ferreira (2008) for discussion on the motivations for, and benefits of, cross-listing in modern exchanges.
[59] For further information on countries using the gold standard, see for instance, information from Lawrence Officer on https://eh.net/encyclopedia/gold-standard/.
[60] It is not clear if all series exclude dividends in the calculation of index. However, since dividends tend to be very stable over time, they are expected to have little effect on variations in the returns series.

region of +/-3%, but the US series is much more volatile with monthly price changes often in the region of +/-8%.[61]

Average returns and variances are presented in Table 3.1. Average monthly returns are highest in the US, Germany and the UK, and lowest in France and Ireland. In terms of variance, the US returns exhibits the highest variance; twice as high as that for any other index. The Irish return has the lowest variance by far, at less than half that of the French market, the second least volatile. Table 3.1 also presents the results for three sub-sample periods, 1879-1890, 1891-1902 and 1903-1914. Interestingly, volatility of the German returns is much higher in the first subsample (during which the index grew very strongly), and is in fact similar in magnitude to that of the US. Volatility in the UK is also higher in this period, driven by the large swings in returns in the early-1880s. While the volatility of the German, French, UK and Irish returns declines in each subsequent sub-period, the volatility of US returns rises in the second subsample, before declining marginally in the final subsample. The volatility of Belgian returns declines in the second subsample before rising again in the third, as returns were high in the early-1900s.

The final row of Table 3.1 contains the coefficient of variation, which is measure of the risk-return trade-off in each market, for the full sample period.[62] Calculated as the standard deviation divided by the mean, a lower 'coefficient of variation' implies a more attractive trade-off of risk and return. Interestingly, the Irish and French markets have the highest coefficients of variation, implying that their low variance does not compensate for their exceptionally low returns. In contrast, the German market has the lowest coefficient of variation, suggesting it has the most attractive risk-return trade-off.

3.3.4 Correlations

Table 3.2 presents correlation coefficients for the returns. Over the entire sub-sample, returns in Belgium and Germany are the most highly correlated (0.38). Intuitively, this may be expected due to their geographical proximity. However, interestingly, the correlation of returns in Belgium with those in France, another close neighbour and one with whom there was no language barrier, are the lowest (0.09). With the exception of a

[61] The collapse of l'Union Générale in 1882 is clearly evident in the French data.

[62] The coefficient of variation is only included for the full sample period in Table 3.1 since sub-period average returns are often negative, making the coefficient of variation difficult to interpret.

correlation coefficient of 0.23 with German returns, French returns generally displays low correlation with the other series, and indeed, exhibit a negative correlation with Irish returns over the sample period. As discussed earlier, this may be due to the unusual institutional set-up of the Paris exchange which tended to isolate it. Furthermore, Le Bris (2013) argues that prior to 1914 French investors in foreign assets were mainly attracted by weak correlation between French and foreign assets, rather than higher returns.

The average of each index's pairwise correlation coefficients is reported in the bottom panel of Table 3.2. Interestingly, the US has a high average correlation (0.31), similar in magnitude to those in Belgium, UK and Germany, which all have average correlations in the region of 0.33-0.37. By contrast, returns in Ireland and France have an average correlation with the other markets of approximately 0.25. This suggests that despite geographical distance and differences in language co-movement across markets at the time. Furthermore, looking across the subsample periods, while average correlations do not increase consistently through each subperiod, all countries exhibit higher average correlations by the final subperiod compared to the first subperiod. In particular, the US, Germany and Belgium have average correlation coefficients in excess of 0.40, while the average correlations of Ireland and France are in excess of 0.25, in the final subperiod.

3.4. Global shocks and national equity returns

The correlation coefficients in the previous section indicate that there is co-movement between all the indices in the sample. This raises the question whether there were common shocks driving the co-movement in returns. In this section I first use principal component analysis to identify a global shock, and then look at the importance of this shock in a VAR framework.

3.4.1 Unit root tests

To conduct principal component analysis, the returns series must be stationary. To test that, I use an Elliott-Rothenberg-Stock test. Here, the lag length is selected for the test using the Hannan-Quinn criterion. The test rejects the null of a unit root for all six series at the 1% level (Table 3.3). This result is robust to whether a trend is included or excluded from the test.

3.4.2 Principal component analysis

Principal component analysis helps us understand better how the stock returns move together. It allows us to identify factors, or principal components, which capture the common variance of the series under review. The first principal component is a series that accounts for as much of the variability in the stock returns as possible, while the second component accounts for as much of the remaining variance as possible, and so on.

The results of the principal component analysis are presented in Table 3.4. The first six columns show the factor loadings of the principal components for each of the returns series. The greater the loading on an individual series (relative to the others), the more it co-moves with the principal component. The final row shows the proportion of the variance of all the series that is accounted for by each component.

The first principal component raises returns in all six countries, and can therefore be interpreted as a global growth shock which affects all markets in much the same way. It accounts for almost a third of the variance of all the series and is thus important. The factor loadings in column 1 indicate that the first principal component explains somewhat more of the variance in the German and US returns, and somewhat less of the variance in the Irish and French returns. This is an important indication of the exposure of these indices to the global shock that will be discussed in further detail below.

Interestingly, the second principal component raises returns in the UK, US and Ireland, while depressing returns in Germany, France and Belgium, suggesting that there are shocks that impact on the returns in the three Anglophone countries in a different way to the continental European countries. This may result from the exceptionally strong trade links between the Anglophone referred to in Section 3.2.2, and indicates that each of these sets of countries is particularly integrated.

These first two principal components account for over 50% of the variance in the series. The four remaining shocks appear to be country specific shocks, for the four large indices in the sample: the third component loads heavily onto France (0.59), the fourth onto the US (0.80), the fifth onto the UK (0.76) and the sixth onto Germany (0.76). This implies that there is a high degree of integration in the markets – less than half of the variance in the series is explained by country-specific shocks.

The six panels in Figure 3.3 show scatter plots of the global shock and each of the returns series. All charts indicate the positive correlation between returns and the shock, although for some countries the relationship is stronger. For instance, the correlation coefficients[63] for Belgian and German markets and the global shock are 0.67 and 0.72, respectively. In contrast, French and Irish returns are markedly less correlated with the global shock, with coefficients of 0.36 and 0.37, respectively. This implies that the Belgian and German indices were more exposed to the global shock than those in the other countries. It can also be seen as evidence that the Belgian and German indices were the most integrated with other markets, while those in Ireland and France were the least integrated.

3.4.3 Risk and return

In general, one would expect that, as risk associated with holding equities rises, so too does the return to holding them. I use two measures of risk: the variances of returns calculated in Section 3.3.3 and the factor loadings of the first principal component, or global shock. Since the indices with higher factor loadings move more when there is a global shock, they offer less diversification benefits and are therefore riskier, and therefore require a higher rate of return.

The two panels of Figure 3.4 show scatter plots of the average return and these two measures of risk in the three subperiods discussed above. It appears that, as measured by variance, risk was generally higher in the first sub-sample period. This could reflect the somewhat turbulent period, particularly in continental Europe, at this time. However, when measured by the factor loadings, risk appears to be similar across all sub-periods.

As would be expected, there is a positive relationship between both measures of risk and return. When risk is measured by variance, this is the case across all sub-periods. However, when risk is measured by the factor loadings, in the middle subperiod there is a slightly negative relationship between risk and return. This may be due to unexpectedly poor performance by the Belgian, French and German indices which experienced negative average returns in this sub-sample. Nonetheless, as shown in Table 3.5, a regression of average returns on these two measures of risk over the full sample period

[63] Essentially, the correlation is the square root of the factor loadings.

indicates that they are significant at the 5% level (although the number of observations is small).

3.4.4 VAR analysis

To analyse the effect of the two shocks on the stock returns, I next conduct a VAR analysis. This will indicate whether the global shock has a statistically significant impact on each of the variables.

A lag length test indicates that, by the Hannan-Quinn and Akaike information criteria, 1 lag is appropriate.[64] A lag exclusion test further indicates that when a second lag of each variable is included, they are jointly insignificant. Furthermore, an LM test for residual serial correlation indicates that there is no residual serial correlation present when 1 lag is included. I therefore proceed with a 1 lag specification. The results of the VAR are presented in Table 3.6.[65]

Next, I turn to the identification of the shocks. There are a number of possible identification schemes which could be employed. Many VAR studies use a Cholesky decomposition, however, this requires a temporal ordering of the series in which the variable ordered first affects all the other variables first, then the second variable affects all the other variables, and so on. However, this makes little sense in this instance since most of the correlation between series is contemporaneous.

Instead, I use the matrix of factor loadings (the eigenmatrix) from the principal component analysis to identify the shocks. This results in each country responding in proportion to its co-movement with each shock. This identification strategy is discussed in Stock and Watson (2005), and is similar to those used in a number of studies of cross-country macroeconomic responses to common shocks, including by Helbling and Bayoumi (2003) and Helg *et al.*, (1995).

Accumulated impulse responses of each of the six returns series to the global shock are presented in Figure 3.5. The global shock has a large and significant effect on the level of

[64] The Schwarz information criterion suggests no lags are necessary. It may appear that no lags is a reasonable specification. However, lags in information and other market inefficiencies which may have occurred before modern regulations were introduced, could lead to one lag being appropriate.

[65] The characteristic roots of the VAR are within the unit circle, implying stability.

stock prices in Belgium, Germany, France, Ireland and the UK. For the US, the shock is initially positive, but by period five, the effect is no longer significant. The significance of the global shock implies that investors should have been influenced by an index's exposure to it when making investment decisions. It also indicates the importance of market integration at the time.

Turning to the second shock, which I label as 'Continental Europe shock' and which affects Belgium, France and Germany relative to Ireland, the UK and the US, Figure 3.6 shows that while there are significant effects on German and French stock prices, but that the effect on Belgian stock prices is insignificant. Similarly, there is a significant effect of the opposite sign the UK and Ireland, but that the effect is not significant for the US.

3.4.5 Parameter stability

Given that I use data for a 35-year period, it is possible that the relationship between the variables changed, such that there is a break in the parameters. In the absence of any prior knowledge of a specific break point, I split the sample in the middle, and carry out a likelihood ratio test comparing the two sub-sample models, to that for the full sample. This test indicates that the models estimated in the two sub-samples are statistically different from that estimated across the full sample (p-value of 0.000).

To explore this further, I use a time dummy which is equal to 0 for the first half of the sample period, and 1 for the second half, and include it, as well as interactions of this dummy with all right hand side variables in the system. If the dummy and interaction variables are jointly significant, it indicates that there is a change in the parameters between the first and second subsamples. A joint significance test in which the null hypothesis is that the coefficients on the dummy and all the interactions are equal to zero returns a p-value of 0.010, indicating that the dummies are significant, and that there is indeed break.

Next, I seek to determine where this break occurred by testing for the significance of the dummies country by country. This indicates that a break is present only in the Belgian equation, since the dummies are significant (p-value 0.013) in this equation, and not in any of the others.

3.4.6 Sub-sample estimates

To estimate the two sub-samples, I first re-estimate the principal component analysis the VAR model for each sub-period, and then the impulse response functions. The impulse response functions to the global shock are reported in Figures 3.7 and 3.8. The impact of the global shock is a similar magnitude for Ireland and France in both sub-periods, whereas it is somewhat smaller in the second sub-sample in Belgium, Germany and the UK. In the US, there is no permanent impact of a global shock in the second subsample period. This may be the result of the more stable environment in the late-19th and early-20th centuries, which was evidenced in the indices themselves in Figures 3.1 and 3.2. Nonetheless, the standard errors of the impulse responses suggest little difference between the impulse responses in the two periods for any of the countries.

3.5. Conclusions

This Chapter examines co-movements in global stock price returns during the classical gold standard, using data from indices in Belgium, France, Germany, Ireland, the UK and the US during the period 1879-1913. To my knowledge, it is one of the most comprehensive comparative studies of the behaviour of stock prices co-movements during this period. As such, the Chapter set out to answer a number of questions, including: How do stock market indices co-move through time? Were there common shocks that affected indices in all countries, or in subsets of countries? Was exposure to such shocks compensated for by higher returns? Was the effect of these shocks significant?

In answering these questions, the Chapter first looked at pair-wise correlations of stock returns across countries to establish the degree to which they co-move. This analysis indicated that correlations are not predicated on geography or language barriers, but that all bilateral correlations are positive, with the exception of France and Ireland. Furthermore, average correlations are increasing through time.

However, it is interesting to consider whether there were common shocks which impacted all indices at the same time. The Chapter therefore next conducted a principal

component analysis to determine more formally whether indices were subject to a common, or global, shock. The analysis identified a global shock, which moves all indices in the same direction, such that returns and the global shock are positively correlated across all countries. This implies that when this shock is negative, returns in all countries fall. Furthermore, the second principal component raises equity return in the UK, US and Irish markets, while depressing returns in the German, French and Belgian markets. As the first two principal components account for over 50% of the variance in the series, there is a high degree of integration in the markets – less than half of the variance in the series is explained by country-specific shocks.

Since countries are affected to different degrees by the global shock, it is interesting to consider whether returns in each country reflect the exposure to it. Here, I find that there is generally a positive, statistically significant correlation between risk and return. Finally, the VAR analysis indicates that the global shock has significant effects on returns in all economies, and that the second shock has a significant effect on returns in five of the six economies.

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Table 3.1: Descriptive statistics, 1879-1914

	Belgium	Germany	France	Ireland	UK	US
			Average return			
Full sample	0.101	0.208	0.053	0.014	0.203	0.103
1879-1890	0.100	0.499	0.123	0.050	0.200	0.071
1891-1902	-0.048	-0.001	-0.045	0.110	0.392	0.237
1903-1914	0.265	0.118	0.083	-0.130	-0.000	-0.008
			Variance			
Full sample	3.364	4.914	2.750	0.973	10.686	4.611
1879-1890	4.585	8.490	4.920	1.333	8.884	6.479
1891-1902	2.399	3.779	1.830	0.821	12.177	4.143
1903-1914	3.068	2.161	1.401	0.730	11.056	3.098
			Coefficient of Variation			
Full sample	18.160	10.657	31.289	70.458	16.103	20.848

Table 3.2: Correlation coefficients, 1879-1914

Full sample	Belgium	Germany	France	Ireland	UK	US
Belgium	1					
Germany	0.380	1				
France	0.091	0.226	1			
Ireland	0.145	0.069	-0.030	1		
UK	0.222	0.251	0.219	0.221	1	
US	0.214	0.267	0.075	0.134	0.194	1
			Average Correlation			
Full sample	0.342	0.365	0.249	0.257	0.336	0.314
1879-1890	0.296	0.341	0.220	0.221	0.332	0.300
1891-1902	0.344	0.371	0.283	0.312	0.316	0.256
1903-1914	0.451	0.459	0.298	0.263	0.386	0.427

Note: average correlation calculated as the average of pairwise correlation coefficients, such as those reported in the upper panel of the table.

Table 3.3: Elliott-Rothenberg and Stock test, p-statistic

	Intercept	Intercept and trend
Belgium	0.160***	0.532***
France	0.122***	0.415***
Germany	0.122***	0.442***
Ireland	0.299***	0.586***
UK	0.488***	1.032***
US	0.310***	0.613***

Note: Lag length selected using Hannan-Quinn criterion. ***/**/* indicate significance at the 1%/5%/10% level.

Table 3.4: Principal Component Analysis

	Principal Component					
	1st	2nd	3rd	4th	5th	6th
Belgium	0.480	-0.004	-0.367	-0.541	0.171	0.560
Germany	0.517	-0.281	-0.209	-0.179	0.018	-0.760
France	0.259	-0.634	0.589	0.164	0.331	0.217
Ireland	0.269	0.686	0.385	-0.024	0.532	-0.158
UK	0.441	0.201	0.422	-0.033	-0.759	0.100
US	0.411	0.929	-0.385	0.804	0.036	0.163
Proportion of variance	0.321	0.180	0.148	0.133	0.121	0.097

Table 3.5: Results of OLS regression of measures of risk on average return, full sample

Measure of risk	Average return (1)	Average return (2)
Average variance	0.019	
	(2.813)	
First principal component loadings		0.599
		(2.938)
Constant	0.026	-0.125
	(0.696)	(-1.485)
Number of observations	6	6

Notes: t-statistics in parenthesis.

Table 3.6: VAR results

Variables	BE	DE	FR	IE	UK	US
Lagged BE returns	0.240	0.230	0.148	0.053	0.272	0.138
	(4.61)	(3.75)	(3.18)	(1.83)	(4.52)	(1.50)
Lagged DE returns	0.058	0.191	0.140	0.011	0.053	-0.020
	(1.31)	(3.65)	(3.53)	(0.46)	(1.04)	(-0.25)
Lagged FR returns	-0.085	-0.140	-0.138	0.019	0.046	-0.102
	(-1.58)	(-2.20)	(-2.87)	(0.62)	(0.74)	(-1.08)
Lagged IE returns	0.009	0.089	-0.113	-0.001	0.007	-0.373
	(0.10)	(0.83)	(-1.40)	(-0.03)	(0.07)	(-2.33)
Lagged UK returns	0.044	0.032	-0.022	0.005	-0.221	-0.111
	(1.03)	(0.63)	(-0.56)	(0.23)	(-4.42)	(-1.46)
Lagged US returns	0.018	0.053	0.052	0.007	0.071	0.301
	(0.63)	(1.62)	(2.08)	(0.43)	(2.20)	(6.12)
Constant	0.062	0.135	0.008	0.00	0.077	0.144
	(0.72)	(1.32)	(0.10)	(0.00)	(0.76)	(0.94)
Log likelihood : -4980.560		Sample: 1879M1-1913M12				N = 419

Notes: t-statistics in parenthesis.

Figure 3.1: Data in log levels, January 1879=100

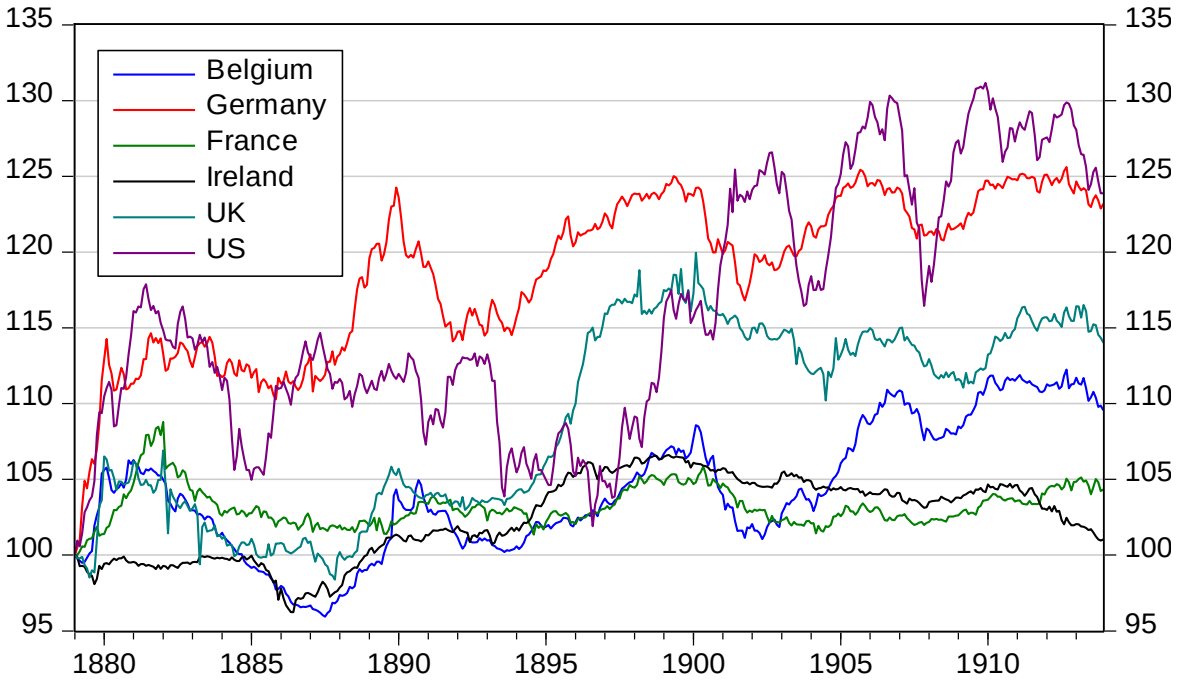


Figure 3.2: Returns to each index

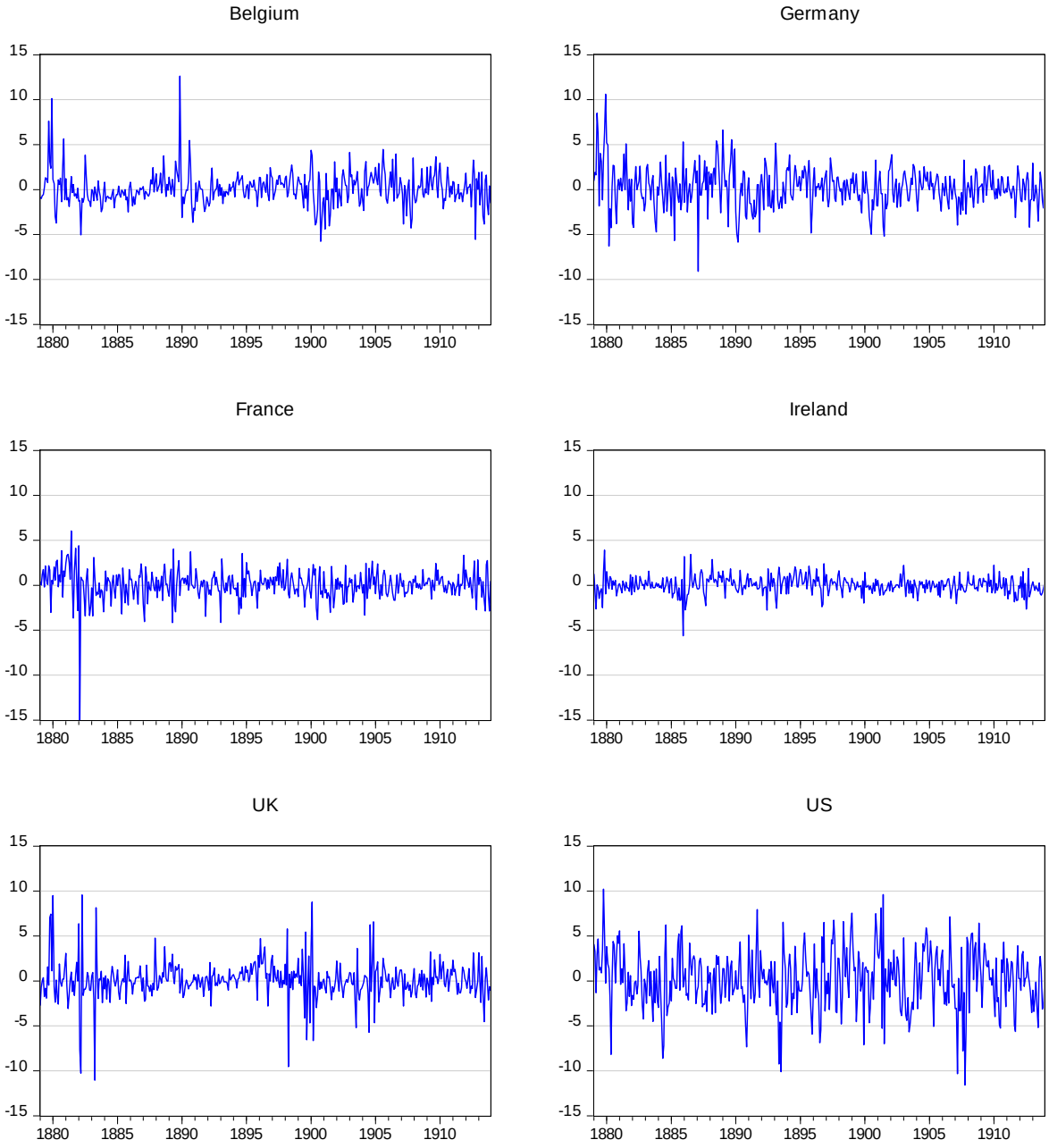


Figure 3.3: Global shock and stock returns in each country

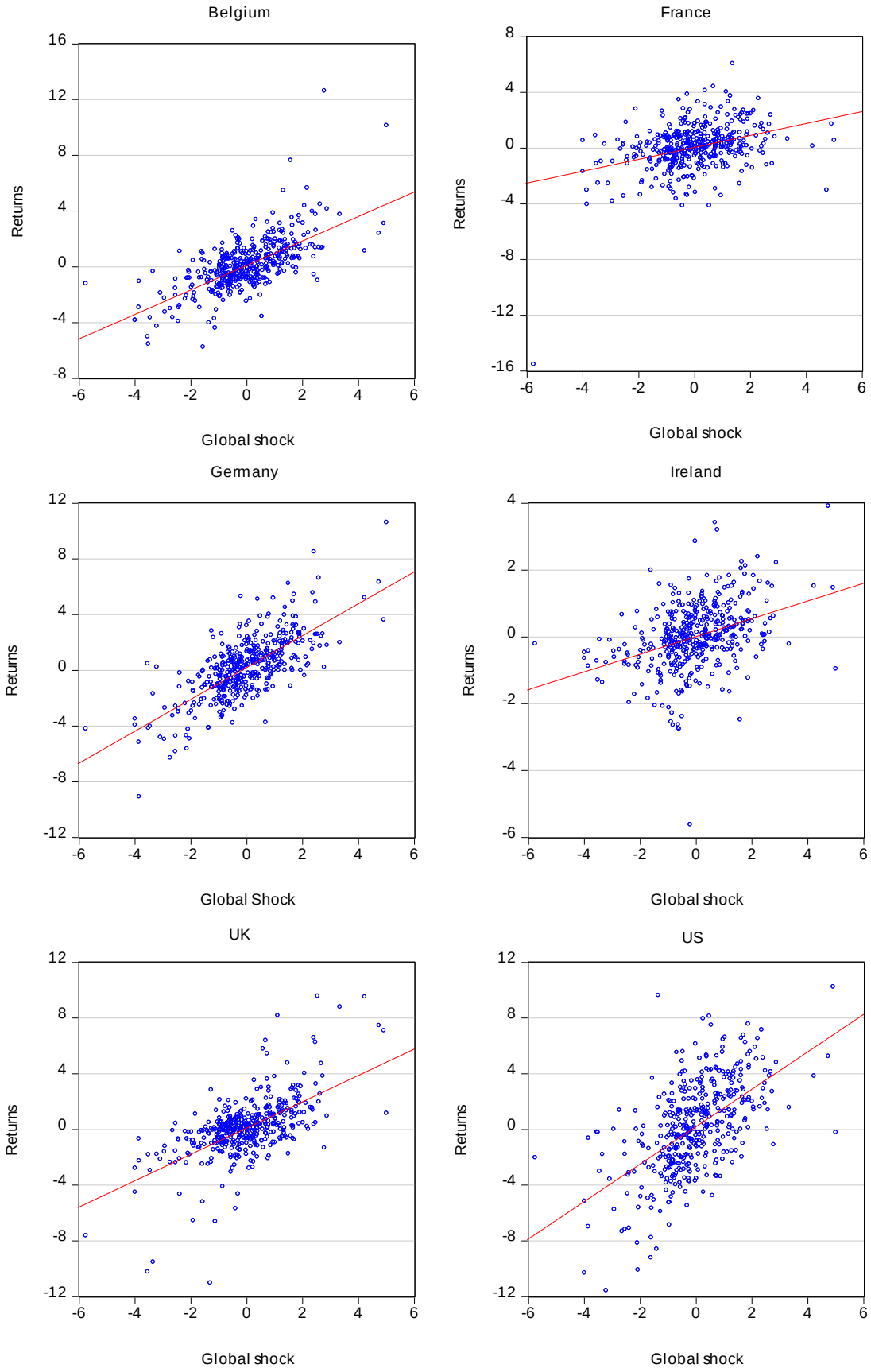
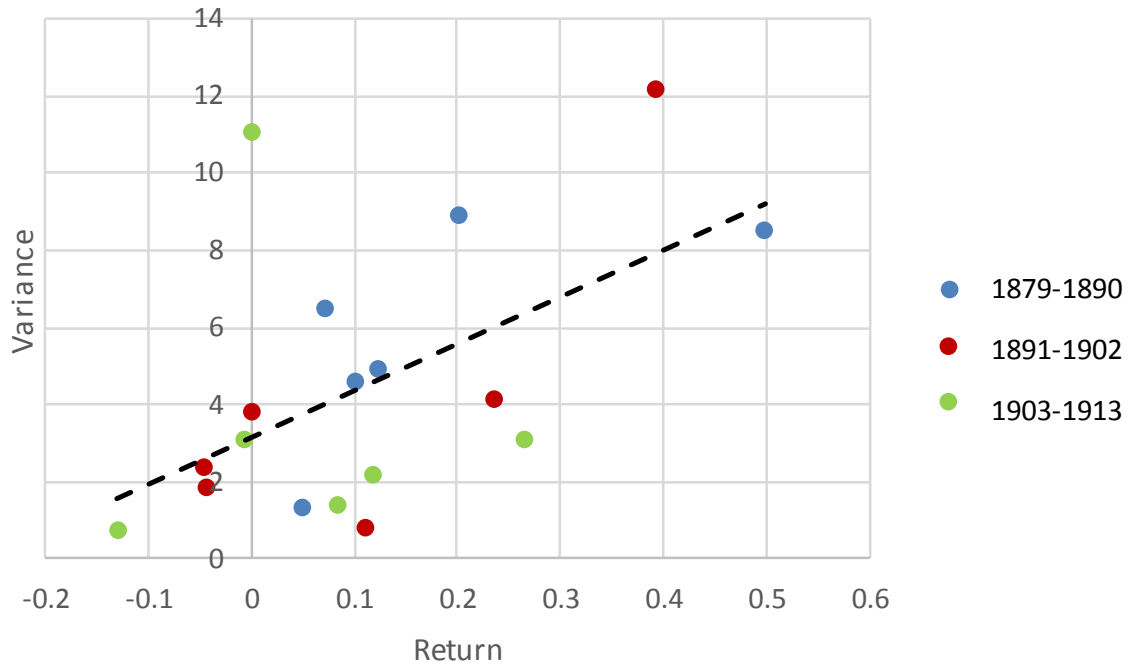


Figure 3.4: Risk and return across sub-periods

(a) Return and variance



(b) Return and first principal component loadings

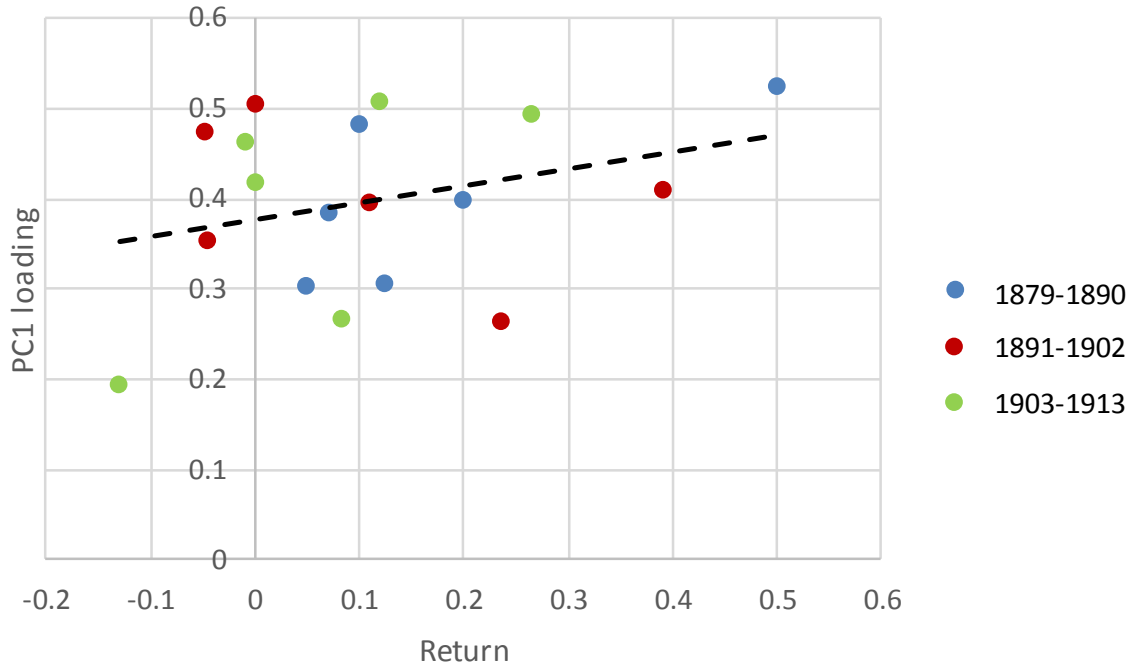


Figure 3.5: Accumulated responses to global shock +/- 2 standard errors, 1879-1914

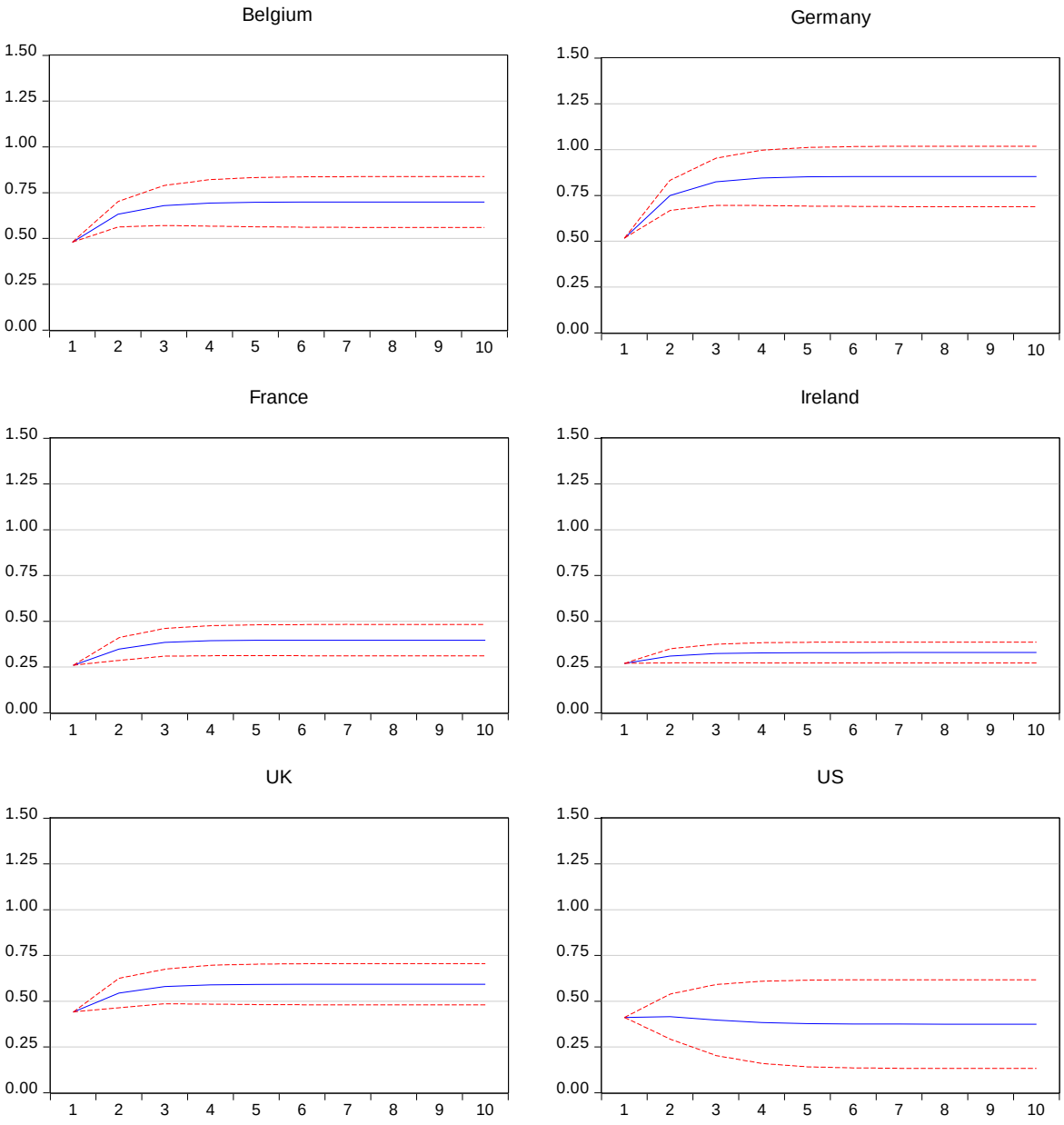


Figure 3.6: Accumulated responses to continental shock +/- 2 standard errors, 1879-1914

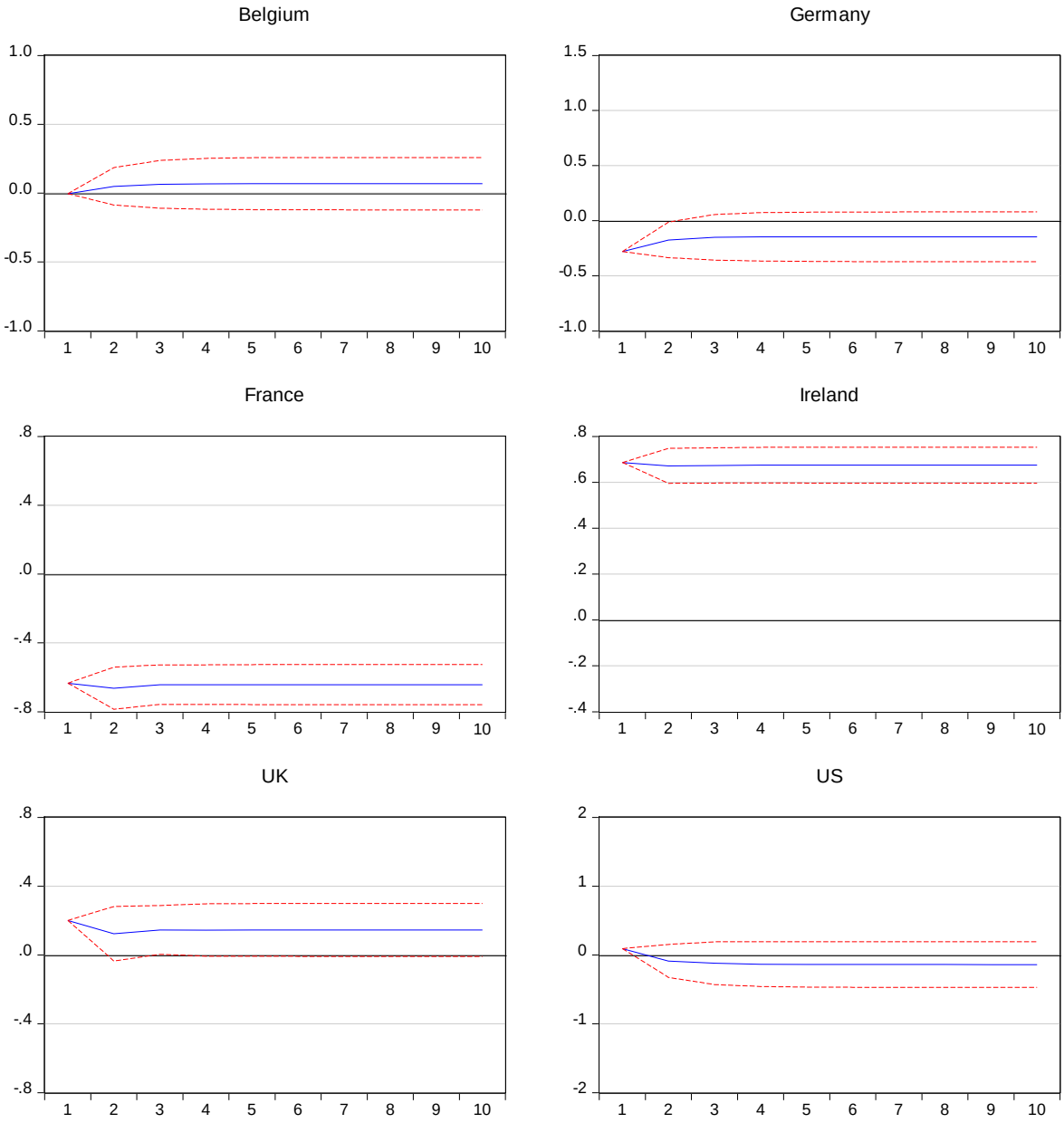


Figure 3.7: Accumulated responses to global shock +/- 2 standard errors, 1879-1896

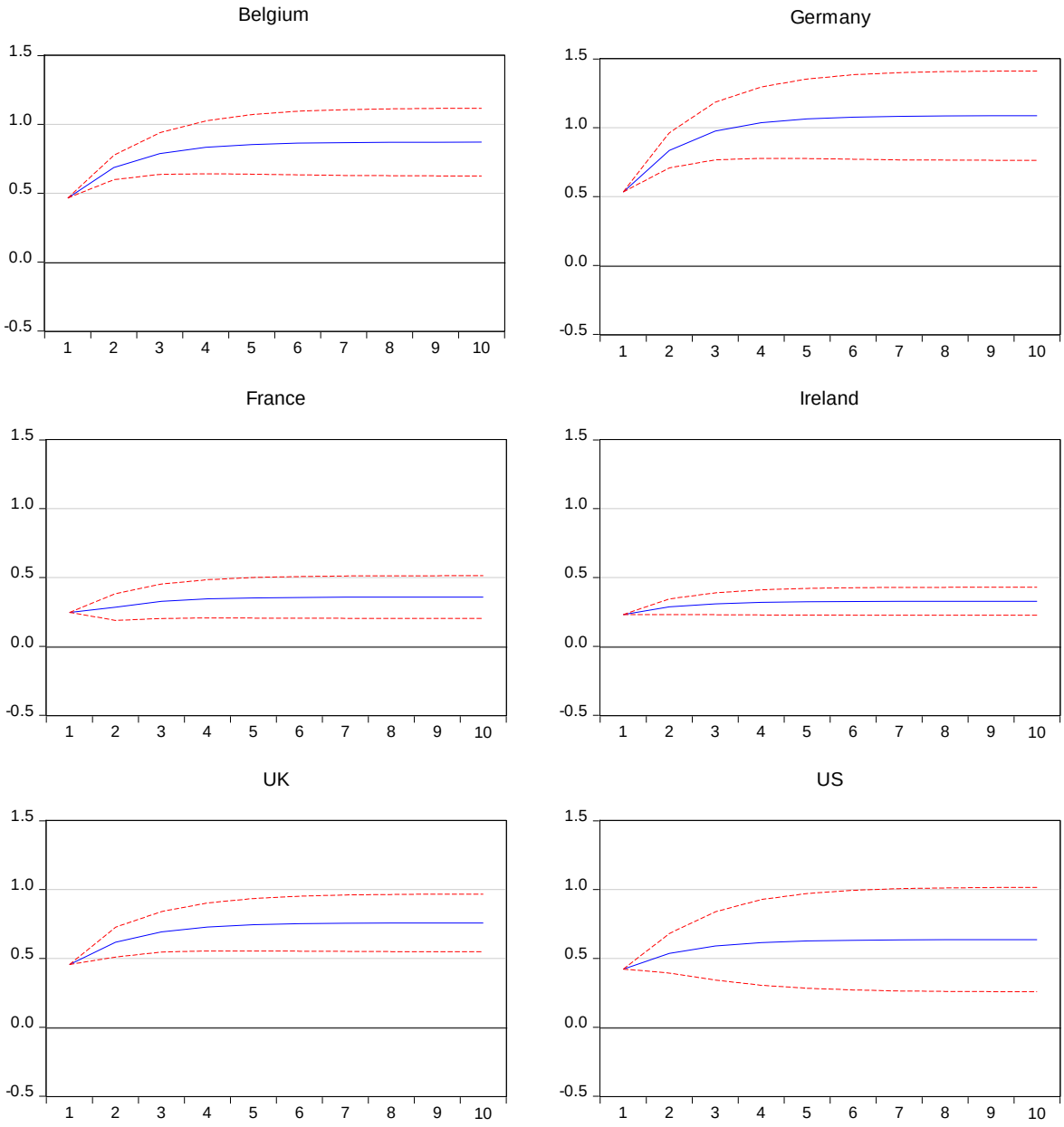
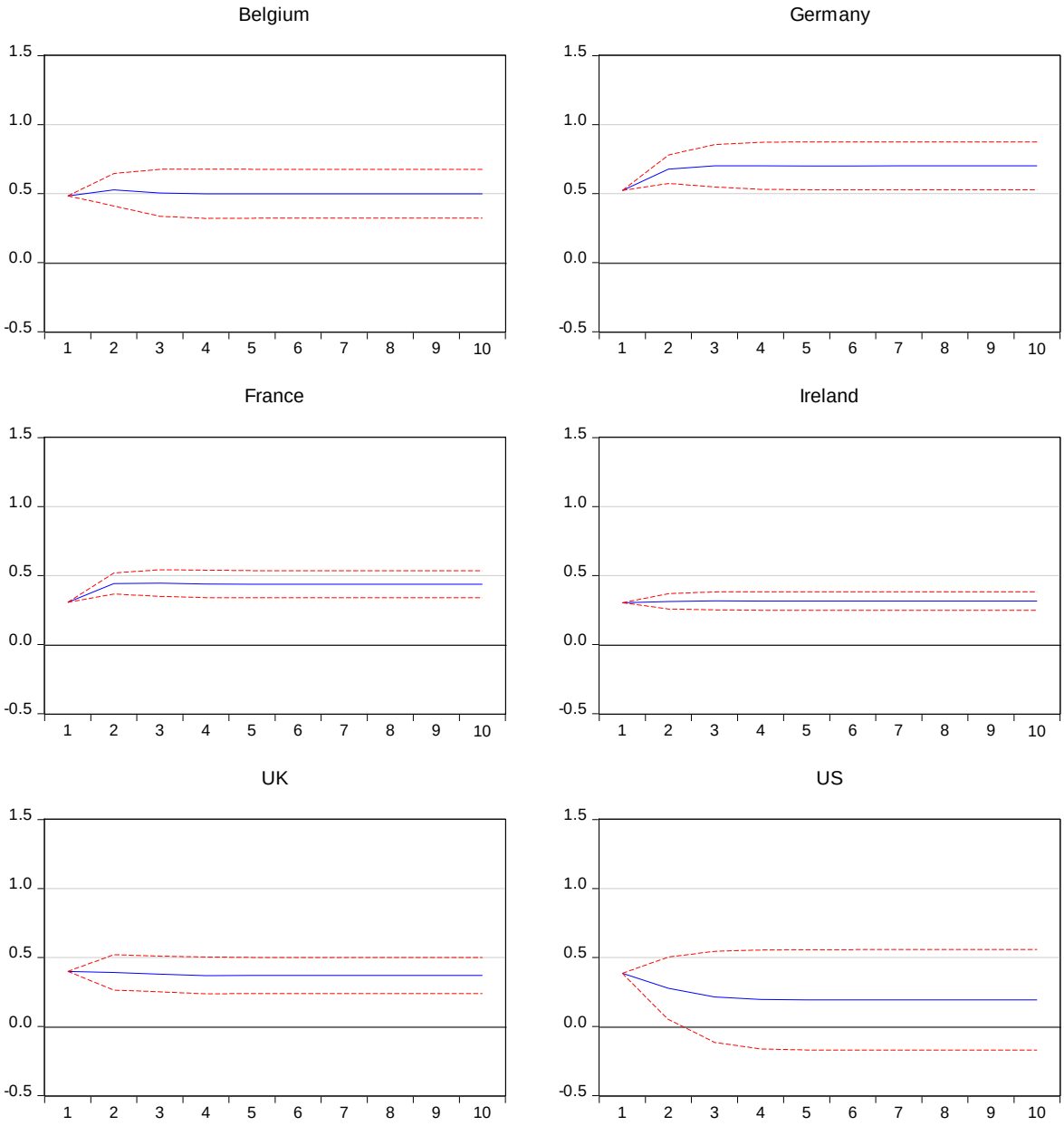


Figure 3.8: Accumulated responses to global shock +/- 2 standard errors, 1896-1913



Chapter 4

UK shocks and Irish business cycles, 1922-1979

4.1. Introduction

In 1922 the Irish Free State was established, effectively separating the administrative and economic functions of the southern counties of Ireland from those of the UK and Northern Ireland. Nonetheless, the two economies, which had been completely integrated up to this point, continued to be closely linked, largely as a result of international trade links, free mobility of labour and a fixed exchange rate policy.[66]

While it is recognized that colonial economies often developed in response to demand from the colonizer (for instance, the specialization in sugar production in the West Indies, or studies of extractive colonial rule[67]), trade, financial and monetary linkages often persist in the post-colonial period. However, although many studies look at the legacy of colonial rule as a determinant of future economic growth – the legal framework,

[66] See for instance, Moynihan (1975), McAleese and Martin (1972) and Fitzgerald (1999).
[67] See Beck *et al.,* (2002) for a discussion.

institutions or investment made by the colonizer[68] – few, if any, look at the ongoing economic influence of the former colonizer on the newly independent state.[69]

This Chapter examines the ongoing influence of the UK on the Irish economic cycle in the period immediately after independence, 1922-1979, during which a rigorously fixed exchange rate policy was in place and sterling bank notes circulated at par with Irish pound notes in the Republic of Ireland. I do so in a SVAR model that includes annual Irish and UK real GDP and consumer prices. UK and Irish aggregate demand and supply shocks are identified, these shocks and their impact on output and inflation are discussed, and a historical decomposition is conducted of the role each shock played in the evolution of the Irish macroeconomy.

The Chapter is interesting for several reasons. First, using a novel identification scheme based on an assumption on the price elasticity of aggregate demand schedule suggested by Ball *et al.*, (1988), I identify the aggregate demand and supply shocks for both the UK and Ireland. The UK shocks should be thought of as capturing both UK and global factors. The Irish aggregate demand and supply shocks reflect largely Irish policy and domestic macroeconomic shocks.

Second, UK aggregate demand and supply shocks have significant effects on Irish inflation throughout the sample period, but they matter less for Irish real GDP growth. The effect of UK shocks is quite large on Irish inflation: a UK supply shock raises UK inflation by 1.8%, and Irish inflation by 1.6%, while a UK aggregate demand shock raises UK inflation increases 2.1% and Irish inflation by 2.3%, in the first year. The effect on Irish GDP is less strong, a UK supply shock raises UK GDP by 1.8% but the impact of Irish GDP is 0.8%, while the impact of an aggregate demand shock on Irish GDP is marginally negative.

Third, the impact of UK shocks on Irish inflation is similar in magnitude to that of Irish shocks: a 1 standard deviation shock to UK aggregate supply raises Irish inflation by 1.6% in the first year, while UK aggregate demand shocks raise inflation by 2.3%, compared to

[68] See, for instance, La Porta *et al.* (1998), Acemoglu *et al.*, (2001) and Huillery (2009).
[69] An exception is the study by Head *et al.*, (2010) which examines post-colonial trade.

1.2% and 1.0% increases for Irish aggregate supply and demand shocks, respectively. However, Irish supply and demand shocks have larger impacts on Irish real GDP growth.

Fourth, the historical decomposition indicates that UK aggregate demand and supply shocks played an important role in the evolution of Irish inflation over the period studied while Irish shocks have a much more muted effect. UK aggregate demand shocks have a large impact on Irish inflation in the wake of the 1929 crash and during the Second World War. UK aggregate supply shocks also tend to have a negative impact on Irish inflation during the late-1950s and early-1960s when UK policy was focused on maintaining a stable balance of payments, whereas following the oil crisis in 1973, the UK aggregate supply shock pushes inflation up substantially.

Finally, the evolution of Irish real GDP is much more driven by domestic shocks than UK shocks. Domestic shocks, relating to policies of the Fianna Fáil government which came to power in 1932 have a clear impact, while in the years following 1958 domestic shocks tend to push up output, suggesting that the Economic Development plan had an impact, and the policy of deficit-spending to promote economic activity in the wake of the first oil crisis is visible in aggregate demand shocks in 1973 and 1974. However, this effect petered out in 1975, in line with the notion that the spending programme was unsuccessful at maintaining economic activity.

The Chapter is structured as follows. The next section discusses the literature on international business cycle coordination and post-colonial development, while Section 4.3 discusses Irish economic developments over the period 1922-1979. The data are described in Section 4.4. The model specification, including the identification scheme, is discussed in Section 4.5. Section 4.6 discusses the results of the SVAR analysis, particularly the impact of the identified shocks on the Irish economy as well as some robustness checks, and Section 4.7 concludes.

4.2. Post-colonial influence on economic outcomes

International business cycle theory suggests a number of transmission mechanisms through which a former colonizer is likely to have an ongoing impact on the economy of the newly independent state: including aggregate demand shocks which can be

propagated through international trade, common external shocks such as changes in oil prices, and the use of foreign goods in the production chain.[70] Eickmeier (2007) conducts an empirical examination of the transmission of US macroeconomic shocks to Germany using data of the period 1975 to 2002 and finds that trade is the most significant transmission channel while monetary policy reactions to strong price movements also play a role. Fidrmuc *et al.,* (2012) (also using recent data) estimate the determinants of output co-movements between OECD countries and find that trade intensity, financial integration, and specialization patterns can have significant effects on co-movements.[71]

However, when considering post-independence development, most studies focus on the 'legacy' of colonial rule. For instance, La Porta *et al.,* (1998) argue that the British legal system left colonies better placed to achieve positive economic outcomes following independence. Similarly, Beck and Levine (2003) provide an overview of the literature examining the role of legal institutions in shaping financial systems. Acemoglu *et al.,* (2001) find that colonizers were more likely to establish institutions that were conducive to growth in areas where settlers experienced lower mortality, and that this difference in institutions can explain income differentials today.[72] Similarly, Nunn (2007) develops a model which shows that 'extractive' colonial rule can result in low levels of production in the longer-run. Huillery (2009) examines the role of investment levels during colonial times on current income inequality in former French West Africa. Banerjee and Iyer (2005) find that the how agricultural property rights were granted in India continued to have an impact on agricultural productivity differences after independence.

Nonetheless, Barry (2014, p. 1), notes that 'political independence is usually associated with an attempt to reduce economic dependency on the dominant or former colonial power'. Somewhat surprisingly, therefore, few studies have examined the transmission of business cycles in a post-colonial environment. An exception is Head *et al.,* (2010) who, noting that Algeria's trade with France declined by two thirds over its first two decades

[70] See, Backus *et al.,* (1995), Baxter (1995), Backus and Crucini (2000) and Burstein *et al.,* (2008).

[71] Another strand of the literature examines the size and volatility of global shocks, without considering the transmission channels; see for instance, Stock and Watson (2005).

[72] Easterly and Levine (2003) show that development more generally is related to institutions, the standard of which can be related to geographical features such as 'tropics, germs and crops' pervasive in a region.

of independence, study the impact of independence on bilateral trade. They find that over four decades, trade between the former colonizers and colonies falls over 65%, although in the case of 'hostile separations', the effect can be faster. They attribute their findings to the decline in institutions and networks of people with knowledge of trade opportunities.

In terms of the international dimension of Irish business cycles, studies focus on the post-EMS period. Goggin and Siedschlag (2010), examine the patterns and determinants of the international transmission of business cycles between Ireland and its trading partners over the period 1980-2009, and find that deeper trade and financial integration had strong positive effects on the synchronisation of Irish business cycles with its trading partners. They also find that the adoption of the euro led to more synchronised business cycles between Ireland and its euro area trading partners. Similarly, Bermingham and Conefrey (2014), find that Irish economic growth is highly sensitive to the performance of its trading partners during the period 1995-2007, but do not study what economic shocks these findings reflect.

Since these Irish studies have focused on recent data, it is interesting to consider a longer sample period, covering the immediate post-independence period. During this time, the UK was the predominant trading partner of the newly independent Irish state, to the extent that is reasonable to think of it as the 'rest of the world' for Ireland. As such it is interesting to consider the extent to which there was correlation between the two economies and to understand whether these correlations reflect aggregate supply or demand shocks.

4.3. The role of the UK business cycle in Irish economic developments, 1922-1979

Economic developments in the Free State and, after 1948[73], the Irish Republic continued to be influenced by those in the UK, particularly during the period of exchange rate fixity that ended in 1979.

Most noticeably, this is seen in the monetary regime in place until 1979.[74] Following the establishment of the Irish Free State, the monetary system was initially unchanged,

[73] 'Republic of Ireland Act' was passed by the Irish Parliament in 1948.

however, in 1926 the Government established a Banking Commission to review the monetary and financial system and propose changes. The Commission advised that the State should establish its own currency at par with Sterling and that a new Currency Commission should assume responsibility for the issuance of bank notes.

While these arrangements fell short of those in economies with a central bank, the Irish financial system functioned well and it was not until the report of the Commission of Inquiry into Banking, Currency and Credit in 1938, and the realisation during the Second World War that Irish banks could not rely upon the Bank of England as lender of last resort, that the Central Bank of Ireland was established in March 1943. However, the fixed exchange rate against Sterling meant that Irish inflation rates and interest rates followed closely those in Britain and were thus determined with little, if any, reference to domestic economic conditions. As such, despite the establishment of the Central Bank, monetary arrangements in Ireland were close to those of a currency board throughout the period up to 1979 when Ireland joined EMS.[75]

Furthermore, economic linkages with the UK remained strong following independence. Unlike, for instance, Finland, which gained independence from Russia in 1917 and consequently faced the almost complete closure of Russian markets to their exports, Ireland maintained access to UK export markets.[76] These markets, already well-established for agricultural products, continued to operate as before. During the 1920s Ireland traded 'almost exclusively with the UK' (Barry and Daly (2011, p. 1)). This relationship remained strong throughout the sample period, although the composition of exports gradually became less agricultural. McAleese and Martin (1972) report that the UK still accounted for 83% of exports in 1951 and 63% in 1971.

In addition, free movement of labour continued throughout this period. Indeed, Walsh (1999) argues that the UK played an important role as a 'safety valve', helping to keep unemployment in Ireland lower than otherwise. Indeed, a number of studies have argued that there is an equilibrium unemployment gap between Ireland and the UK, whereby

[74] For a detailed discussion of monetary developments see, for instance, Brennan (1931), Moynihan (1975), Ó Gráda (1995) and Gerlach and Stuart (2014).
[75] See Honohan (1995).
[76] Russian share of Finnish export trade fell from an average of approximately 40% in 1860-1916, to 2% with the Soviet Union over the period 1917-1944. See Ollus and Simola (2006) for a discussion.

emigration from Ireland ensured that the Irish unemployment rate never rose too far above that in the UK.[77] The intuition is that when the gap increases, emigration follows, reducing supply in the Irish labour market and increasing wage and price inflation. Honohan (1984) estimates the equilibrium level of the unemployment gap at which there would be no net flow of migrants, while Honohan (1992) shows that the Irish unemployment rate has tended to adjust in the medium term to movements in the UK rate.

However, while important aspects of the Irish economy remained closely tied to that of the UK, the structure of the Irish economy was different to that in the UK, while Ireland also asserted independence in a number of instances, and pursued its own economic objectives. For instance, in 1929, following the Wall Street crash, having less developed financial markets, Ireland was, initially at least, less affected than other economies (Barry and Daly (2011)).

Furthermore, as noted by Barry (2014), the assertion of Irish independence is most clearly demonstrated through attempts to reduce economic exposure to the UK through tariff protection and restrictions on foreign ownership. In 1932, the new Fianna Fáil government instigated the Economic War as it withheld land annuities from the UK. The UK retaliated by introducing a tariff on Irish cattle exports. While the final settlement of the War, in which the capitalised £100m Irish liability was settled for a lump sum payment of £10m, appears favourable when compared with the loss of GNP as a result of tariff impositions (see O'Rourke (1991)), for its duration the Economic War was likely to have had a larger impact on Ireland than the UK. The Economic War and the broader introduction of protectionist policies that followed, led to a decline in net agricultural output, but an increase of some 46% in industrial output.[78]. Neary and Ó Gráda (1991) note that the employment effect in the Irish agricultural sector was smaller however, since tariffs imposed on cattle exports by the UK as part of the economic war resulted in a shift in agricultural production away from land-intensive grazing towards labour-intensive tillage.

[77] For a discussion, see Fitzgerald (1999).
[78] For a discussion, see Lee (1989).

At the onset of the Second World War the Irish Free State declared its neutrality, placing the two economies on very different paths. While in the UK government spending increased rapidly and the labour force was reorganized, Lee (1989) notes that Ireland was 'unusually ill-equipped' for the economic impact of the Second World War. In particular, in contrast to other small, neutral, European economies, Ireland had no industrial base: while Switzerland, for instance, saw unemployment fall from 13.2% in 1936 to 1.6% in 1945 as a result of an armament drive, Ireland had no similar reduction in unemployment, and no consequent shift towards industrial employment. In the post-war period, Ireland pursued a policy of import substitution, in an attempt to move closer towards self-sufficiency. Out of step much of the rest of Europe, which experienced a period of strong growth in the 1950s and 1960s, Irish economic performance was comparatively very poor. Although industrial production began to rise as domestic firms benefited from a lack of foreign competition, and jobs in industry increased by over 50,000 from 1946 to 1952, the industrial workforce remained less than half the size of that in agriculture, and only 20% of the entire workforce (Lyons (1972)).

The introduction of Whitaker's program for Economic Development in 1958[79] began the process of opening the Irish economy, and reversing the policy import-substituting-industrialisation. While the immediate effect was an increase in redundancies as domestic firms lost out to foreign competitors, the size of the industrial workforce surpassed that in agriculture in the late-1960s. Throughout the 1970s, industrialization continued, and output increased by approximately 66%. Nonetheless, growth was by no means spectacular, and this is not considered the period during which Ireland 'caught up' for the lack of growth in the post-War period.[80] Indeed, growth is considered to have underperformed during the entire post-War period until after the end of the sample, with a number of factors identified as playing a role, including low investment rates, love-quality investment decisions, trade policies, and rent seeking (O Gráda and O'Rourke (2000)).

[79] Which was foreshadowed by the export profits tax relief policy in 1956.

[80] See Honohan and Walsh (2002)) who argue that this did not occur until the 'Celtic Tiger' period in the 1990s.

Ireland's response to the oil crises in the 1970s was not dissimilar from that in the UK: the government undertook a programme of deficit-spending to promote economic activity. However, as a small open economy, the government spending measures were largely unsuccessful in boosting the economy. In 1975, the National Economic and Social Council noted that Ireland appeared to have lost its competitive advantage over the UK entirely, attributing this to, among other things, fiscal efforts to prioritise employment and maintain living standards which were funded by taxes that contributed directly to CPI increases[81] and the world recession in the wake of the first oil crisis which reduced demand for exports at the same time domestic costs were rising rapidly.[82] It was not until after our sample period that tough fiscal measures were implemented to address a rapidly rising debt-to-GDP ratio resulting in a gradual decline in inflation in the mid- to late-1980s.

Overall then, the development of the Irish economy during this period was determined both by its exceptionally close links to the UK economy and by domestic policy decisions. This raises a number of questions. First, can Irish aggregate supply and demand shocks be identified separately from UK and global shocks? What is the effect of these shocks on Irish macroeconomic variables? Finally, to what extent did each of these forces determine Irish macroeconomic outcomes over the sample period? I next turn to these questions.

4.4. Data description

The data which are used in this analysis are taken from a number of sources. For the UK, data on inflation are from the Office of National Statistics (ONS), for which the consumer price index (CPI) are available from 1800. For UK real GDP, data are taken from the *Three Centuries of Data* spreadsheet of Hills *et al.*, (2015) for the period to 1947, and thereafter data from the ONS are used. For Ireland, CPI data are available from the Central Statistics Office (CSO) from 1922. The Irish real GDP data are described in Gerlach and Stuart (2015). Briefly, data from 1922 to 1938 are taken from the Maddison website. Data from

[81] For instance, increases in indirect taxes and excise duties on petrol alone added 3% to CPI.
[82] National Economic and Social Council, (1975).

1938 to 1947 are taken from official estimates of national income published in 1946 and 1951.[83] Data on real GDP are available from the CSO from 1947 to 2012.

The Maddison data for Ireland are based on an estimate Maddison made for 1920 and data thereafter originated in papers by Duncan in 1940 and 1941. These data are available for 1926, 1929, 1931, 1933, 1936 and 1938, and Maddison therefore interpolates data for the years in between. As a result, for robustness the analysis is carried out both including and excluding these data.

The growth rates of the final series are shown in Figures 4.1 and 4.2. The inflation rates, computed using the CPI indices, are generally similar (Figure 4.1). The main differences occur around the Second World War, perhaps unsurprisingly since Ireland remained neutral. While both economies experienced rising inflation in 1940, Irish inflation remained high in 1943 before declining thereafter. In the years following the War, Irish inflation was generally marginally lower than that in the UK. Inflation in the UK declined after the Conservative Government came to power in 1952. The focus at this time was on maintaining the balance of payments and interest rates were raised ending the era of cheap money.[84] While both economies experienced high inflation during the first oil crisis, Irish inflation was already rising in the late-1960s. This somewhat higher rate of inflation was much discussed at the time: Geary *et al.*, (1970, p. 347) noted that while Irish and UK process moved similarly in the post-war period to 1966, they began to diverge thereafter, and argue that *'the restoration of the parity, in the interest of our great exports to UK, will obviously be a difficult task. At present we are pricing ourselves out of the British market.'*

In contrast, the GDP data move much less closely together than the inflation series. Figure 4.2 shows the growth rate of the final GDP series for both countries, while Table 4.1 shows growth rates across sub-periods.[85] The UK was much more severely affected by the

[83] See, White Paper (1946) and CSO (1951). In both cases, the data are for total national income, and are reported only in nominal terms. However, a retail price trend is also reported in both publications,
and this is used to deflate the series for real GDP.

[84] See Booth (2001) for a discussion.

[85] Sub-periods are chosen to be economically meaningful: the period up to the Great Depression, (1922-1929), from the Great Depression to the Second World War (1930-1938), the Second World War and its immediate aftermath (1939-1949), the post-War period up to the first oil crisis (1950-1973), and the period thereafter.

Great Depression than Ireland was, as evidenced by a large decline in UK GDP in 1929. As a result, it is perhaps unsurprising that UK GDP grew more strongly than Irish GDP over the period 1930-1938 as the UK economy recovered. Growth also diverged significantly during the Second World War; the UK experienced a large increase in output for most of the War, before a decline in the latter years and immediate post-war period, with the overall effect that GDP growth over this period was similar in Ireland and the UK (1.91% and 1.85%, respectively). In the immediate post-War period, the UK experienced stronger increases in GDP, however, growth in the two economies begins to move more closely in the early-1960s and continues to do so in the early-1970s, and overall the two economies have a similar average growth rate (3.19% and 3.08% in Ireland and the UK, respectively). In the final subperiod, Irish GDP growth outstrips that of the UK, in large part due to strong growth in the period leading up to the second oil crisis.

4.5. Econometric analysis

Next, I examine the impact of both UK and Irish shocks on the Irish economy in a Vector Autoregression (VAR) framework. However, before proceeding, I test for stationarity in the series.

4.5.1 Unit root tests

Both the Augmented Dickey-Fuller (ADF) unit root test and the Elliott-Rothenberg and Stock (ERS) test are performed on the series, with lag length selected using the Hannan-Quinn information criterion. The tests are performed including just an intercept and also an intercept and trend. The results of the test for the four variables are presented in Table 4.2. The test is first carried out on the variables in levels. All the tests fail to reject the null of a unit root at the 1% level. The ERS test for UK GDP rejects the null at the 5% level when a trend and intercept is included. However, the ADF test using a trend and intercept returns a p-value of 0.14. I therefore proceed to testing for stationarity in differences.

For both Irish and UK GDP, the tests reject the null hypothesis of a unit root at the 1% level in almost all cases. The exception is the ERS test on Irish real GDP when only an intercept is included; in this instance the null is rejected at the 5% level. With respect to

UK and Irish inflation, the results are somewhat more mixed. For UK inflation, the ADF test rejects the null at the 5% level when a trend and intercept are included, and at the 10% level when only a trend is included. Although the ERS test fails to reject the null when only an intercept is included, it rejects at the 10% level when both trend and intercept are included. For Irish inflation, when a trend and an intercept are included, the ADF test rejects at the 10% level and the ERS test at the 5% level, but the test fails to reject when only an intercept is included. Overall, these results point towards stationarity, and I proceed on this basis.

4.5.2 Testing for cointegration

The model would be misspecified if cointegration was present and not taken into account, and I therefore next test whether the series are cointegrated. To do so first requires determining the appropriate lag length of a VAR in differences. The Hannan-Quinn information criterion and the Schwarz information criterion indicate that one lag is the appropriate specification. Moreover, a lag exclusion test indicates that when second lags are included in the VAR they are jointly insignificant (p-value = 0.28), whereas the first lags are highly significant (p-value = 0.00). Finally, an LM test indicates that there is no serial autocorrelation in the residuals in the first 6 lags. I therefore proceed with a 1-lag specification.

Based on this lag length structure, a Johansen test is next used to determine whether the series are cointegrated. Both the Trace test or the Maximum Eigenvalue test indicate that there is one cointegrating vector. This result is robust to whether or not a trend or intercept is allowed for (Table 4.3).

4.5.3 SVAR specification

Since the variables are cointegrated, they can be described by a Vector Error Correction (VECM) model, that is, by a restricted VAR model for the levels of the variables.[86] Since the appropriate lag length for the VAR in differences is one, it is likely that the appropriate lag length in levels is two. Although the Schwarz criterion indicates that two lags is appropriate, the Hannan-Quinn information criterion indicates that three lags is

[86] Imposing the restrictions of the VEC model in estimation improves efficiency but is not necessary. For computation convenience I do not do so here.

now appropriate. However, a lag exclusion test indicates that the third lags are not jointly significant (p-value = 0.29), and an LM test indicates that there is no serial correlation when just two lags are included. Overall, I proceed with a two lag specification.

The cointegration test indicates that there may be a trend in the cointegrating relationship. This would make it appropriate to include a trend as an exogenous variable in the VAR. A likelihood ratio test indicates that this trend should be included (p-value = 0.00). I therefore include one in the VAR, although the coefficients on the trend are not significant in the individual equations. The results of the VAR are presented in Table 4.4.

4.5.4 Identification of the shocks

I first estimate a VAR specification which can be written in matrix form as:

$$Y_t = AY_{t-1} + e_t \qquad (1)$$

Here e_t is a vector of regression residuals which are a convolution of underlying structural aggregate supply and demand shocks. The structural shocks, u_t, are a combination of these reduced form shocks such that:

$$Be_t = Cu_t \qquad (2)$$

Assumptions over B and C are necessary in order to identify the structural shocks. There are a number of possible identification schemes that can be employed. One is the Cholesky decomposition which assumes B is triangular and C is the identity matrix so that the first shock affects all variables at time t, the second shock affects the first and second variables at time t, and so on, with the last shock affecting all variables at time t. Such an identification structure is inappropriate in the current setting: since the data are annual, aggregate supply and demand shocks affect prices and quantities within one period.[87] An alternative approach follows the SVAR model studied by Bernanke (1986) who also relied on contemporaneous restrictions but constrained B in other ways than forcing it to be diagonal.

[87] An entirely different approach to identification scheme uses long-run restrictions, similar to those used in Blanchard and Quah (1989) and Bayoumi and Eichengreen (1992). These restrictions assume that some shocks have no long-run impact on some variables, although all shocks have short-run effects. However, long-run restrictions such as these often give unreliable results (see Faust and Leeper (1994) for a discussion).

Here, to identify supply shocks I proceed as in Ball *et al.*, (1988) and assume that the price elasticity of aggregate demand is minus unity. In that case, an expansionary aggregate supply shock will increase GDP and reduce prices by the same percentage, leaving nominal GDP unaffected. While this restriction seems natural, to my knowledge it has not been used to date to identify aggregate supply shocks in a SVAR framework. Ball *et al.*, argue that this assumption seems plausible, given available empirical estimates of the slope of IS LM curves.[88] However, for robustness, I will also estimate the model assuming that the price elasticity of aggregate demand is half (-0.5) and twice (-2.0) as large. In addition, I assume that Irish shocks do not impact on the UK aggregate demand shocks. This seems reasonable given the comparative size of the two economies.

In this case, the identifying structure in (2) can be written as follows:

$$\begin{bmatrix} 1 & -b_{12} & 0 & 0 \\ 1 & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & -b_{34} \\ b_{41} & b_{42} & 1 & 1 \end{bmatrix} \begin{bmatrix} e_{inf}^{UK} \\ e_{gdp}^{UK} \\ e_{inf}^{IE} \\ e_{gdp}^{IE} \end{bmatrix} = \begin{bmatrix} -c_{11} & 0 & 0 & 0 \\ 0 & c_{22} & 0 & 0 \\ 0 & 0 & -c_{33} & 0 \\ 0 & 0 & 0 & -c_{44} \end{bmatrix} \begin{bmatrix} u_{AS}^{UK} \\ u_{AD}^{UK} \\ u_{AS}^{IE} \\ u_{AD}^{IE} \end{bmatrix} \quad (3)$$

UK and Irish shocks are formulated slightly differently. Contemporaneous events in Ireland have no impact on UK shocks, a reasonable assumption since Ireland is a small economy relative to that in the UK. However, when considering Irish aggregate demand and supply shocks, it is reasonable to assume there may be some effect from the UK.[89] As such, UK inflation and output are allowed impact Irish shocks.

4.6. UK aggregate supply and demand shocks, Irish business cycles

It is now possible to calculate the estimated aggregate supply and demand shocks, and to consider their impact on the Irish economy over the course of the sample period.

[88] Theory suggests that a small, open economy which is a price-taker would have a flat aggregate demand curve. However, this is only the case if all goods are tradeable, which they are not in practice. The robustness checks allow for a flatter and steeper aggregate demand curve than the base case identification.

[89] It is also possible to specify that the UK has no effect on Irish aggregate demand and supply shocks, resulting in an overidentified VAR. However, a likelihood ratio test indicates that these restrictions are not appropriate.

4.6.1 Aggregate supply and demand shocks

The estimated aggregate supply and demand shocks for both the UK and Ireland are presented in Figures 4.3 and 4.4. As noted, the UK shocks should be considered as capturing both UK idiosyncratic and global factors. Turning to these shocks first, Figure 4.3 indicates that there is a strong positive aggregate supply shock in 1927, following the resolution of general strike in 1926 and subsequent banning of such strikes in the Trade Disputes and Trade Unions Act, 1927. The Great Depression led to a negative aggregate demand shock through much of the 1930s. However, Britain experienced a stronger recovery than most democracies[90], as a result of leaving the gold standard earlier than other countries.

The Second World War is marked by a large positive aggregate demand shock in 1940. The end of the Second World War is market by an increase in aggregate demand, however, the 'twin crises' of 1947[91] resulted in negative supply shock. Nonetheless, the following year a positive supply shock coincides with the establishment of the Organisation of European Economic Cooperation (the forerunner of the OECD), of which Britain was one of the key participants.

In line with the accepted narrative that the return of the Conservative party to Government in 1951 did not result in any large shift in economic policy, there is no particularly marked shock at this time, although this is perhaps due to the negative aggregate supply shock in 1951 and 1952, corresponding with the Korean War, during which raw materials prices increased sharply. A concurrent positive aggregate demand shock may be associated with the process of British re-armament. The negative aggregate supply shock in 1956 is associated with the Suez crisis, which led to restrictions on energy and oil rationing in the UK. The fiscal difficulties of the first Wilson government, 1964-1970, which resulted in a series austerity measures, is marked by a series of negative demand shocks through the late-1960s, with a reprieve only coming with a currency devaluation.

[90] See Booth (2001).

[91] Resulting from a shortage of fuel in the spring and dollars in the summer.

A positive supply shock in 1973 coincides with the aftermath of the celebrated 'Heath U-turn' during which the government of the day, led by Ted Heath, switched industrial policies from non-interventionist to support (Booth 2001), and also with Britain joining the European Economic Community. However, the effect is short-lived: the first oil crisis in the 1973 is marked by a severe negative aggregate supply shock in 1974. Nonetheless, the new Labour government's spending policies are marked by a positive aggregate demand shock in the same year. The early effects of the second oil crisis in 1979 are also evident as a negative supply shock.

It is interesting to consider the impact of the exchange rate, briefly referred to above, on the UK economy also. While the UK exchange rate was fixed for much of the period, there were a number of periods during which it floated and a number of devaluations. In theory, exchange rate shocks should manifest as aggregate demand shocks, with prices and output moving in the same direction. This is indeed what we see when looking at the correlation between the effective exchange rate and the aggregate demand and supply shocks. While the correlation of the exchange rate and aggregate supply shocks is zero, the correlation with aggregate demand shocks is -0.2. Although this is a low correlation coefficient, it likely stems from the long periods during which there is little movement in the exchange rate. This is evident from Figure 4.4 which shows the nominal effective exchange rate and the aggregate demand shock. The devaluations as Britain left the gold standard in 1931, immediately prior to their joining the Bretton Woods agreement in 1940, in 1949, 1967 and following the break-up of Bretton Woods in 1971 are all apparent in this chart. The aggregate demand shocks around the time of these devaluations is also apparent in all cases, although somewhat lagged in 1949/1950.

Turning next to the Irish shocks (Figure 4.5), there is a marked domestic shock aggregate supply shock in 1932 coinciding with the start of the Economic War. This is followed by an aggregate demand shock in 1934, which is perhaps related to the spending policies of the Fianna Fáil government which came to power two years earlier. The start of the Second World War is not marked by any idiosyncratic Irish shock, however there are negative aggregate demand and supply shocks in 1941 and 1943, respectively. These were two years when the effects of the War were particularly felt in Ireland. Following the end of the 'phony war' in 1940, wartime conditions began in earnest in 1941. Ó Gráda (1997)

reports that the number of new private cars registered dropped from 7,480 in 1939 to just 240 in 1941. The government introduced a 'standstill' on wages in May 1941, such that the share of wages in net manufacturing output declined from an average of 48.9% in 1936-40 to 46.0% in 1941-43. In 1943 war time shortages began to take hold strongly. Lyons (1972) notes that in 1943 private motoring virtually ceased, long distance travel became increasingly difficult even using public transport, gas and electricity usage was cut, coal became almost unobtainable at times, and rationing began of bread, tea, butter, sugar and clothes.

Positive supply shocks are evident with the end of the War and in 1948. An aggregate demand shock is evident in 1958 with the conclusion of a balance of payments crisis that began in 1955 and the announcement of the Economic Development Plan. Negative demand shocks in 1965 and 1966 were reversed thereafter perhaps because the benefits of the Anglo-Irish Free Trade Agreement began to filter through. Finally, in addition to the wider global shock, there is a clear negative effect in Ireland following the first oil crisis.

4.6.2 Impact of the shocks

The responses of the UK and Irish economies to UK aggregate supply and demand shocks are displayed in Figure 4.6. The first column of Figure 4.6 shows that aggregate supply shocks tend to lower UK and inflation and raise UK GDP inflation, as would be expected. In addition, the shocks spillover to the Irish economy, lowering Irish inflation and raising Irish GDP. It is interesting to consider the pass-through of a UK shock to Irish and GDP. A one standard deviation shock to UK aggregate supply reduces UK inflation by 1.8%, and Irish inflation by 1.6% in the first year. The effect on Irish GDP is less strong, a shock raises UK GDP by 1.8% but the impact of Irish GDP is 0.8%.

From the second column of Figure 4.6, UK aggregate demand shock tends to raise both inflation and GDP in the UK. Again, this is as would be expected for a demand shock. The shock also tends to raise inflation in Ireland, and the pass-through from the UK appears to be quite high: UK inflation increases 2.1% in the first period, and Irish inflation increases by 2.3%. However, there is initially a small, marginally significant decline in Irish output. Irish output then rises thereafter. A possible explanation for this result arises from the dynamics of the Irish and UK labour markets. As already noted, studies have

shown that when UK real wages rise relative to Irish real wages, emigration from Ireland to the UK occurs. As a result, a UK aggregate demand shock may have two offsetting effects in Ireland. In the first instance, the aggregate demand shock transmits through Irish imports and has a similar effect on demand in Ireland. However, rising UK wages and falling unemployment may attract labour to the UK, acting like a negative supply shock in Ireland. If this effect dominated, then an effect as in Figure 4.6 would be expected.

In Figure 4.7, we can see the response of Irish inflation and GDP to the idiosyncratic Irish aggregate demand and supply shocks. The impact of both shocks on output and inflation is significant. Aggregate demand shocks raise both inflation and output, and aggregate supply shocks tend to reduce inflation and raise output. Since all four shocks are of the same magnitude[92], it is interesting to compare their impact on Irish inflation and output. Interestingly, the impact of UK shocks on Irish inflation is larger than Irish shocks: in the first year, UK aggregate supply shocks lower Irish inflation 1.6% compared to 1.2% for Irish shocks, while UK aggregate demand shocks tend to raise Irish inflation 2.3% compared to 1.0% for Irish shocks. In contrast, the effect of Irish shocks on GDP is greater than that for UK shocks: in the first year, UK aggregate supply shocks raise Irish GDP 0.8% compared to 1.2% for Irish shocks, while UK aggregate demand shocks tend to reduce Irish output, while Irish shocks raise it 1.6%.

4.6.3 Historical decomposition

It is interesting to assess the role of UK and Irish shocks in the evolution of Irish CPI and GDP over the period. To do this, I next decompose the movements in Irish inflation and real GDP growth (since it is easier to interpret the effect of shocks on the growth rate, rather than the level, of the variables) into the four shocks. Figures 4.7 and 4.8 show this decomposition of inflation and real GDP growth (relative to a deterministic trend) into the parts due to the four shocks.

Turning first to Figure 4.8, UK aggregate demand shocks play an important role in the evolution of Irish inflation over the period to 1979. They tended reduce inflation relative to trend during the Great Depression between 1929 and 1933, before markedly increasing

[92] The shocks in Figures 4.5 and 4.6 are 1 standard deviation innovations.

it during the early years of the Second World War. The effect is then subdued during much of the 1950s and 1960s, before raising inflation relative to trend during the years of the oil crises in the 1970s. By contrast, UK aggregate supply shocks have a more muted effect. There is a noticeable UK aggregate supply shock in 1941 when war time conditions began in earnest after the 'phony war' ended. Also notable are 1951 and 1952, when the Korean War led to a supply shock which raised Irish inflation. Similarly, the oil crisis in the 1970s caused a negative supply shock, which raised inflation in Ireland.

The Irish aggregate supply shock raises inflation between 1932 and 1938 during the Economic War with Britain. Domestic demand shocks also have a positive impact on inflation in 1934-1936. These may be attributable to the programme of house building instituted by the same government during this time.[93] There are few domestic shocks during the Second World War, indicating no idiosyncratic domestic effect of the war. Interestingly, no domestic shocks raise inflation relative to trend in the years following the Economic Development plan in 1958 and the opening up of Irish trade. Indeed, negative aggregate supply and demand shocks in the following years may indicate the negative employment effect of opening domestic firms to foreign competition. Furthermore, domestic supply shocks over the period, 1969 to 1971 tend to raise inflation relative to trend. Although not large, they give some support to the view at the time that rising Irish inflation that diverged from UK inflation was largely attributable to increasing wage and other domestic pressures.[94]

In contrast to inflation, domestic shocks play much more of a role than UK shocks in the evolution of Irish real GDP (Figure 4.9). UK aggregate demand shocks are apparent as UK economy began to pick up in 1931 following the crash in 1929, and in 1940 at the beginning of the Second World War. In the immediate post-War period, UK aggregate demand shocks tend to raise GDP growth. UK supply shocks tend to push GDP growth down relative to trend during the Korean War, and are also in evidence following the oil crisis. Although there are no other major shocks, UK supply and demand shocks are in evidence throughout the period, indicating its ongoing influence on the Irish economy.

[93] For a discussion of these measures see Lee (1989).
[94] See Geary *et al.*, (1970).

In terms of domestic shocks, the Fianna Fáil government which came to power in 1932 instigated the Economic War in 1932 and 1933, the impact of which on output is evident in both supply and demand shocks. In contrast, positive domestic aggregate demand shocks over the years 1934-1936 may be attributable to that government's already-mentioned programme of house building. We can see a large negative aggregate supply shocks in 1940 and 1941 as the scale and impact of the Second World War became apparent, as discussed in Section 4.6.1.

Interestingly, and in contrast to inflation, in 1958 there is a shift in the role of domestic shocks on output. In the years prior to 1958, domestic shocks had generally played a negative role, pushing output down relative to trend. However, from 1958 onwards, we see that these shocks tend to push up output, suggesting that the Economic Development plan introduced in 1958 had an impact.

Domestic aggregate supply and demand shocks are also evident during the period of increasing wages in the late-1960s and early-1970s. Subsequently, the oil crisis in the 1973 prompted the government into a policy of deficit-spending to promote economic activity in its immediate aftermath. The immediate effect of this is evident in aggregate demand shocks in 1973 and a 1974; however, the effect petered out in 1975. This is in line with the common understanding of the period, that the government spending was unsuccessful at maintaining economic activity.

4.6.4 Robustness checks

The above shocks are identified on the basis of a price elasticity of demand of -1. While this specification is based on the arguments of Ball *et al.*, (1988) and seems plausible, it is of interest to explore how sensitive the results are to it. I therefore re-estimate the model assuming the price elasticity is half (-0.5) and twice (-2.0) as large. This is implemented by varying how u_{AD}^{i} is defined. Specifically, instead of setting the coefficients on the residuals from the output equations, e_{gdp}^{UK} and e_{gdp}^{IE}, equal to 1 as in equation (3), they are now set equal to 0.5 and 2.0. The resulting aggregate demand and supply shocks are presented in the four panels of Figure 4.10. While the magnitude of the shocks is slightly different depending on the elasticity, there is little change to the sign or timing of the shocks as a result of this change in specification. Indeed, the matrix in Table 4.5 indicates

that the correlation between aggregate demand shocks when a unit elasticity is assumed and when and elasticity of -0.5 and -2.0 are assumed, is in excess of 0.94 in all cases. For aggregate supply shocks, the correlation coefficient is in excess of 0.95 in all cases.

It is arguable that the Second World War period is different from the remainder of the sample period. I therefore re-estimate the VAR for the sample period 1924-1939 and 1946-1979, and calculate the shocks using these residuals, assuming a unit price elasticity of demand. The estimated shocks are very similar to those using the entire sample period (Figure 4.11). Furthermore, the first row in Table 4.6 indicates that the correlation coefficients between the shocks estimated excluding and including the Second World War period are always 0.90 or higher.

Furthermore, the robustness of the Maddison data has been questioned. At the least, these data are based on estimates of GDP made at a very much later date. It may be argued that the data after 1938, which is taken from official sources, may be a more reliable estimate of output. I therefore re-estimate the shocks using data only from 1938 onwards (Figure 4.12). This removes almost 30% of the sample and is therefore likely to have a relatively large impact on the estimated shocks. Nonetheless, as the second row in Table 4.6 indicates, the correlation coefficient of the shocks when these data are excluded is never less than 0.79.

Finally, since the period covered by the Maddison is immediately followed by the Second World War, I re-estimate the model using only the post-1945 period. Since the estimation is carried out on just 34 observations, the correlation of the shocks is lower and the impulse responses are less significant. The bottom row in Table 4.6 indicates that the correlation between these shocks and those from the baseline model are between 0.62 and 0.88. The impulse responses indicate that Irish shocks impact Irish variables as would be expected, and that UK shocks also operate as would be expected from the baseline model, although the responses are less significant, particularly of Irish variables to UK shocks (Figure 4.13).

4.7. Conclusions

Few studies have considered the ongoing economic ties of post-colonial economies. Although many studies consider the legal and institutional legacy of colonial rule, this Chapter is one of the first to examine the ongoing economic influence of the former colonizer on the newly independent state. While the Irish Free State was established in 1922, Irish economic developments, in many respects, remained tightly bound to those of the UK, due to trade, labour market and exchange rate links. Nonetheless, the Free State, and later the Republic, asserted its independence in a number of ways that placed the two economies on separate paths.

This Chapter developed a SVAR framework to examine the ongoing influence of the UK on the Irish economic cycle in the period immediately after independence. There are a number of findings in the Chapter.

First, idiosyncratic Irish aggregate demand and supply shocks are identified which capture the effect of Irish policy and domestic macroeconomic shocks. Second, the model indicates that, while UK aggregate demand and supply shocks have relatively large and significant effects on Irish inflation, they have a much smaller impact on Irish real GDP growth. Third, the impact of UK shocks on Irish inflation is similar in magnitude to that of Irish shocks.

In addition, the historical decomposition indicates that UK aggregate supply and demand shocks played a more important role than domestic shocks in the evolution of Irish inflation. In contrast, the evolution of Irish real GDP is driven by idiosyncratic domestic aggregate supply and demand shocks than by UK shocks. In particular, the role of the Economic War in 1932, the Economic Development Plan in 1958 and the government policy of deficit-spending to promote economic activity in the wake of the first oil crisis all play a role.

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Table 4.1: Comparison of average UK and Irish real GDP sub-period growth

Sub-period	Irish real GDP growth	UK real GDP growth
1922-1929	1.23	2.82
1930-1938	0.83	1.80
1939-1949	1.91	1.85
1950-1972	3.19	3.08
1973-1979	4.12	2.36

Table 4.2: Unit root tests, p-values and p-statistics, 1924-1979

	Augmented Dickey-Fuller test, p-value		Elliott-Rothenberg and Stock test, p-statistic	
	Intercept	**Intercept and trend**	**Intercept**	**Intercept and trend**
Variable	Levels			
UK CPI	0.999	0.984	140.301	52.240
UK real GDP	0.967	0.147	268.970	5.039**
Irish CPI	0.996	0.963	120.784	39.066
Irish real GDP	1.000	0.989	888.062	155.066
	Differences			
UK CPI	0.087*	0.0463**	9.139	6.252*
UK real GDP	0.001***	0.004***	0.826***	3.046***
Irish CPI	0.112	0.056*	4.865	5.302**
Irish real GDP	0.000***	0.000***	2.187**	1.736***

Note: Lag length selected using Hannan-Quinn criterion. ***/**/* indicate significance at the 1%/5%/10% level.

Table 4.3: Johansen cointegration test, number of cointegrating relations indicated

Data trend	**None**	**None**	**Linear trend**	**Linear trend**
Test type	No intercept, no trend	Intercept, no trend	Intercept, no trend	Intercept, trend
Maximum eigenvalue	1	1	1	1
Trace test	1	1	1	1

Note: Selected at the 5% significance level.

Table 4.4: VAR results, 1924-1979

	UK CPI	UK Real GDP	Irish CPI	Irish Real GDP
Lagged UK CPI	1.112	0.337	0.293	0.016
	(0.251)	(0.249)	(0.284)	(0.203)
Twice lagged UK CPI	-0.620	-0.233	-0.461	0.024
	(0.206)	(0.204)	(0.233)	(0.167)
Lagged UK real GDP	0.296	1.191	0.391	-0.049
	(0.147)	(0.146)	(0.167)	(0.119)
Twice lagged UK real GDP	-0.413	-0.337	-0.302	0.093
	(0.159)	(0.158)	(0.180)	(0.129)
Lagged Irish CPI	0.266	-0.245	1.231	-0.042
	(0.233)	(0.231)	(0.264)	(0.179)
Twice lagged Irish CPI	0.206	0.107	-0.121	1.128
	(0.221)	(0.220)	(0.251)	(0.161)
Lagged Irish real GDP	-0.141	-0.051	0.030	-0.203
	(0.199)	(0.198)	(0.226)	(0.160)
Twice lagged Irish real GDP	0.274	0.130	0.083	-0.203
	(0.198)	(0.197)	(0.225)	(0.160)
Constant	-1.775	1.643	-2.534	0.130
	(0.990)	(0.983)	(1.122)	(0.802)
Trend	0.003	0.003	-0.002	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
Log likelihood:	-557.7998			No. of obs: 56

Note: Standard errors in parenthesis.

Table 4.5: Correlation of shocks under assumption of varying price elasticities

	Aggregate supply shocks		Aggregate demand shocks	
	UK	**Ireland**	**UK**	**Ireland**
Price elasticity	**Price elasticity = -1.0**			
-2.0	0.98	0.95	0.94	0.94
-0.5	0.97	0.96	0.94	0.96

Table 4.6: Correlation of shocks excluding Second World War and excluding data pre-1938

	Aggregate supply shocks		Aggregate demand shocks	
	UK	**Ireland**	**UK**	**Ireland**
	Full sample, 1924-1979			
Excluding Second World War	0.98	0.92	0.93	0.90
Excluding pre-1938 data	0.94	0.88	0.79	0.94
Post-1945 sample	0.61	0.8	0.79	0.88

Figure 4.1: UK and Irish inflation, 1923-1979

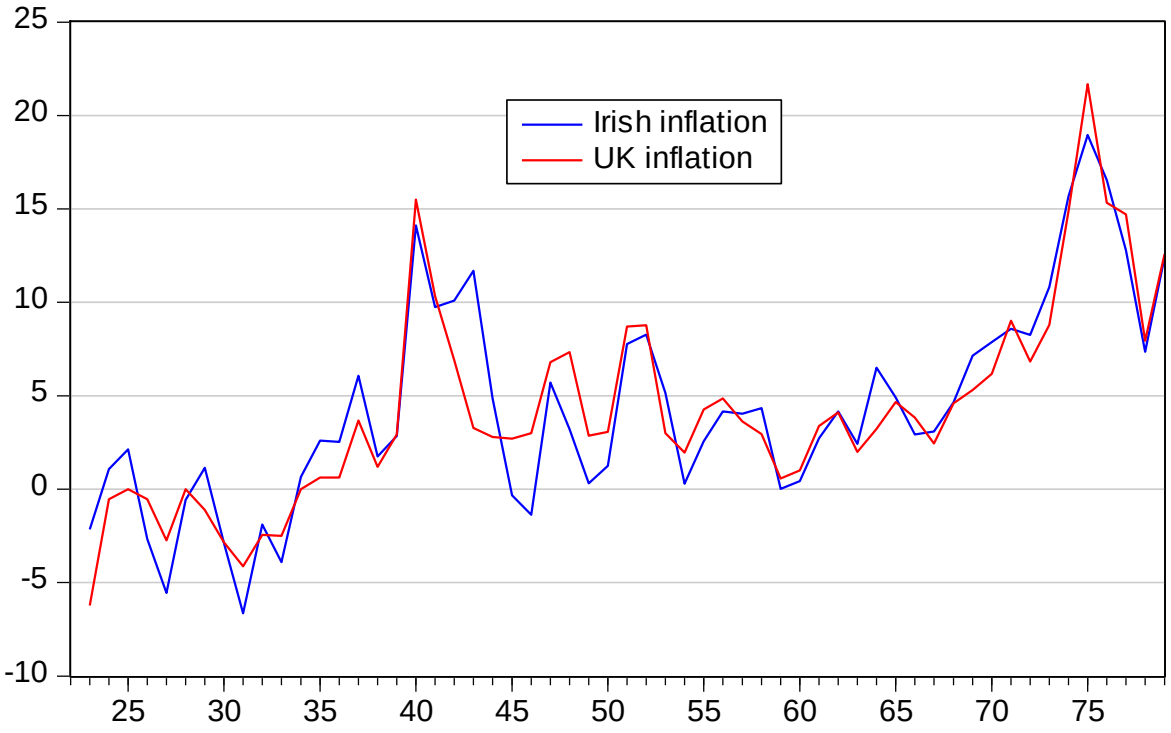


Figure 4.2: UK and Irish real GDP growth, 1923-1979

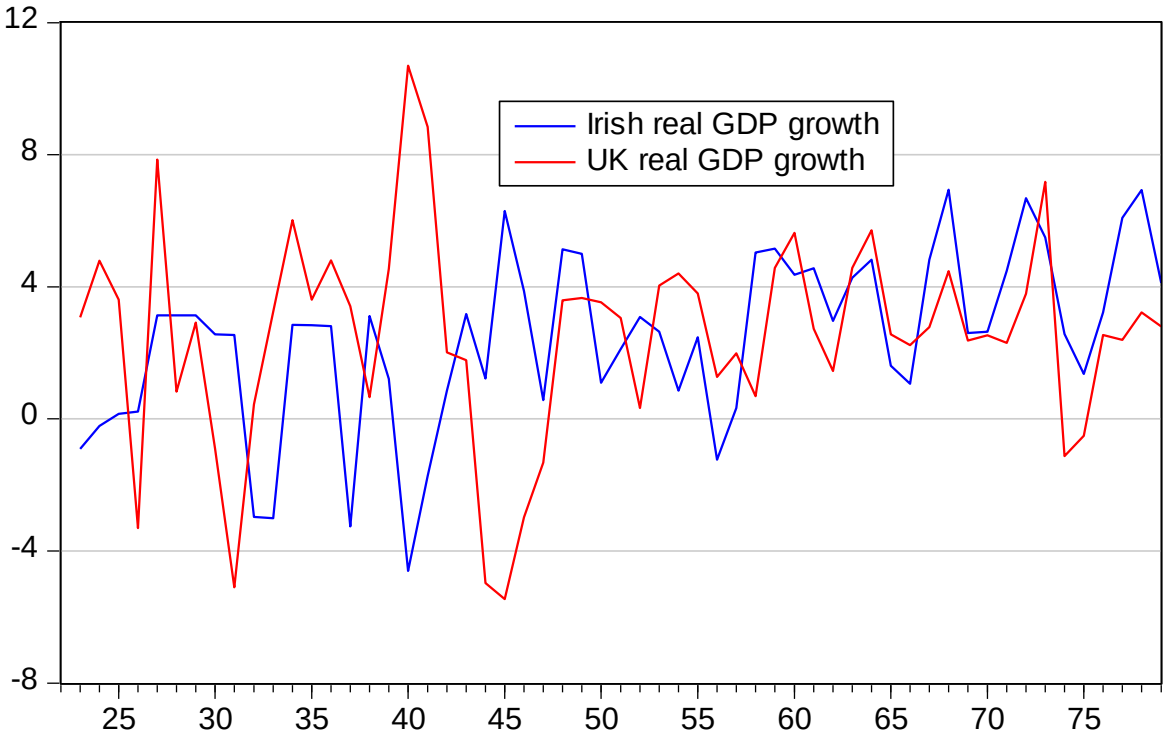


Figure 4.3: Estimated UK aggregate supply and demand shocks, 1924-1979

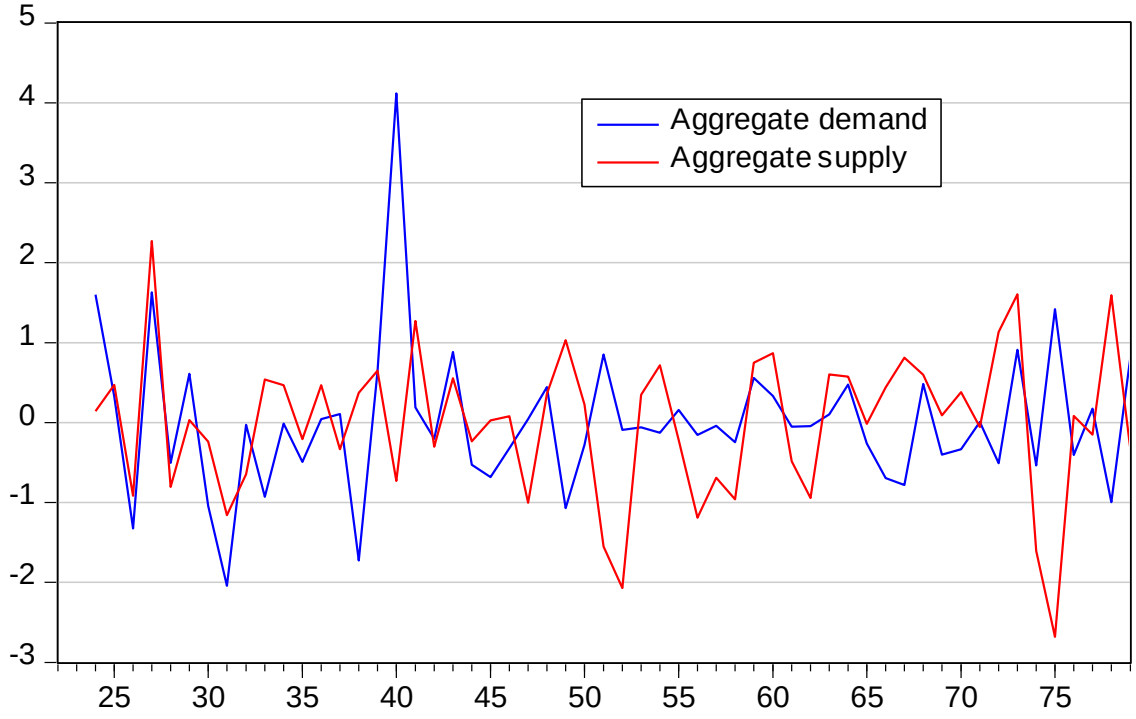


Figure 4.4: Changes in the UK nominal effective exchange rate and UK aggregate demand shocks, 1924-1979

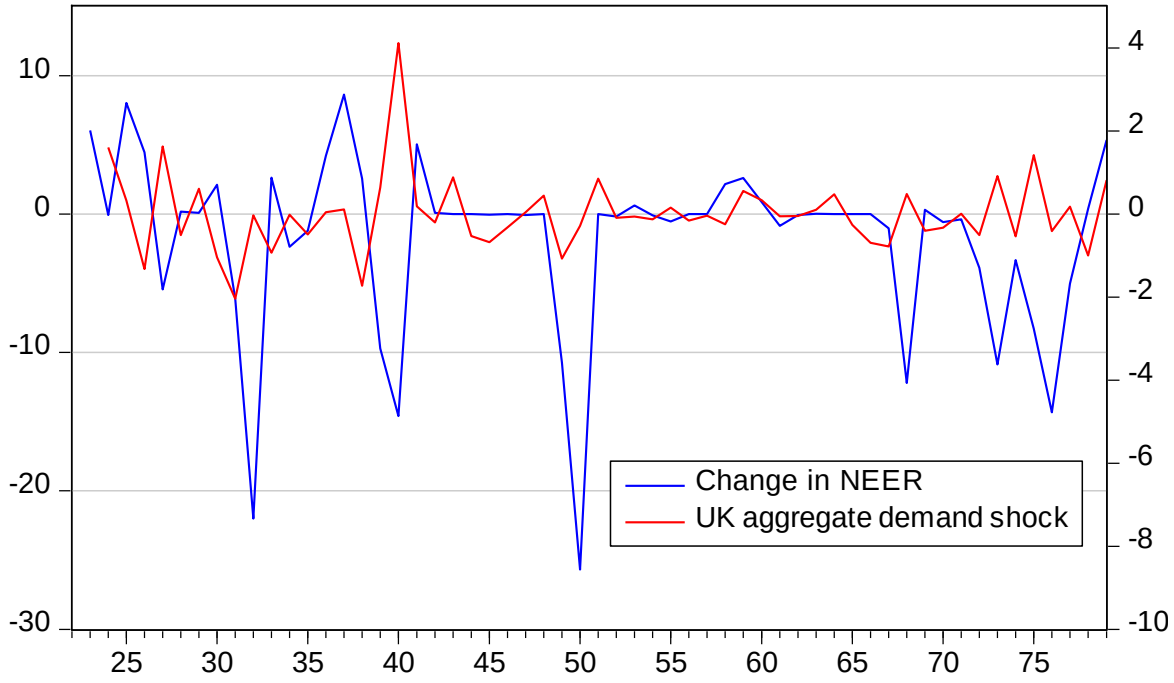


Figure 4.5: Estimated Irish aggregate supply and demand shocks, 1924-1979

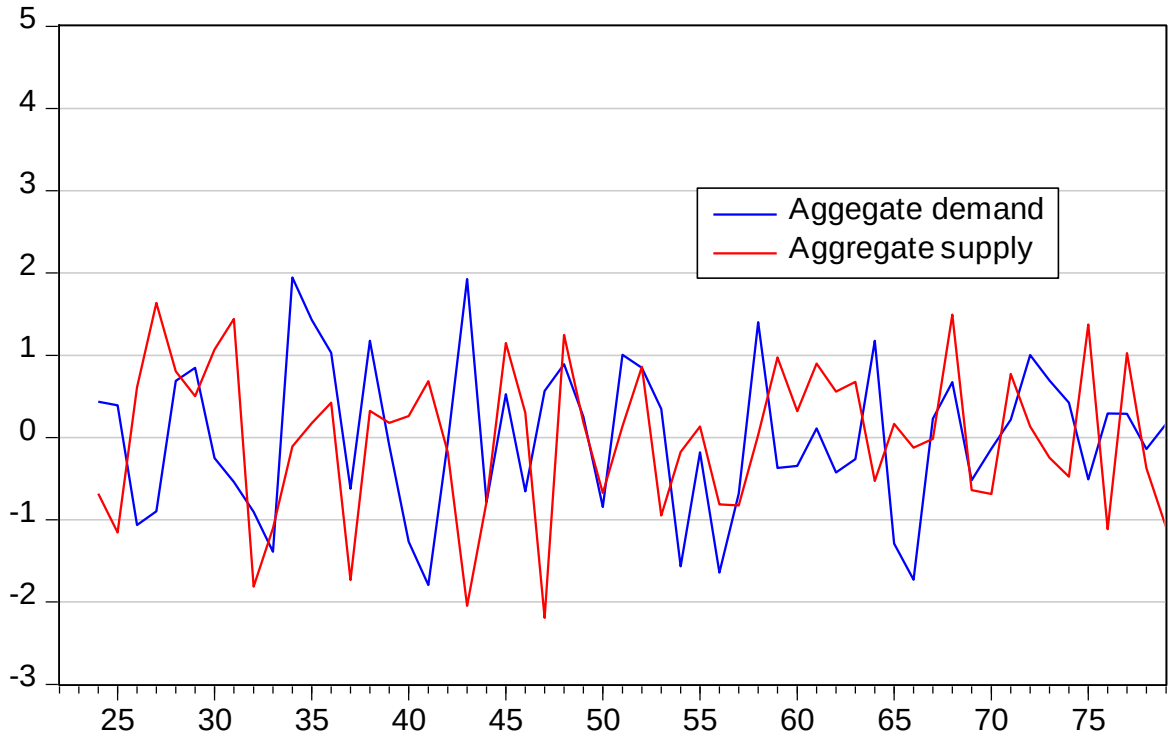


Figure 4.6: Impulse responses to UK aggregate demand and supply shocks

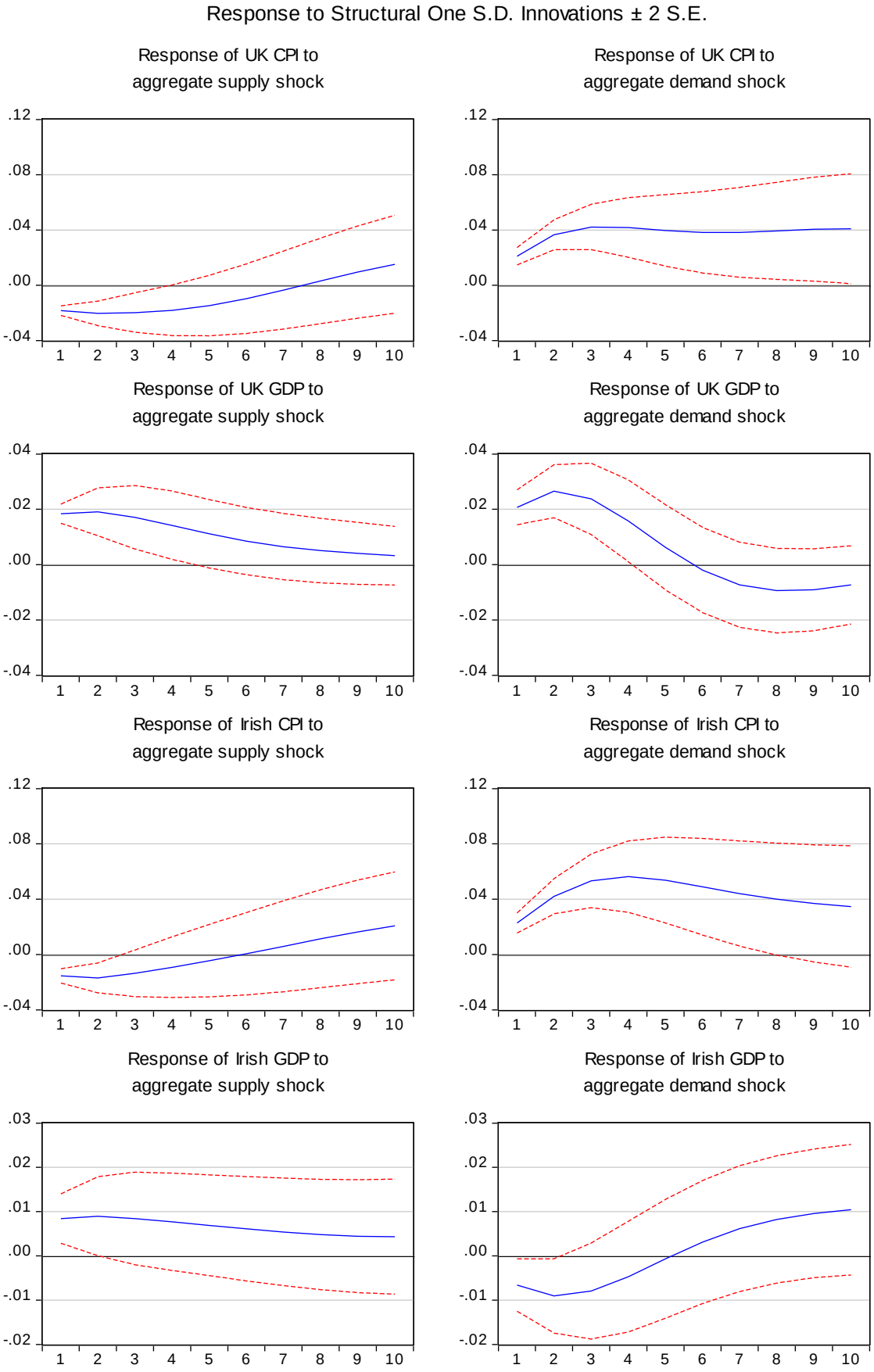


Figure 4.7: Impulse responses to Irish aggregate demand and supply shocks

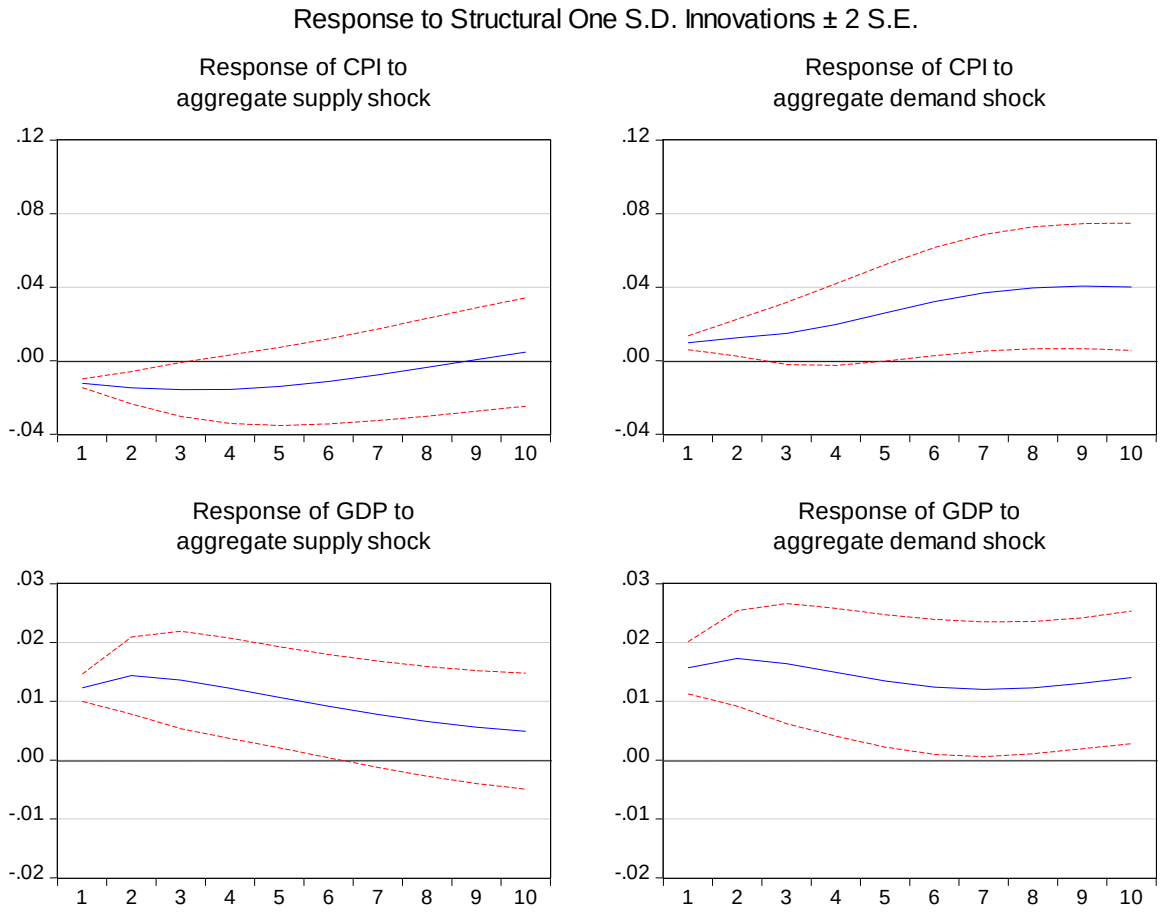


Figure 4.8: Historical decomposition of Irish inflation, 1924-1979

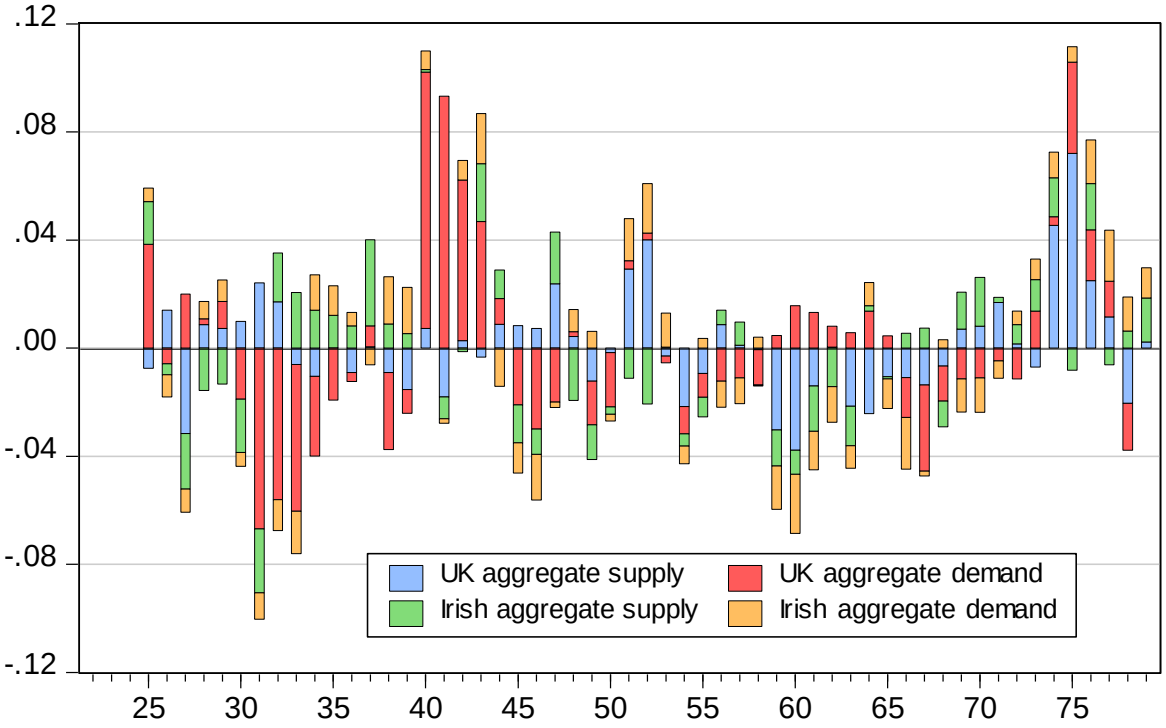


Figure 4.9: Historical decomposition of Irish real GDP growth, 1924-1979

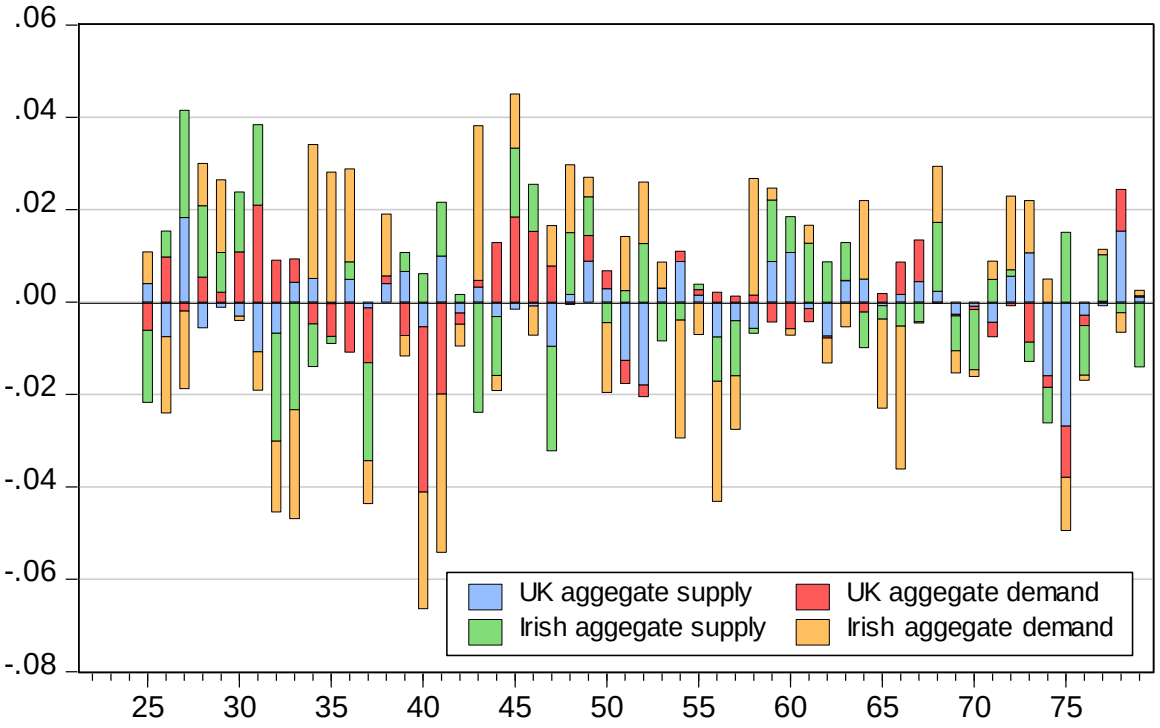


Figure 4.10: Aggregate supply and demand shocks under varying price elasticities

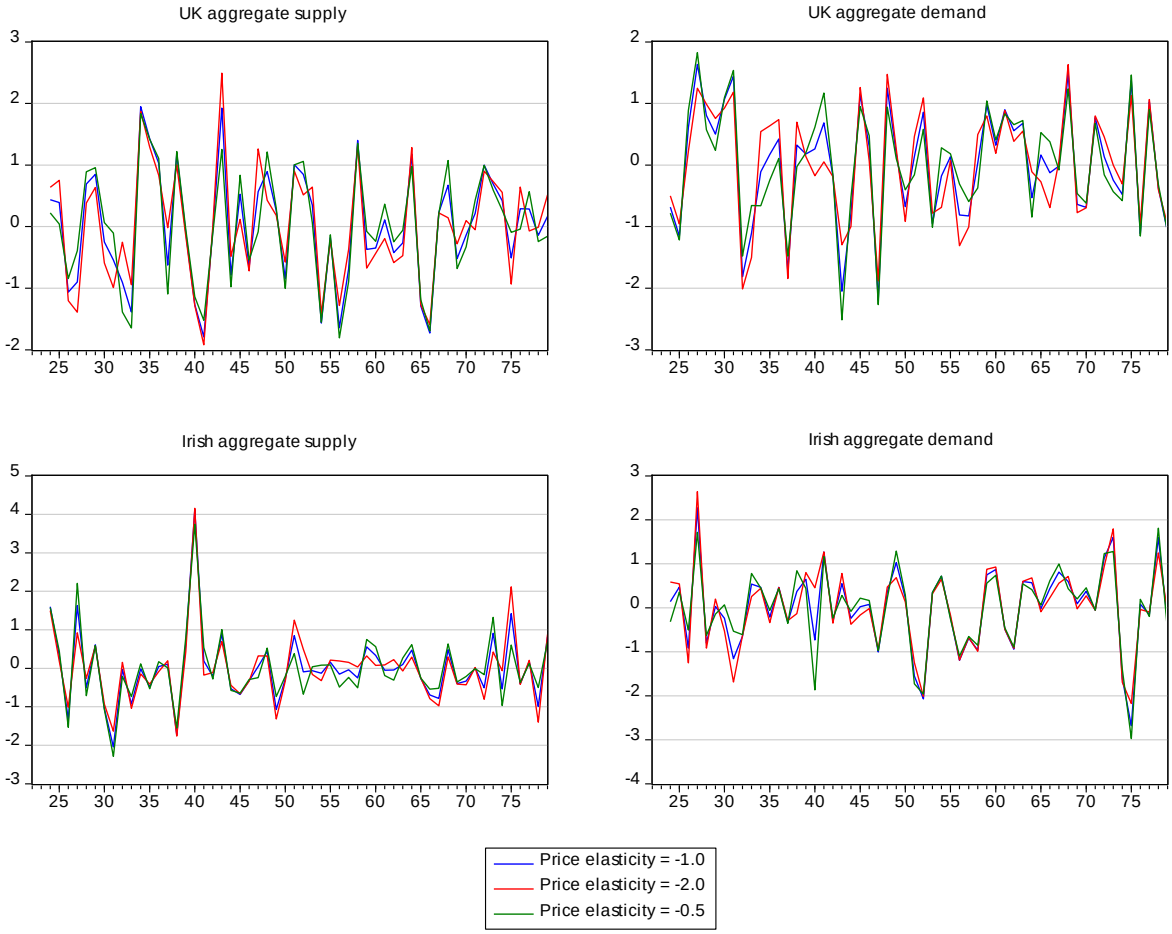


Figure 4.11: Aggregate supply and demand shocks, full sample and excluding Second World War

Figure 4.12: Aggregate supply and demand shocks, full sample and excluding pre-1938 data

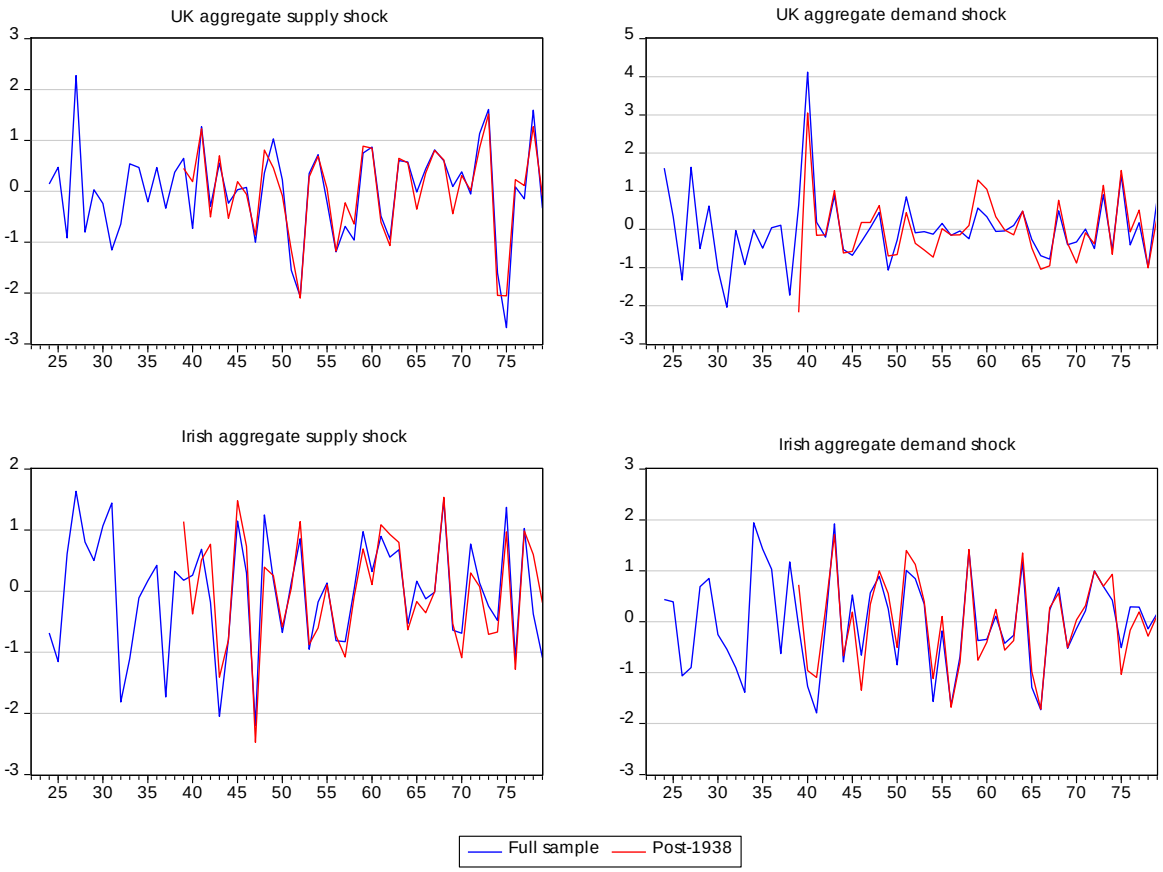
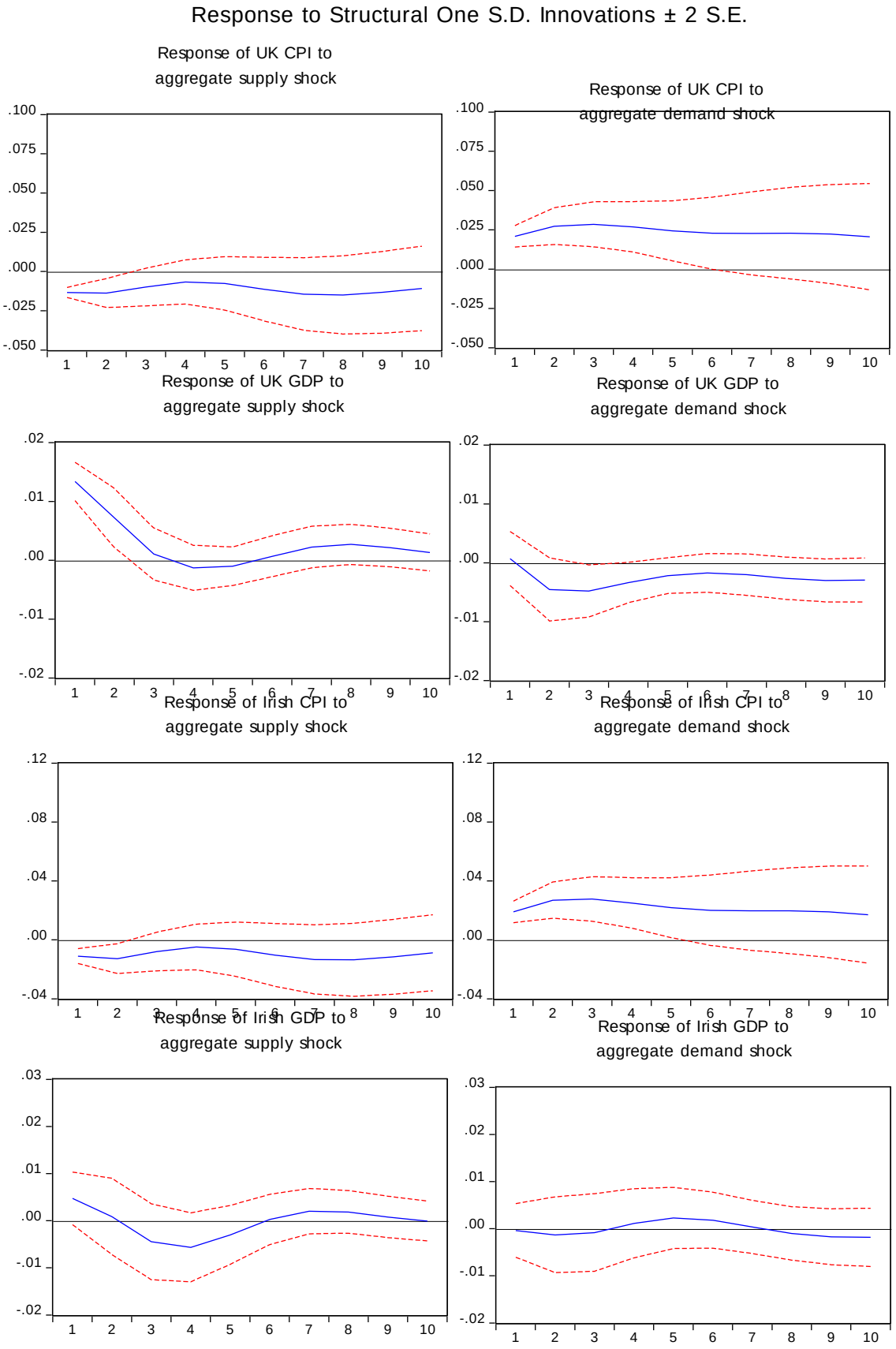


Figure 4.13: Response of UK and Irish CPI and GDP to UK supply and demand shocks, 1946-1979



Chapter 5

70 years of personal disposable income and consumption in Ireland

5.1. Introduction

Although Ireland is a small open economy, domestic factors still play an important role in the business cycle. This was evident during the recent financial crisis when the fall in domestic demand was one of the main drivers of the decline in GDP. Personal consumption, which currently accounts for approximately 60% of domestic demand, declined almost 6.5% in real terms between 2008 and 2013.

Was this unusual, given the severity of the crisis? How did personal consumption develop during previous economic downturns in Irish history? During the crisis real personal disposable income fell by over 17%, far more than personal consumption. How has the relationship between personal disposable income and personal consumption evolved over time? While the international literature on consumption and income is extensive, there are surprisingly few studies on Irish data[95].

Despite this dearth of studies, the economic fluctuations since the 1940s make it interesting to consider the evolution of consumption, particularly in relation to income,

[95] Exceptions include, Kennedy and Dowling (1970), Honohan (1979) and Lyons *et al*., (2009).

over the period. During this time, Ireland moved from the inward-oriented policies of the 1940s and 1950s, through the opening of the economy to international trade in the 1960s and into the global oil crises in the 1970s. These were followed by serious fiscal difficulties for the Irish State. In the 1980s, however, the economy recovered, triggering the Celtic Tiger boom of the 1990s and early-2000s, followed by the construction boom in the mid-2000s which finally ended in 2008 with one of the most expensive financial crises in history. This Chapter uses data over a 70-year period to examine the relationship between personal consumption and personal disposable income throughout these phases of development.

In the first instance, I collect annual data over the period 1944 to 2014 on personal consumption and personal disposable income, and examine the relationship between these variables over the sample period, focussing on the extent movements in personal disposable income can explain the behaviour of personal consumption. Having determined that the series are cointegrated, I estimate an error-correction model of changes in personal consumption and personal disposable income. The model shows that these variables are closely linked. While consumption responds by a fraction of any change in personal disposable income in the short run, in the long run the response is one-for-one. The estimates thus suggest behaviour that is similar to that implied by the permanent income hypothesis.

Nonetheless, a number of Irish and international studies focus on the role played by credit, lending conditions and asset prices in determining consumption demand.[96] I therefore go on to estimate some extensions of the models which, in addition to private disposable income, include financial and macroeconomic variables.

The Chapter is interesting for a number of reasons. First, while these data are available from official sources over the entire period, to my knowledge they have neither previously been compiled into consistent series nor analysed econometrically. Compared to shorter data samples, very long time series such as those used here can make it easier to detect the underlying dynamics in the data, since the relationships between macroeconomic data are often subject to long lags.

[96] See, for instance, Slacalek (2009) for a panel study, and Hogan and O'Sullivan (2007) in the Irish context.

Second, I find that the behaviour of the savings ratio fits well with consumption theory. In particular, I find that the savings ratio tends to be low in periods when a narrative history of the macroeconomy suggests that future income was expected to grow sharply, and *vice versa*. In addition, I find that the savings ratio Granger causes changes in income as one would expect if expectations of future income were an important determinant of consumption. I also find that the savings ratio is stationary, implying that income and consumption are cointegrated.

Third, since the series are cointegrated I estimate an error correction model of changes in consumption. I find a stable relationship between changes in consumption and income over the entire 70-year period studied. Performing dynamic out-of-sample forecasts for this specification indicates that the model performed well through the crisis, although it fails to predict the full extent of the fall in consumption in 2009, the largest decline on record.

Finally, although there are limited time series available for the entire sample period, I test whether interest rates, credit, house prices and unemployment are significant drivers of consumption. I find that all four variables are significant, but that diagnostic tests indicate that the unemployment rate is subject to simultaneity bias and that movements in consumption impact on unemployment.

The Chapter is structured as follows. The next section reviews the economic developments in Ireland during the sample period. In Section 5.3, I discuss some theoretical considerations and empirical evidence. Section 5.4 discusses the compilation of the data and reviews the final series. In Section 5.5, the data are discussed. Here the focus is on the savings ratio, the stationarity of which confirms that consumption and income are cointegrated. Section 5.6 develops an error correction model of the short-run relationship between changes in consumption and income. Section 5.7 extends this model by testing whether financial and macroeconomic variables should also be included. Section 5.8 concludes.

5.2. Historical background

The Irish economy experienced a number of different episodes during the sample period, 1944-2014. In the first instance, it underwent three distinct monetary regimes. Although the Central Bank of Ireland was established in 1943, a one-for-one exchange rate link between the Irish punt and Sterling was the overriding priority of monetary policy. As a result, it has been argued that monetary arrangements in Ireland are best described as those of a currency board, at least until the early-1970s.[97] The consequence was that Irish interest rates were determined with little, if any, reference to domestic economic conditions and interest rates and inflation tended to closely follow those in Britain.

This relationship ended in 1979 when Ireland joined the European Monetary System. This second monetary regime continued to have exchange rate stability as its objective, although the Irish pound was devalued vis-à-vis the Deutsche Mark seven times between September 1979 and January 1987.[98] The pound was devalued by 8% in January 1993, and the EMS bands were subsequently broadened to +/- 15% in the summer of 1993. The third monetary regime began in January 1999 when Ireland became a founding member of European Monetary Union. As a small member of a currency union, Irish interest rates and inflation rates were again largely determined by developments outside of the domestic economy.

In terms of macroeconomic policy, at the very start of the sample period the Second World War, during which the Irish Free State remained neutral, was coming to an end. In the immediate post-war period, the Irish Free State (the Irish Republic after 1948[99]) pursued a policy of import-substituting industrialisation, in an attempt to move closer towards self-sufficiency. Out of step with much of the rest of Europe which experienced a period of strong growth in the 1950s and 1960s, and despite being in receipt of Marshall aid, Irish economic performance was comparatively poor.

The introduction of Whitaker's Programme for Economic Development in 1958 began the process reversing the policy of import-substituting industrialisation, the positive effects of which began to be seen in the 1960s and 1970s. However, the late-1960s and 1970s were

[97] See Honohan (1995).
[98] See Artis and Taylor (1994, Table 1).
[99] 'Republic of Ireland Act' was passed by the Irish Parliament in 1948.

marked by a policy of deficit spending by governments. Spending increased prior to the first oil crisis, with the result that deficits soared with the first oil crisis in 1973 and during the period thereafter. However, as a small open economy, the government spending measures were largely unsuccessful in boosting aggregate demand.

Harsh fiscal measures in the early-1980s finally brought government finances and inflation under control. Alongside extremely successful efforts to attract foreign direct investment (FDI)[100], increases in labour force participation and social partnership agreements which kept wage inflation under control fueled the Celtic Tiger boom of the 1990s. In this period Ireland 'caught-up' for the 'golden age' experienced by much of the rest of Europe after the Second World War.[101] However, the Celtic Tiger progressed from a fundamentals-driven boom during the 1990s to a credit-fueled property bubble in the early-2000s. Coinciding with the bursting of the property bubble in 2008, the global financial crisis following the collapse of Lehman Brothers in September 2008 led to a severe economic contraction.

5.3. Consumption: theory and empirical evidence

5.3.1 Theory and international evidence

The permanent income hypothesis, developed by Milton Friedman[102], is one of the most influential and studied theories of the consumption-income relationship. Consider the utility function for consumption, C_t, of a consumer who lives T periods:

$$U = \sum_{t=1}^{T} u(C_t)$$

Abstracting from the possibility that the individual has any initial level of wealth, and allowing the individual to borrow and save as they wish at an interest rate that we set equal to zero for simplicity, their budget constraint is given by:

[100] By 1995, foreign-owned manufacturing accounted for approximately 45 per cent of employment in manufacturing (Barry *et al*., (1999)).
[101] For a discussion see Honohan and Walsh (2002).
[102] See Friedman (1957) for the original work, and Romer (2001), Chapter 7 for a discussion and formal set-up similar to the one outlined here.

$$\sum_{t=1}^{T} C_t \leq \sum_{t=1}^{T} Y_t$$

The maximization problem[103] is therefore given by:

$$L = \sum_{t=1}^{T} u(C_t) + \lambda\left(\sum_{t=1}^{T} Y_t - \sum_{t=1}^{T} C_t\right)$$

Since the first order condition for C_t is given by:

$$u'(C_t) = \lambda$$

the marginal utility of consumption is constant in every period, implying that consumption should also be constant in every period. Thus the budget constraint becomes:

$$C_t = \frac{1}{T}\left(\sum_{t=1}^{T} Y_t\right)$$

Since this implies that consumption in any period is not determined by income in that period, but by lifetime income, the permanent income hypothesis terms the right hand side of this budget constraint 'permanent income', Y^P, and the difference between the right and the left hand side, 'transitory income', Y^T, such that, at any given time, current income is the sum of permanent and transitory income:

$$Y_t = Y^P + Y^T$$

Here, permanent income can be considered as expected average income, such that it may be above or below the current level of income depending on expectations for the future. Transitory income is the temporary deviations from permanent income that are experienced from time to time. They may persist for a single period or for a number of periods, but over the long run sum to zero.

Now, since saving is the difference between income and consumption, it can be written as:

$$S_t = Y_t - \frac{1}{T}\left(\sum_{t=1}^{T} Y_t\right)$$

[103] Since the marginal utility must always be positive, the budget constraint must hold with equality.

This implies that saving is high when current income is high relative to permanent income, i.e., when transitory income is high. As a result, perceptions of future income are important in consumption decisions. For instance, if people believe their income is likely to rise, perhaps because of a boom in the economy, their current income is below their permanent income. In anticipation of this higher future income, they will raise consumption now, reducing saving.

While it is generally believed that the permanent income hypothesis does a good job in accounting for the broad features of consumption over time, a number of studies formally reject the theory. For instance, Campbell and Deaton (1988) argue that there is little reason to believe that permanent income evolves smoothly over time, so that the implication of the theory that consumption is smooth is not warranted. Of course, if households are able to predict their future income on the basis of current information, consumption could be smooth (since information about income in the far future is discounted heavily and will therefore elicit little response in consumption today). Indeed, the authors demonstrate that the fact that consumption is so smooth appears due to the fact that it responds slowly to changes in income, which may be evidence against the permanent income hypothesis. However, it is also possible that people use simple recursive rules to update their perceptions of permanent income. This highlights how any test of the permanent income hypothesis is also a test of how expectations are formed.

An alternative argument is that credit or liquidity constraints matter. The hypothesis assumes that consumers can borrow and save freely at the same interest rate in order to smooth their consumption in response to transitory shocks to income. These are strong assumptions which are unlikely to hold in practice. For instance, Flavin (1984) uses the unemployment rate as a proxy for the proportion of the population who are liquidity constrained, and finds that such constraints are important in explaining such excess sensitivity of consumption to current income.[104]

[104] On the other hand, DeJuan and Seater (1999), using data from the US Consumer Expenditure Survey between 1986 and 1991, find that the permanent income hypothesis is not generally rejected and that there is little evidence of either liquidity constraints or rule of thumb behaviour. Runkle (1991) studies panel data at the household level to determine whether liquidity constraints exist. He finds no evidence of such constraints, and argues that aggregation of data may lead to rejection of the permanent income hypothesis.

Overall, and recognizing the strong assumptions made by the literature, the permanent income hypothesis is unlikely to be literally true, but notions of permanent income may nevertheless be useful for understanding broad developments in consumption over time.

Campbell and Mankiw (1990) attempt to reconcile these issues with the permanent income hypothesis by incorporating liquidity constraints into a model of consumption. In the extended model, some households are credit constrained and therefore consume their current income, whereas, other households are not credit constrained and can consume relative to their expected income.[105] The authors find that this model fits the data well.

A number of other studies use models which cannot be directly derived from the permanent income hypothesis to understand the drivers of consumption. Of particular relevance are studies using traditional error correction models which have been employed in a number of studies (see, for instance, Davidson *et al.,* (1978) and Davidson and Hendry (1981)). These models are intuitively appealing since they suggests that consumption and income will move together in the long run, as theory suggests, but that there are other drivers of short-run deviations from this path. Recently, variations of this framework have been developed, sometimes including a lagged dependent variable, thus allowing for the role of habits, sticky expectations and adjustment costs – all of which are not considered in the permanent income hypothesis -- in explaining short-run deviations from the long-run relationship (see, for instance, Poterba (2000), Mehra (2001), Ludwig and Slok (2002), Sommer (2007) and Slacalak (2009)).[106]

5.3.2 Studies of consumption and income in Ireland

There are surprisingly few macro studies of Irish consumption and income. Kennedy and Dowling (1970) examine the determinants of the savings ratio over the period 1947 to 1968 and find that the dependency rate, the change in the population, the rate of change

[105] DeLong and Summers (1986), Hall and Mishkin (1982) and Hayashi (1982) consider similar models.

[106] Wealth is also considered an important determinant of consumption, although it does not feature in the permanent income hypothesis. For instance, Carroll, Otsuka and Slacalek (2006) use US data to estimate the short and long-run effects of changes in housing wealth. They find that the one-quarter impact of a $1 increase in wealth is to increase consumption by approximately 2 cents, while the long-run effect is approximately 9 cents. Similarly, Case, Quigley and Shiller (2005) examine the effect of house price on consumption in a panel of developed countries, and find that a 1% increase in housing wealth increases consumption by approximately 0.11%.

in credit growth and measures of taxation are significant determinants. Interestingly, they also find that while real income per capita is a significant determinant of the savings ratio, real farming income per capita has more explanatory power. Honohan (1979) examines the role of inflation in the consumption decision over the period 1947 to 1976. He argues that in periods of high inflation, such as those prevailing during the 1970s, consumers can mistake high prices of goods they usually purchase as high relative prices, rather than a reflection of a generally rising price level, and that this may lead to lower than expected consumption. Ryan (2003) examines quarterly Irish consumption data over the period 1981-1999 in an error correction framework and finds that disposable income and wealth have explanatory power in determining long-run consumption, while changes in unemployment and real interest rates determine short-run consumption. Hogan and O'Sullivan (2007), investigating the role of housing wealth in Irish consumption patterns, find that income and real interest rates are the main determinants of consumption over the period 1972-2003.[107] Slacalek (2009), using data from the 1970s to the early 2000s for a panel of 16 countries, finds that the role of lagged consumption in determining current consumption is relatively high in Ireland, but that changes in wealth have little effect.

Other work on consumption includes Lyons *et al*., (2009), who study consumption patterns in Ireland over the period 1975 to 2003, finding that although income per capita increased rapidly, consumption patterns had not fully converged to those of higher-income countries. Some focus has also been placed on the role of Ricardian equivalence. Moore (1987) considers Irish consumption over the period 1960-1984, and finds evidence in favour of Ricardian equivalence-type behaviour.[108] However, Whelan (1991) argues that Moore's test specification and data are inappropriate, and that when these are altered accordingly, there is no evidence of Ricardian equivalence.[109]

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[107] Although they find that the marginal propensity to consume out of housing wealth is zero.

[108] Walsh (1988) confirmed that Moore's results were robust to data revisions and changes in definition.

[109] There has also been discussion of expansionary fiscal contractions. Giavazzi and Pagano (1990) argue that an expansionary fiscal contraction in Ireland during the 1980s was curtailed by traditionally tight credit conditions. On the other hand, Bradley and Whelan (1997) use a small structural model to argue that external factors, rather than an expansionary fiscal contraction, explain Ireland's growth. Furthermore, Corsetti *et al.,* (2012) find that fiscal multipliers increase during financial crises, suggesting that contractionary fiscal policy can have markedly negative impacts on consumption.

The lack of papers examining consumption and income in the long run means that many questions are left unanswered. For instance, the finding that farming income was important in determining consumption in the 1940s and 1950s, inflation in the 1970s, unemployment in the 1980s and 1990s, and interest rates during much of the housing boom, suggests that results may to some extent be driven by the sample periods examined. What is the relationship between consumption and income in Ireland over the long run? How does consumption behaviour compare to theory? Can a stable relationship explaining consumption be identified over an extended sample period? I next turn to these questions.

5.4. Data description

5.4.1 Compilation of the data

In this Chapter, I use annual real personal consumption and real personal after tax (disposable) income, hereafter referred to as 'consumption' and 'income' for simplicity. The data are all taken from official Central Statistics Office (CSO) sources. However, no single, consistent time series is available over a 70-year period. In the absence of objective criteria for constructing long time series, the current vintage of data is used as far back as possible under the assumption that it is subject to smaller measurement errors than older vintages. Older data are then spliced by re-basing the series.

Data from 1944 to 1946 are taken from a 1951 CSO publication, Tables of National Income and Expenditure (NIE). This is the earliest CSO NIE publication that I have found.[110] For the period 1949 to 1970, the CSO published NIE tables annually which are available in hard copy and contain data for the period to 1947. In particular, I use the NIEs from 1968 and 1977 which contain extended appendices providing data back to 1947 and 1960, respectively. From 1970 to 1995, data are available from the CSO's historical NIE spreadsheet which is available online. Thereafter, the CSO's online database provides the data.

[110] Prior to this, a government White Paper in 1946, contained data for the period 1938 to 1944. However, it appears that the rubric of NIE tables was not established at this time, and some key data, such as personal income, is not available, even though private income (personal income plus corporate profits) and personal consumption are.

One important data issue arises from a difference in the level of consumption in the CSO's online historical spreadsheet and in the NIE hard copy publications. This appears to be due to an adjustment for depreciation which raises the level of consumption in the 1970 spreadsheet compared to the data for the earlier period. While the growth rates in the various vintages of data during the 1970s are similar (Figure 5.1), the level change creates a difficulty in splicing the data. This is because re-basing the pre-1970 consumption data raises the level of consumption relative to income, skewing the consumption-income ratio. In fact, the effect is to increase the nominal level of consumption above that of income for much of the early period, which is unreasonable (Figure 5.2).

I use three different methods of splicing the data to deal with this problem, and hereafter refer to the resulting series as Consumption 1, Consumption 2 and Consumption 3:

- Consumption 1: I estimate a trend consumption-income ratio over the entire sample period using a Hodrick-Prescott filter[111]. I then use the level of the filter in 1969 to calculate consumption in that year, and splice the older data using this figure.
- Consumption 2: This is similar to the previous method, but I use a band-pass filter[112] to estimate the level of the ratio is 1969, and splice the older data using this value.
- Consumption 3: For this method, I take the consumption-income ratio from the nominal data in each period, and use it to calculate the consumption series before 1970. This ensures that the consumption-income ratio is unaffected by the level change in the consumption data.

Figure 5.3 shows the three consumption measures in log differences over the period 1944 to 1970. The effect of the various methods of splicing the data is to shift down the level of consumption over the period. Table 5.1 shows the correlation coefficients of the changes in all three series: all are in excess of 0.98.

[111] Since the data are annual, $\lambda = 100$ is used in the filter.
[112] With a frequency band of 2 to 8 years.

For the entire period, both real and nominal consumption data are available. Real income data are not available during the period. I use a consumption deflator, calculated from the original nominal and real consumption expenditure data to deflate the income series. I do not adjust these for the step change in consumption, since any change which affects the levels of both series equally falls out of the deflator. The consumption deflator is preferable to a GDP deflator here, since a consumption deflator takes account of the impact of taxes on income, whereas a GDP deflator will not allow for this.

5.4.2 Review of the final series

Figures 5.4 and 5.5 show the three measures of consumption along with the final income series in log levels and log differences. It is clear from the figures that income and consumption move closely together. Both series increase quite rapidly in the period immediately after the Second World War, before slowing in the late-1940s and through much of the 1950s as the negative effect of the policy of import substituting industrialization is felt. Towards the very end of the 1950s the series begin to grow more strongly again as the effect of the Whitaker Plan and the opening of the economy takes hold. This period of growth continues, with a brief slowdown for the oil crisis in 1973 until the late-1970s and early-1980s when tight fiscal policy was required to bring finances under control following the deficit spending during the oil crises period. Thereafter, the series begin to increase again, become more rapid during the late-1990s and early-2000s, before the bursting of the property bubble and the financial crisis cause the most marked and persistent reduction in income and consumption in the sample period.[113]

The same pattern is evident from the growth rates in the series presented in Figure 5.5. This chart also shows that there several episodes when consumption rises strongly in advance of income increases, for instance in 1947 consumption grows rapidly, whereas income does not grow at a similar pace until 1949. Similarly, in 1970, the growth in consumption appears to anticipate the growth in income two years later, and again in 2000, consumption growth is high in advance of strong income growth the year after.

[113] An interesting question is how per capita income and consumption evolved. However, the growth rate of the population (using data from the CSO interpolated using a cubic spline from 1944 until annual estimates become available in 1992) is so low and stable compared to that of both income and consumption that per capita growth rates are almost identical to those in Figure 5.5.

While the first instance of this, in 1947, may partly reflect increasing consumption resulting from the end of forced saving during the Second World War, these observations suggest that income expectations, which the permanent income hypothesis holds as the dominant determinant of consumption, played a crucial role in Ireland. I discuss this issue further in the next section.

5.5. The savings ratio

In this section I study the relationship between consumption and income data more formally. In doing so, I consider the evolution of the savings ratio, and what can be learnt from this. Letting lower case letters denote logs, the savings ratio is defined as $y_t - c_t$. Here, the savings ratio can be thought of as the fraction of income not consumed.

While a large body of literature rejects the permanent income hypothesis, it is nonetheless interesting to explain some implications of this theory. In particular, it is interesting to see whether changes in the savings ratio anticipate future income, which would be expected if people base their consumption decisions today on their expectation of future income.

5.5.1 Narrative discussion of the savings ratio

I first take a narrative approach in considering whether historical developments in the Irish macroeconomy can explain changes in the savings ratio in light of the permanent income hypothesis.

Figure 5.6 shows that the savings ratio fell in the immediate post-War period, implying that consumption is high relative to income. This is consistent with expected income rising as uncertainty about the outcome and duration of the War is removed[114], the Wages Standstill Order (which regulated wages from 1941 to 1945) is removed, and rationing is lifted.[115] Consumption falls relative to income in 1952 and 1953 during the Korean War. Following the experience of the Second World War, the outbreak of the Korean War resulted in hoarding and uncertainty about the scope and scale of the conflict. As a result,

[114] In this instance, forced saving during the war may partially explain this result, as well as anticipated future income increases.
[115] CSO (2000) reports that rationing of most items was lifted in 1949.

expectations of future income fell, since the war might have dragged on, and resulted in much greater loss and disruption than it eventually did.

The savings ratio fell again in 1958, which coincides with Whitaker's Economic Development plan. It may be that there was an increase in expected income as a result of changing economic policy in that year. Another fall in the savings ratio takes place in 1970-1972, immediately before the first oil crisis. This was the period of changing government spending policy and real wage increases, which may have raised expectations of future income. The oil crisis in 1973 changed this, however, and the ratio is high throughout the period 1973-1978, as the country struggled to deal with the effects of high fuel prices, slowing economic activity and rising fiscal deficits. Thereafter, the ratio gradually declines through the late-1980s as the resulting dire sovereign debt position is brought under control, and it began to appear that Ireland may be fiscally viable.

The emergence of the Celtic Tiger boom in the 1990s resulted in an initial rise in the savings ratio, but after 1997, consumption rose rapidly relative to income, with spending actually higher than income in 2000. The ratio falls in 2006 and 2007, consistent with a belief that the property bubble was in fact fundamental, and that high income levels would persist into the future. However, the bursting of the property bubble, and the reappraisal of likely future income that resulted thereafter, led to a dramatic rise in the ratio between 2007 and 2009. The recovery of the economy in more recent years is likely to have increased expectations of future income, and as a result the ratio has risen again to very high levels.

5.5.2 Granger causality and stationarity

I next consider two properties of the savings ratio. The first is whether the savings ratio Granger causes income, and the second is whether it is stationary.

The results of Granger causality tests are presented in Table 5.2 for savings ratios calculated using all three measures of consumption. This test is employed to examine whether changes in consumption anticipate changes in income as theory would suggest, and should not be interpreted as implying causality between the variables. The test is run

using two lags.[116] In all cases, the null that saving does not Granger cause changes in income can easily be rejected, whereas the null that changes in income do not Granger cause saving cannot be rejected, even at the 10% level. This suggests that changes in saving anticipated changes in income and is evidence in favour of the permanent income hypothesis in Ireland.

The second test I perform is for the stationarity of the savings rate. This is because in the long run, changes in income should pass fully through to changes in consumption with the result that the two series are cointegrated. As a result, the difference between consumption and income – saving – should not trend over time, but be stable around a mean. In Table 5.3, I present Augmented Dickey Fuller and Elliott-Rothenberg and Stock (ERS) unit root tests for the three measures of consumption. All tests reject the null of a unit root at the 1% or 5% level, with the exception of consumption calculated using method three, when a trend is included in the ERS test. However, overall, the evidence seems in favour of the stationarity of savings, indicating that income and consumption are cointegrated. This suggests that, in the long run, changes in income are reflected one for one in consumption.

5.6. The short-run relationship between consumption and income

5.6.1 Specification

Since consumption and income are cointegrated and therefore in the long-run changes in income pass through fully to consumption, it is interesting to consider the short-run relationship between consumption and income. This I do in an error correction framework (for similar models see, for instance, Davidson *et al.*, (1978), Davidson and Hendry (1981), Mehra (2001) and Ludwig and Slok (2002)).

I first construct a simple model where the log change in consumption, c_t, is determined by log changes in current income, y_t, lagged log changes in income and consumption and

[116] In a VAR, the Schwarz information criteria indicates that one lag is appropriate, while the Hannan-Quinn criteria indicates that two lags are appropriate. However, a lag exclusion test indicates that the second lags are jointly significant, and they are therefore included in the test (p-value = 0.01).

the lagged savings ratio.[117] Since the lag structure is not known a priori, I include two lags of income and consumption in the initial model, which can thus be written:

$$(1) \qquad \Delta c_t = \alpha_0 + \alpha_1 \Delta y_t + \alpha_2 \Delta y_{t-1} + \alpha_3 \Delta y_{t-2} + \alpha_4 \Delta c_{t-1} + \alpha_5 \Delta c_{t-2} + \alpha_6 (y_{t-1} - c_{t-1}) + \varepsilon_t$$

where, Δc_t denotes change in consumption in period t, Δy_t denotes change in income and ε_t is an error term.

This model is deliberately over-parametrised and all lags are unlikely to be needed, especially when it is considered that the data are annual. However, since we have no priors about the lag patterns, I begin with this loose specification and let the data speak. I do so by using general to specific modelling. This indicates that the first lag of income and the second lags of both income and consumption are not needed and should be removed from the equation. The final specification can be written as:

$$(2) \qquad \Delta c_t = \alpha_0 + \alpha_1 \Delta y_t + \alpha_2 \Delta c_{t-1} + \alpha_3 (y_{t-1} - c_{t-1}) + \varepsilon_t$$

As would be expected, lagged savings are significant and act as an error correction term in the model, since the savings were shown to be stationary above, implying a unit long-run relationship between consumption and income. The coefficient on savings indicates the speed of adjustment to the log run relationship in response to short-run deviations.

5.6.2 Results

The results of the model are presented in the first column of Table 5.4 for consumption constructed using the first method (Consumption 1). There is no significant difference in the results if the other consumption series are used, and therefore for brevity they are not included here. The results indicate that 1% rise in current income result in a 0.49% increase in current consumption. The error correction term has a coefficient of 0.31 indicating that almost one third of any deviation from the long-run path is offset in the year after it occurs.

Over a 70-year period the relationship between the variables may have changed. However, a Bai-Perron multiple breakpoint test[118] indicates no breaks at the at the 1%

[117] Here savings is the error correction term, since it is the difference between income and consumption.

level. A Quandt-Andrews test similarly fails to reject the null of no breaks in the in the equation.[119] [120] The Durbin-Watson statistic (1.79) indicates serial correlation is unlikely to be present in the residuals and a LM test for serial correlation confirms this.[121] Finally, a White test indicates no heteroskedascity present in the error term (p-value = 0.94).

One question that arises concerns the consumption of durable goods. Many studies use only the consumption of non-durable goods and services, however, such a breakdown of consumption is not available over the sample period in question. Mankiw (1982) has argued that the durability of goods can introduce a first-order moving average term into the change in consumer expenditure. However, a first order moving average term was not significant when it was introduced into the model (p-value = 0.13).

5.6.3 Endogeneity of income

The econometric analysis above has assumed that income is exogenous. As an exogenous shock to consumption increases demand, and is therefore likely to increase also income, this seems unlikely. This means that Δy_t could be correlated with the error term, ε_t. The question therefore arises as to whether the estimated parameter on income is subject to endogeneity bias.

To examine this possibility, I use a Durbin-Wu-Hausmann (DWH) test to determine whether or not income is endogenous. This test requires that the current change in income is instrumented, and the equation estimated using two-stage least squares (TSLS). The test statistic is distributed as a Chi-squared random variable with degrees of freedom equal to the number of regressors tested for endogeneity.

In the first instance, instruments for income must be identified. Any lagged values of income or consumption are potentially valid instruments, since they are orthogonal to ε_t

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[118] Test is run with a trimming of 15%, 5% critical value: 16.19, scaled F-statistic: 10.02.

[119] Maximum LR F-statistic p-value = 0.31.

[120] Furthermore, it may be expected that the shift in consumption in 1969 might have an impact on the results. To address this, I first include a dummy that takes a value of 1 prior to 1970, however, it proves to be highly insignificant (p-value = 0.81). As the consumption-income ratio rises in the 1950s, it is possible that the shift in consumption declines over time. I therefore interact the dummy variable with a linear trend, but it remains insignificant (p-value = 0.80). However, an inspection of the residuals from the regression indicates a large outlier in 1970. I therefore include a dummy that takes the value of 1 in 1970 in this and the following regressions.

[121] F-statistic (2, 61), p-value = 0.85.

if the model is correct. Furthermore, as pointed out by Goodfriend (1986), aggregate variables are not available in real time and using lagged variables as instruments can alleviate the problem of what is known to an individual when making their decision.

However, instruments must also explain income well in order to be valid. Stock and Staiger (1997) proposed that, in the case of a single variable potentially subject to simultaneity bias, for an instrument not to be weak, in the first stage regression the F-statistic should be greater than 10. Stock and Yogo (2005) refined this further, presenting a set of critical values based on the number of endogenous variables, instrumental variables and the maximal acceptable level of bias against which the first stage F-statistic can be compared.[122] If the F-statistic exceeds the appropriate critical value, the instruments can be considered strong, at the 5% level.

While it may at first appear that lags of income are likely to be the best instruments, the permanent income hypothesis suggests that lags of consumption may be better, since consumption in one period is based on expectations of consumption in future periods. Since the first lag of consumption is already included in the model, it is not a candidate instrument. However, the second lag of consumption is a possible instrument. Furthermore, variables not included in the original model can also be considered as instruments. As such, lagged changes in real GDP are a possible instrument. GDP may be a particularly good predictor of future income if wages are sticky and take some time to adjust to changes in the macroeconomy.[123]

The first stage regression indicates that neither of the lags of income are significant at the 5% level. I therefore use only the first lag of GDP and the second lag of consumption as instruments. The first stage F-statistic and the Stock and Yogo (2005) critical values are presented in the second column of Table 5.4. Since the F-statistic exceeds the critical values, the instruments appear strong. The TSLS results are also presented in the second column of Table 5.4, together with the p-value for the DWH test. When income is instrumented, it remains significant in the regression, and the DWH test indicates that we

[122] These critical values are taken from Table 5.2 on page 101 of Stock and Yogo (2005).
[123] GDP data are taken from Gerlach and Stuart (2015) who describe how they are compiled in detail.

cannot reject the hypothesis that income is in fact exogenous (p-value 0.28). I therefore proceed under the assumption that it is exogenous.

5.6.4 Dynamic forecast

Finally, I re-estimate the model up to 2006, and present the results in the third column of Table 5.4. The model passes the same stability and residual diagnostic tests as the full sample model. A dynamic out-of-sample forecast together with a 95% confidence band is then calculated for 2007-2014, the period of the financial crisis and its aftermath (Figure 5.5). The forecast captures the crisis period well; the actual data are within the confidence interval with the exception of 2009, at the height of Ireland's financial crisis. Indeed, this crisis is unusual since the one-period drop in consumption is by far the largest on record at -5.5%. For instance, in the period immediately after the second oil crisis consumption falls by a similar percentage, but over two periods, rather than one. The fact that shock in 2009 was so large that consumption declines very sharply even before income starts to decline, may explain the model's failure to forecast consumption in that year.

5.7. Extensions

Having estimated a model of the relationship between consumption and income growth that is stable over a 70-year period, in this section I consider some other variables which may influence consumption. While there are limited data series available over this extended time period, here I examine interest rates, unemployment, household credit growth and house prices.

5.7.1 Interest rates

Friedman (1957) argues that the rate of interest at which consumers can borrow and lend will influence consumption. Since the rate relates both to borrowing and lending, nominal short or long term interest rates may be important, and I will therefore test each.[124] Here I

[124] Real interest rates, calculated using either the consumption deflator or CPI (which is available from the CSO for the full sample period), are not significant.

use nominal short and long term interest rates from Gerlach and Stuart (2015), who describe their compilation in detail.[125]

The first column of Table 5.5 shows the regression results when short and long interest rates are included in the model. Since short rates are insignificant, they are dropped in the regression results in the second column. In both columns, the coefficient on the long term interest rate is significant and negative, implying that when rates fall, the return to saving declines, and people consume more of their income.

It is likely that rates are exogenous since Ireland operated on fixed exchange rate over the sample period and domestic interest rates were largely driven by external factors, rather than domestic activity. However, it is possible that long-term rates are endogenous if, for instance, interest rates rise because of high consumption, as might be the case during an economic boom. I therefore repeat the Durbin-Wu-Hausmann test, instrumenting for long term interest rates. I find that the first lag of interest rates is a strong instrument based on Stock and Yogo (2005) critical values and these, along with the results of the TSLS regression. The fact that the instruments are strong, but the coefficient on instrumented interest rates in the TSLS regression is insignificant suggests that the variable may be endogenous. However, the DWH test p-value, which is included in the third column of Table 5.5, indicates that the test fails to reject the null that interest rates are exogenous.

5.7.2 Unemployment rate

The unemployment rate could matter for consumption because it signals the degree economic uncertainty. When unemployment is low, it is possible that people feel confident in their job security, or their ability to find an alternative job quickly if necessary, and therefore they are willing to spend more. Similarly, when unemployment is high, people worry about their future income prospects since the risk of becoming unemployed would seem high. As such, they may reduce consumption today. On the

[125] In brief, the short rate is based on the annual average of the open-market rate of discount in London, quoted in Homer (1963, pp. 417-420) for the period 1944 to 1962 as a proxy for Irish short-term rates, a discount rate from the IMF for the period until 1984, and data on the short-term rate from the OECD for the most recent period. Long-term interest rates prior to 1952 are proxied using UK interest rates taken as the mid-point of annual high and low bond yields reported in Homer (1963). Thereafter, data from the IMF's International Financial Statistics (IFS) are from 1952 to the present.

other hand, such uncertainty may lead people to emigrate, thus reducing the unemployment rate.[126]

Unemployment rate data are taken from Gerlach *et al.,* (2015), and are compiled using data from Mitchell (2007) for the period 1944 to 1982, while for the period thereafter data are available from the Central Statistics Office (CSO). When added individually, both unemployment and lagged unemployment are insignificant.[127] However, when both are added to the equation, they are significant (Table 5.5, column 4). Although the sign on lagged unemployment is counter-intuitively negative, it is smaller in magnitude than the coefficient on current employment, such that the overall effect of an unemployment shock is positive.

Again, endogeneity is a possibility. When more goods are consumed, output must increase to meet demand, and jobs are created. While the lagged unemployment rate is by definition exogenous, I next instrument the current rate using lagged GDP growth and the twice lagged unemployment rate. These are strong instruments, and the F-statistic well in excess of the Stock and Yogo (2005) critical values. The results are presented in column 5 of Table 5.5. The coefficient estimate for the unemployment rate is very different when it is instrumented, and the unemployment rate becomes insignificant, despite the strength of the instruments. The DWH statistic is 0.06, implying that the unemployment rate may be endogenous. It therefore appears that the unemployment rate should not be included in the model.

5.7.3 Credit growth

Next I consider the role of credit growth. It may be that increased credit availability leads people to borrow more, and thus increases consumption. This is a common assertion in the literature since Flavin (1984). Similarly, Blundell-Wignell *et al*., (1995) explore the effect of financial liberalization, during which credit availability increased, on consumption within the framework of the permanent income hypothesis. On the other

[126] See, for instance, the discussion in Honohan (1992) of the role of emigration in stabilising Irish unemployment rates.

[127] A Bai-Perron multiple breakpoint test indicates that there is a break in 1999. An inspection of the residuals indicates that there is a large residual in 2000; when a dummy is included for this, no break is detected.

hand, it is likely that as expectations of future incomes rise, people borrow more to increase current consumption. In this case, consumption drives credit growth rather than *vice versa*. It is therefore not entirely clear whether credit growth is endogenous or exogenous in the model. I therefore proceed to test the role of credit growth in the same manner I have the other variables above.

Credit data are collected for the personal sector from Central Bank of Ireland Quarterly Bulletins. The earliest sectoral lending data available are from 1948. At that time, lending to the 'personal and professional' sectors were categorized together. Only in 1968 was personal sector credit split out separately. Data on lending by building societies for residential mortgages is available from 1959 onwards, and these are added to bank lending from when they become available until 1996 when building societies were re-classified as banks. From 1971 onwards, the data are taken from Sherman (2015). There are two years in the series for which growth rates are not available. The first year for which there is no growth rate is 1967, since there is no overlap between the old and new series when personal and professional lending are split. I apply the 1968 growth rate to 1967. The data are made real using the CPI. Data are also missing in 1970 as a result of the bank dispute. I take three approaches to this. First, I halved the change in the level of lending between 1969 and 1971, so that the increase is the same in each of 1970 and 1971. However, since the banks were closed, it is likely that credit growth in 1970 accounted for less than the full increase between 1969 and 1971. In the second approach I therefore set the growth rate equal to zero in 1970, and attributed the full increase in credit over the two-year period to 1971. Finally, in the third approach, I assume that credit fell by 5% in 1970, and that this is 'made up' in 1971.

The OLS results using the credit growth constant growth rate over the 1970-1971 period are presented in column 6 of Table 5.5. They indicate that credit growth is significant, and that increases in credit result in increases in consumption, as would be intuitively expected. In column 7, credit growth is instrumented using lagged credit growth which is a strong instrument when it is compared to the Stock and Yogo (2005) critical values. Credit is significant at the 5% level in the TSLS estimates, but the DHW test indicates that

it is just exogenous (p-value = 0.14). Using the alternative specifications of credit in 1970 returns similar results (p-value = 0.12 and 0.11, respectively).[128]

5.7.4 House prices

Increases in house prices may raise household wealth, leading people to consume more. I therefore next test the role of real house prices in determining consumption.[129] The data used are from Lyons (2015) where their compilation is described in full. The results including house prices in the model are reported in Column 8 of Table 5.5, where they are significant at the 5% level. However, endogeneity is again a possibility here, since rising consumption could reflect a boom in the economy that also affects house prices. I therefore instrument house prices using the first lag of house prices and the first lag of personal credit. These prove strong instruments based on the Stock and Yogo (2005) criteria. Column 9 reports the two-stage least squares result. Again, house prices are significant at the 5% level when instrumented, however, the DWH test indicates that house prices are not endogenous (p-value = 0.26).

While the results above suggest that long-term interest rates, credit and house prices are exogenous variables, it is there useful to consider the issue of endogeneity in some more detail. The DWH test may lack power, particularly in small samples. If the coefficients in the TSLS regression are poorly estimated, that is the standard errors are large, then it will always be difficult to compare the two estimates and reject that they are same. Consider Figure 5.7, which shows the distribution of the estimated coefficients on house price growth from the OLS and the TSLS regressions. Since the standard errors from the TSLS equation are large, it will make it difficult for a test to identify differences in the estimates.

It is important, therefore, to bear in mind that although the test results indicate these variables are exogenous determinants of consumption, there are nevertheless good reason why they may be endogenous.

[128] Here, the instrument is again lagged credit, and the first stage F-statistics are 25.96 and 20.38, respectively. The Stock and Yogo (2005) critical value is 16.38 in both cases.

[129] Other studies test the effect on consumption of changes in housing wealth (see for example Hogan and O'Sullivan (2007) and Slacalek (2009)) rather than house prices; however, housing wealth is not available over the period in question.

5.7.5 Combined model

Finally, I include long term interest rates, credit growth and house prices in the basic model. The results are presented in column 10 of Table 5.5. Credit growth is less significant in this model (p-value = 0.08), while the other two variables remain significant at the 5% level. In addition, both a Bai-Perron multiple breakpoint test[130] and a Quandt-Andrews test[131] indicate that the model is stable. The coefficient on current income is lower than in the basic model. In this specification almost 40% of changes in current income are transmitted directly to current consumption, compared to 50% in the basic specification. In contrast, the coefficient on the error correction term has increased; approximately 40% of any deviations from the long-run path are made up in the first period, compared to 30% in the basic model.[132]

5.8. Conclusions

As a small open economy, Ireland is often affected by events in the global economy. However, during the recent financial crisis, Irish exports performed well, whereas domestic demand, namely consumption, investment and government spending, collapsed. This Chapter has examined the largest component of domestic demand, personal consumption, considering its behaviour in relation to income and consumption theory.

In the first instance, the Chapter compiled 70 years of data on consumption and income for the first time. The data were then discussed in the context of the consumption theory. The behaviour of the savings ratio, taken in the context of the economic and political events of the time, is compatible with the main propositions of the permanent income hypothesis over the sample period. In particular, it Granger causes changes in income and is stationary. That said, I do not formally test whether the permanent income

[130] Test is run with a trimming of 15%, 5% critical value: 20.08, scaled F-statistic: 14.57.
[131] Maximum LR F-Statistic p-value=0.27.
[132] Although not shown here, a dynamic forecast similar to that carried out for the basic model in Section 5.6.4 also fails to capture the 2009 decline in consumption, and in fact has only a marginally lower root mean squared error (3.2%) compared to the basic model (3.1%).

hypothesis is accepted on these data, since the established literature suggests that it would not be.

Since the series are cointegrated, an error correction model of changes in consumption and income can be estimated. The model is stable over the entire 70-year period and passes various other diagnostic tests. A dynamic out-of-sample forecast for the recent financial crisis period indicates that this for this model would have performed, although it fails to predict the full extent of the fall in consumption in 2009, the largest decline on record.

Finally, extensions of the model to include some financial and macroeconomic variables are discussed. Credit growth, house prices and long-term interest rates appear to have explanatory power. However, although formal tests suggest that these variables are not endogenous, there are a priori reasons to think that they may be. The unemployment rate appears to be endogenous.

In light of the relatively few studies of consumption and income in Ireland, and the lack of any similar study over such a time period, this Chapter adds significantly to our understanding of the behaviour of consumption and income in the post-War period.

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Table 5.1: Correlation consumption compiled using different techniques

	Consumption 1	Consumption 2	Consumption 3
Consumption 1	1		
Consumption 2	0.999	1	
Consumption 3	0.986	0.981	1

Table 5.2: Granger Causality tests

Savings measured using:	Income growth does not Granger cause saving	Saving does not Granger cause income growth
Consumption 1	0.90	0.00
Consumption 2	0.89	0.00
Consumption 3	0.89	0.00

Table 5.3: Unit root tests of the savings ratio, p-values and p-statistics

	Augmented Dickey-Fuller test, t-statistics		Elliott-Rothenberg and Stock test, p-statistic	
Saving measured using:	Intercept	Intercept and trend	Intercept	Intercept and trend
Consumption 1	-4.01***	-4.00**	1.43***	4.32**
Consumption 2	-3.78***	-3.73***	1.39***	4.70**
Consumption 3	-4.27***	-4.71***	3.46*	4.05***

Note: Lag length selected using Hannan-Quinn criterion. ***/**/* indicate significance at the 1%/5%/10% level.

Table 5.4: Regression results, dependent variable: change in consumption

	Dependent variable: change in consumption		
	Full sample: 1947-2014		1947-2006
	(1)	(2)	(3)
Explanatory variable	**OLS**	**TSLS**	**OLS**
Change in income	0.494	0.661	0.513
	(0.00)	(0.00)	(0.00)
Lagged change in consumption	0.285	0.193	0.315
	(0.01)	(0.17)	(0.00)
Lagged savings	0.308	0.334	0.322
	(0.00)	(0.00)	(0.00)
Constant	-0.014	-0.018	-0.017
	(0.09)	(0.05)	(0.08)
Dummy 1970	0.057	0.055	0.056
	(0.02)	(0.03)	(0.02)
Adjusted R-squared	0.52	0.50	0.53
Endogeneity diagnostics			
First stage F-statistic		32.54	
Stock and Yogo (2005) critical value		19.93	
Durbin-Wu-Hausmann p-value		0.29	

Note: p-values in parenthesis. Stock and Yogo (2005) critical values taken from Table 5.2, page 101 and are based on a maximal bias of 0.10, the lowest level of bias for which critical values are provided.

Table 5.5: Extensions to the model, 1947-2014 (continued on next page)

	Dependent variable: change in consumption									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Explanatory variable	**OLS**	**OLS**	**TSLS**	**OLS**	**TSLS**	**OLS**	**TSLS**	**OLS**	**TSLS**	**OLS**
Δ income	0.460 (0.00)	0.501 (0.00)	0.501 (0.00)	0.450 (0.00)	0.504 (0.00)	0.361 (0.00)	0.025 (0.93)	0.413 (0.00)	0.367 (0.00)	0.378 (0.00)
Δ lagged consumption	0.327 (0.00)	0.325 (0.00)	0.326 (0.00)	0.061 (0.46)	0.247 (0.10)	0.204 (0.04)	0.168 (0.17)	0.146 (0.16)	0.046 (0.73)	0.177 (0.06)
Lagged savings	0.557 (0.00)	0.568 (0.00)	0.575 (0.00)	0.341 (0.00)	0.317 (0.00)	0.226 (0.01)	0.116 (0.39)	0.274 (0.00)	0.251 (0.01)	0.408 (0.00)
Δ nominal short interest rate	0.193 (0.19)									
Δ nominal long interest rate	-0.536 (0.00)	-0.339 (0.00)	-0.004 (0.00)							-0.227 (0.01)
Unemployment rate				-1.238 (0.00)	-0.123 (0.85)					
Lagged unemployment rate				1.151 (0.00)	0.191 (0.73)					
Δ personal credit						0.105 (0.00)	0.29 (0.03)			0.061 (0.08)
Δ house prices								0.110 (0.00)	0.185 (0.03)	0.066 (0.03)

Table 5.5 continued: Extensions to the model, 1947-2014

	Dependent variable: change in consumption									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Explanatory variable	**OLS**	**OLS**	**TSLS**	**OLS**	**TSLS**	**OLS**	**TSLS**	**OLS**	**TSLS**	**OLS**
Constant	-0.001	-0.006	-0.006	-0.00	-0.021	-0.009	-0.002	-0.007	-0.003	-0.002
	(0.91)	(0.43)	(0.45)	(0.99)	(0.20)	(0.23)	(0.23)	(0.35)	(0.69)	(0.83)
Dummy 1970	0.061	0.058	0.058	0.071	0.062	0.055	0.048	0.059	0.060	0.057
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.08)	(0.01)	(0.01)	(0.01)
Dummy 2000				0.048	0.055					
				(0.01)	(0.02)					
Adjusted R-sqaured	0.62	0.61	0.61	0.76	0.69	0.62	0.44	0.60	0.59	0.69
					Endogeneity diagnostics					
First stage F-statistic/t-statistic			21.43		125.70		31.36		21.81	
Stock and Yogo (2005) critical value			16.38		19.93		16.38		19.93	
Durbin-Wu-Hausmann p-value			0.82		0.06		0.14		0.26	

Note: p-values in parenthesis. Stock and Yogo (2005) critical values taken from Table 2, page 101 and are based on a maximal bias of 0.10, the lowest level of bias for which critical values are provided.

Figure 5.1: Growth rates of vintages of consumption data, 1970-1985

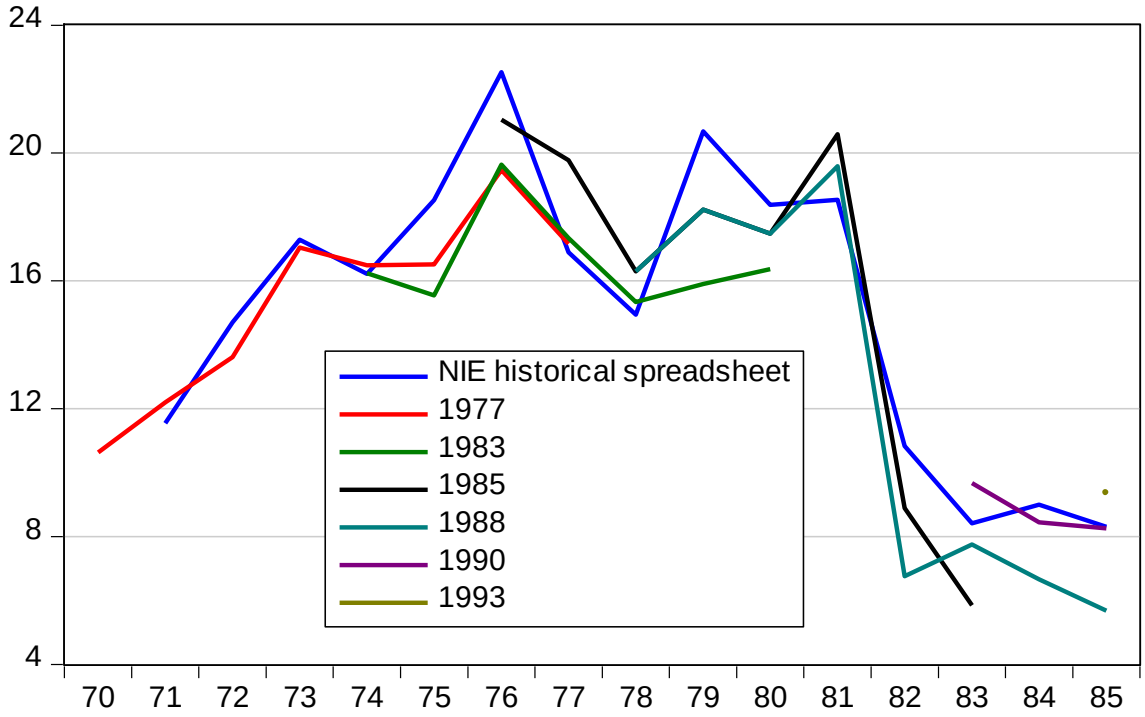


Figure 5.2: Data on raw and rebased pre-1970 consumption, post-1970 consumption, and income (log levels)

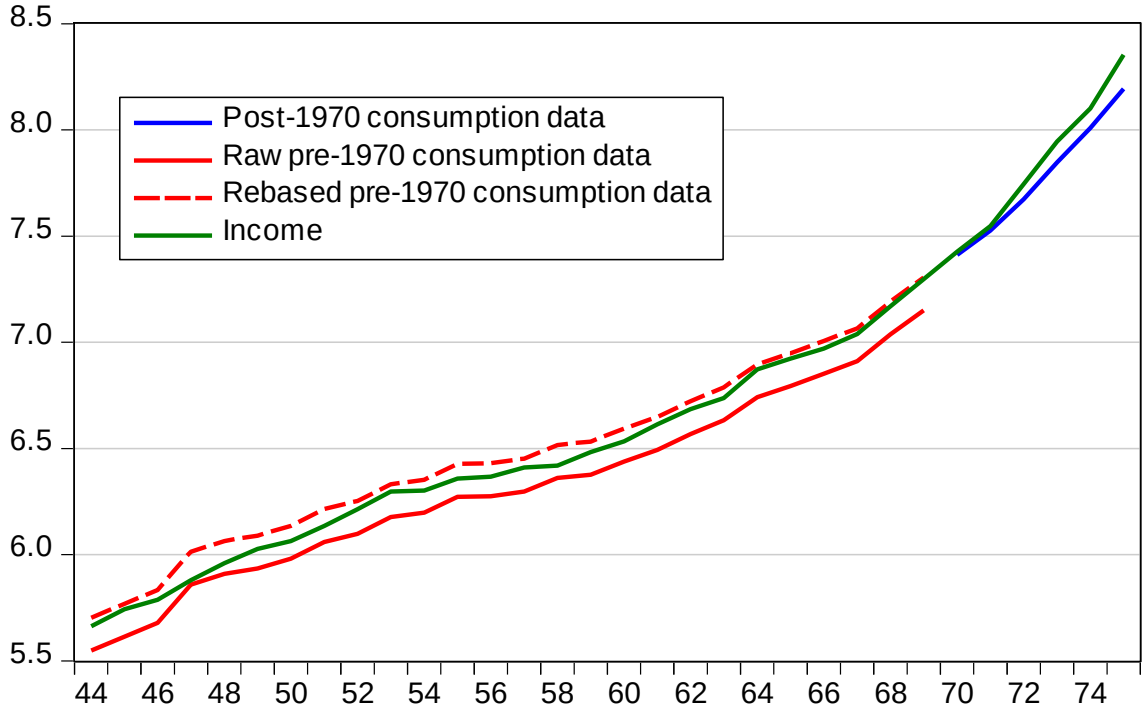


Figure 5.3: Three measures of consumption in log levels, 1944-1970

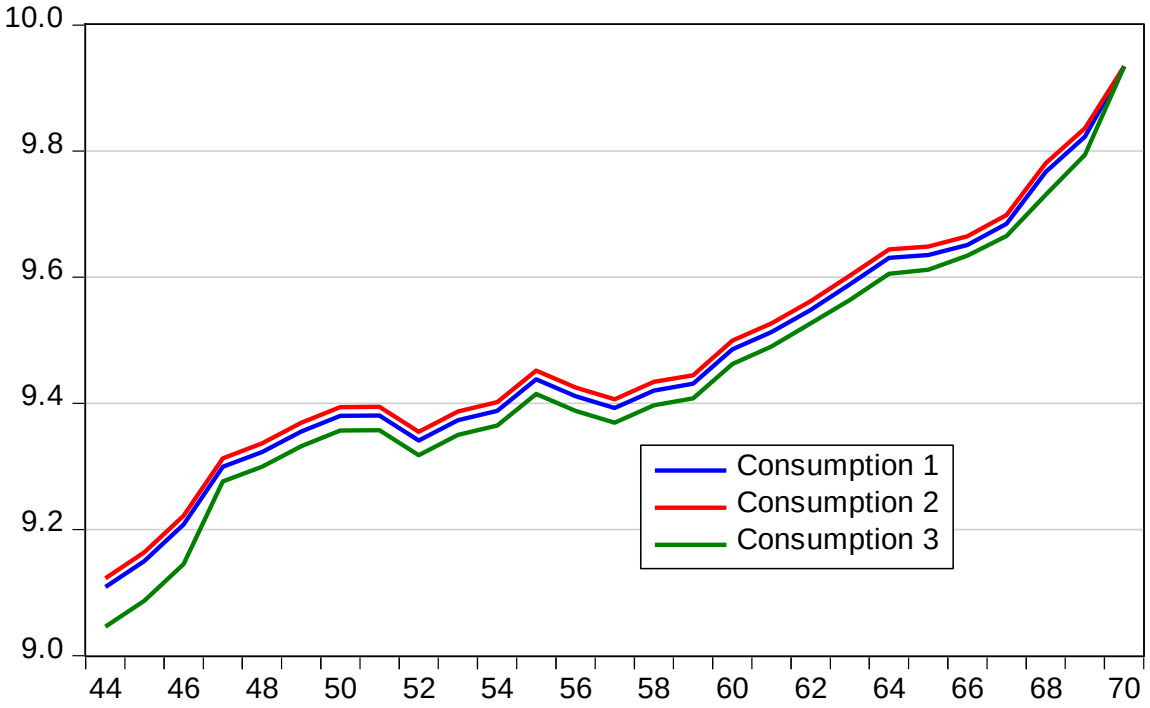


Figure 5.4: Consumption and disposable income in log levels, 1944-2014

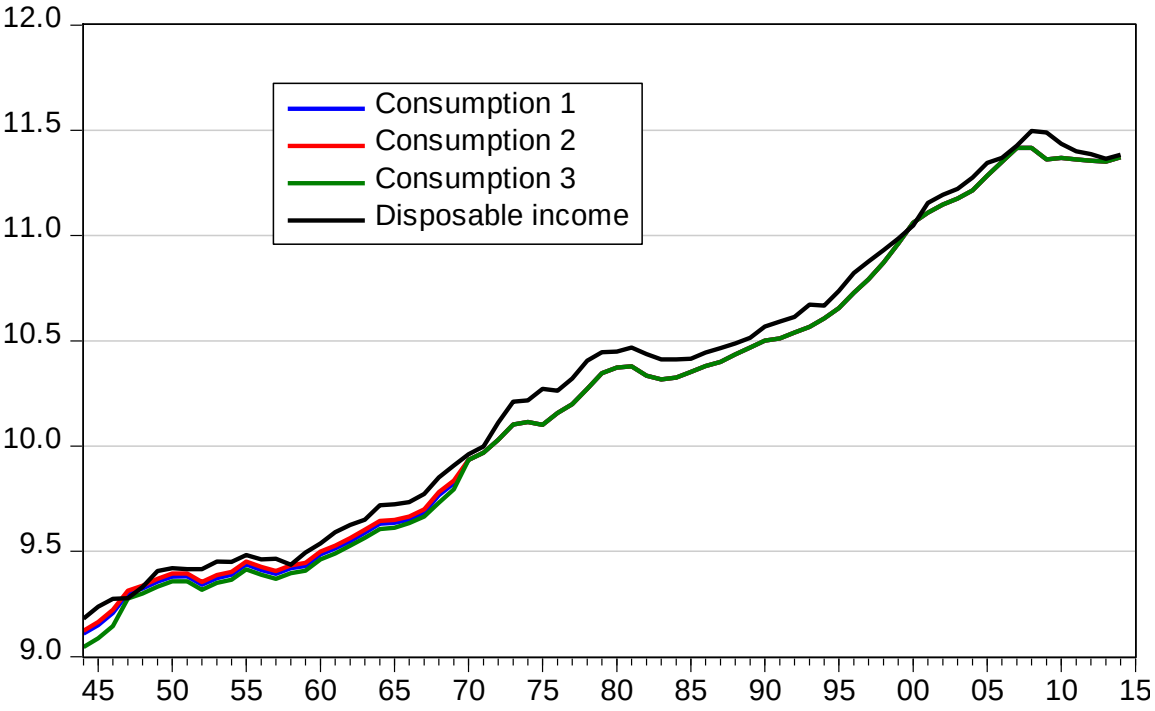


Figure 5.5: Growth rates in consumption and income in log levels, 1944-2014

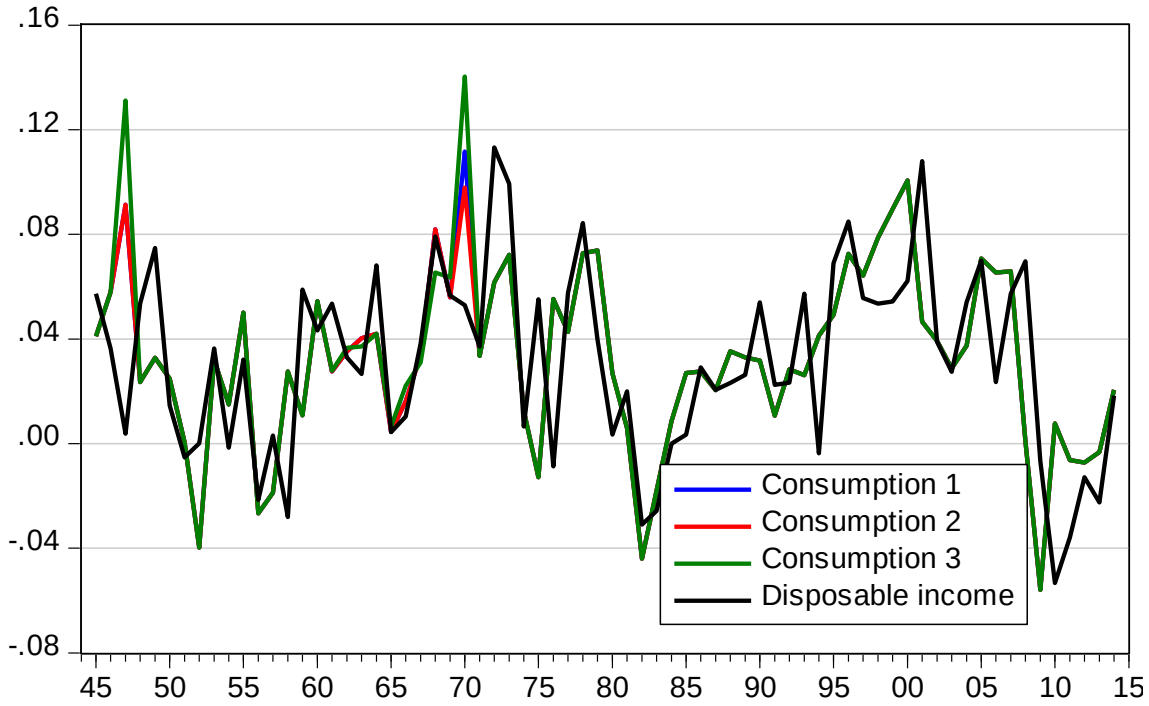


Figure 5.6: Savings ratio, 1944-2014

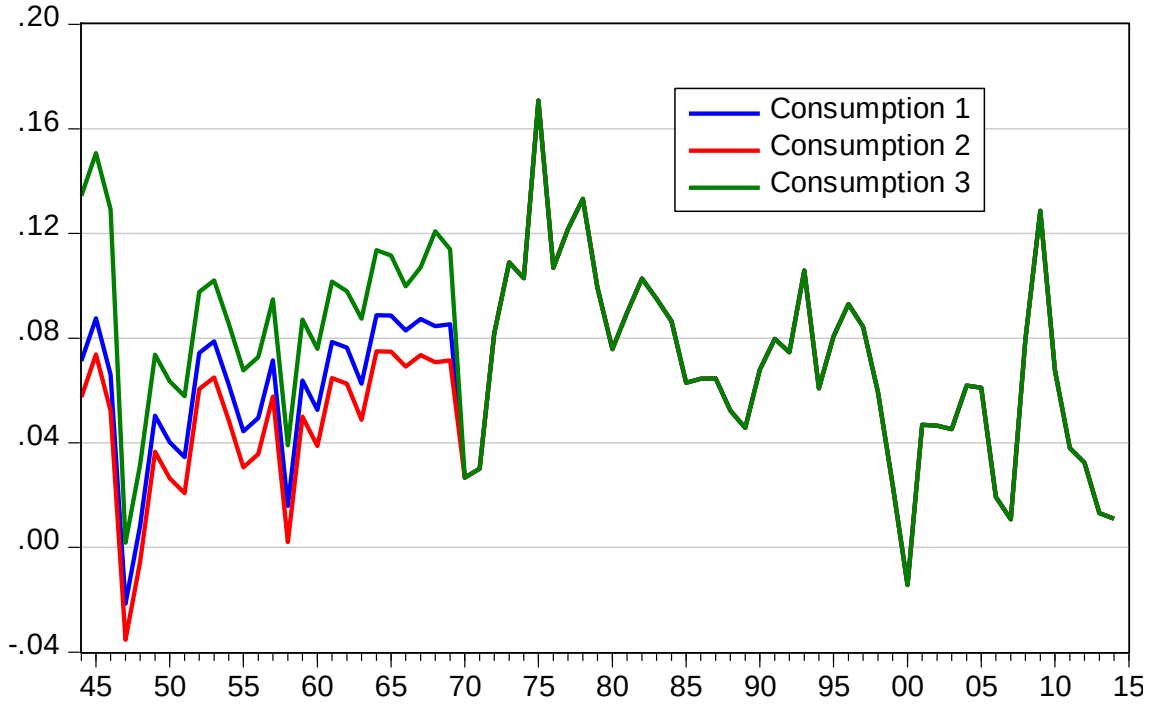


Figure 5.7: Dynamic out-of-sample forecast of consumption

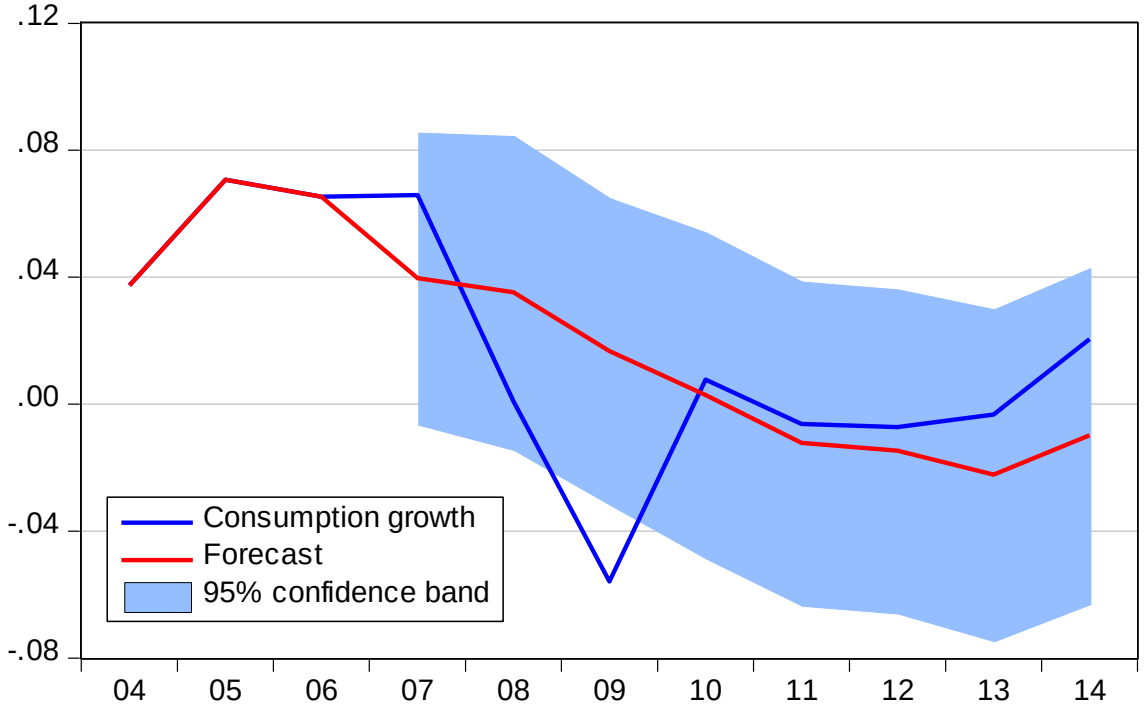
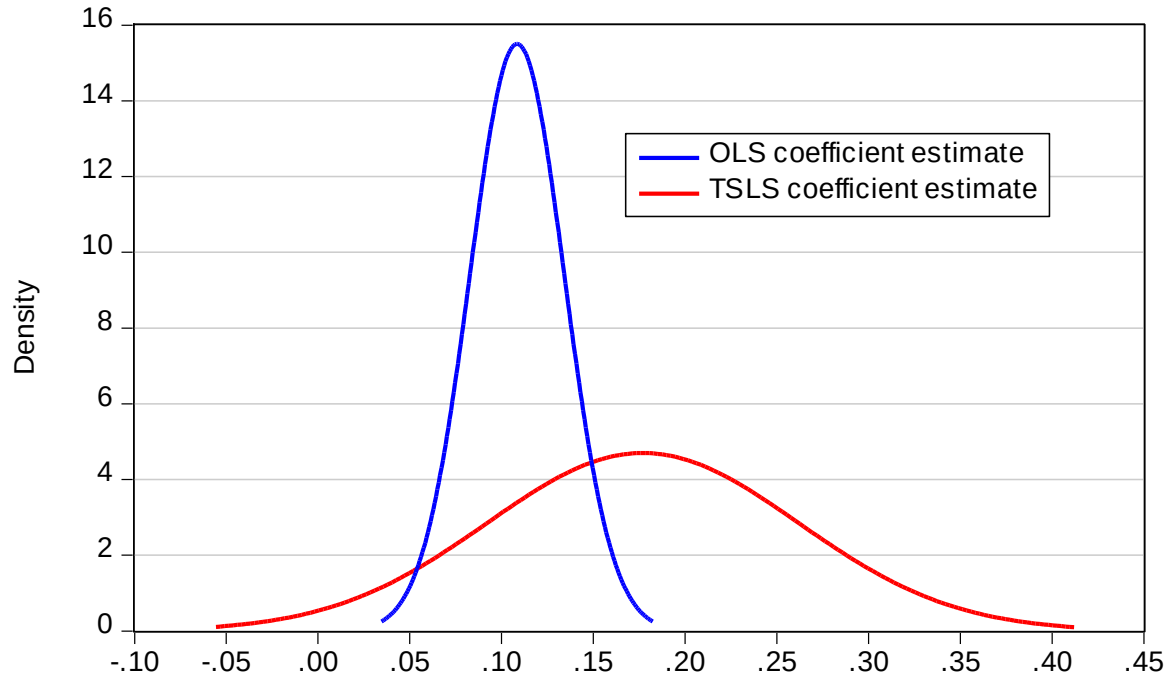


Figure 5.8: Distribution of coefficient on credit growth, OLS and TSLS



Chapter 6

Conclusion

This thesis studies four topics in Irish financial and macroeconomic history since the 19th century. The first two Chapters detail the development of the stock market, particularly examining the relationship with the UK and the role of global shocks in stock market developments. The relationship with the UK is again a focus of Chapter 4, but this time as it relates to the development of the macroeconomy during the period of the rigorously fixed exchange rate between Sterling and the Irish Punt from 1922-1979. The final Chapter also focusses on the macroeconomy, examining the relationship of personal consumption and personal disposable income since the Second World War.

Chapter 2 analyses the transmission of equity returns and volatility between stock market returns in Ireland, the UK and the US over the period 1871-1939. As such this Chapter presented a first and preliminary analysis of the behaviour stock prices in this countries, with the aim of understanding the joint behaviour of returns. In the first instance, it provided descriptive statistics and compared stock returns across the three countries. From these there appears to be supporting evidence for the theory that increasing liquidity in markets is associated with higher volatility.

By estimating the joint behaviour of returns in a multivariate DCC-GARCH model, Chapter 2 showed that global shocks, proxied by US returns, impacted on UK returns, but

not *vice versa*. However, there is clear evidence that UK stock returns impacted on local markets, proxied by Irish stock returns. Since there is little evidence that events in the US played an important role in determining Irish stock returns, it appears that in smaller, local economies the UK stock market had a structural relationship, reflecting the political and economic integration of the two economies through much of the period.

Furthermore, while developments in the UK market continued to have a role in Ireland, perhaps as a result of Ireland's increasing independence, the correlation between returns in the two markets declined through the period. Conversely, UK returns became increasingly influenced by global factors, as evidenced by increasing correlation with US returns. The result is that the correlations converge over time, suggesting that markets became more integrated. Alternative specifications of the exchange rate and index weighting methodologies do not significantly affect this result.

Chapter 3 examines the role of broader global shocks on stock markets across countries during the classical Gold Standard era. Using data for Belgium, France, Germany, Ireland, the UK and the US during the period 1879-1913, the Chapter used principal component analysis to identify shocks to equity returns in these six countries, and a VAR analysis to examine the effect of these shocks on stock returns across countries. The results indicated that geographical location and common language are not indicators of the correlation of indices, pointing towards a globalised financial market that was becoming increasingly integrated.

The principal component analysis indicated the existence of a global shock to equity prices. The VAR analysis suggested that the global shock has significant and permanent effects on equity prices in all economies. Equity markets which were more correlated with this shock, thus exhibiting higher 'market risk', were associated with higher returns, whereas those with lower correlations and less exposure to market risk, had lower returns. The principal component analysis also indicated that there was also a 'Continental European' shock, which moved equity returns for the countries located in continental Europe (Belgium, Germany and France) relative to the English-speaking countries. This may have been due to the extremely close trade linkages between the Anglophone countries. While this Chapter fits into the modern literature on market

integration, in the absence of a historical literature on integration across a number of markets, it is one of the most comprehensive comparative studies of the behaviour of stock prices movements during this period.

Chapter 4 focusses on the macroeconomic relationship of Ireland with the UK, examining the economic effect of UK shocks on Ireland over the period 1922-1979. Although many studies consider the legal and institutional legacy of colonial rule, this Chapter is one of the first to examine the ongoing economic influence of the former colonizer on the newly independent state. This Chapter developed a SVAR framework to examine the ongoing influence of the UK on the Irish economic cycle in the period immediately after independence.

UK aggregate demand and supply shocks (which are considered as global shocks) and idiosyncratic Irish shocks were identified within the SVAR framework. The model indicates that while these shocks had relatively large and significant effects on Irish inflation, they had a much smaller impact on Irish real GDP growth. Furthermore, the impact of UK shocks on Irish inflation was similar in magnitude to that of Irish shocks. A historical decomposition indicated that UK aggregate demand and supply shocks played an important role in the evolution of Irish inflation. In contrast, the evolution of Irish real GDP was driven by idiosyncratic domestic aggregate supply and demand shocks.

Chapter 5 turns to more domestic drivers of the Irish business cycle, studying the relationship between consumption and income over the 70-year period. There are surprisingly few macro studies of consumption and income in Ireland, and none over such a long sample period. The Chapter compiles consumption and income data for the first time over the period 1944-2014, and then studies the relationship between the variables with reference to consumption theory.

The Chapter finds that the savings ratio predicts changes in income: the ratio tends to be low in periods when a narrative history of the macroeconomy suggests that future income was expected to grow sharply, and *vice versa*. Having established that income and consumption are cointegrated, an error correction model of changes in consumption and income indicates a stable relationship over the entire 70-year sample. Furthermore, a dynamic out-of-sample forecast indicates that the model performed well through the

recent financial crisis, although it fails to predict the full extent of the fall in consumption in 2009. Finally, the Chapter tests some extensions of the model, finding that although interest rates, credit, house prices and unemployment are significant, diagnostic tests indicate that the unemployment rate is subject to simultaneity bias.

Each of these studies applies time series econometric techniques to long samples of data. This is an overlooked approach in Irish economic history which is unfortunate since, compared to shorter data samples, the use of long time spans of data can make it easier to detect the underlying dynamics in the data. As such the thesis addresses a gap in the existing literature on Irish economic history.

Appendix

A long-run macroeconomic database for Ireland, 1922-2014

A1. Introduction

Long time series macroeconomic data on Ireland are difficult to source. While the Central Statistics Office (CSO) provides a comprehensive set of modern statistics, long time spans of data, for the most part, are often not available online. While there have been a number of recent projects developing macroeconomic and financial data for Ireland including, for instance, Grossman *et al.,* (2013), Lyons (2015) and Kenny and Lennard (2015), these generally provide a single series, or a number of series for a specific topic.[133] Furthermore, the Historical National Accounts Group (HNAG) provide data online on various topics.[134] However, none of these sources provide headline macroeconomic data over an extended time period.

In contrast, such data can be sourced relatively easily for other countries. For instance, Hills *et al.,* (2015), compile data for the UK which is available in in the *Three Centuries of Data* spreadsheet on the Bank of England website. Data for the US is available through

[133] For instance, Grossman *et al.,* (2013) compile stock price data, Lyons (2015) compiles house price data, and Kenny and Lennard (2015) compile monetary and credit aggregates.
[134] See: https://www.tcd.ie/iiis/HNAG/HNAG_database.htm

websites such as the FRED and the NBER macrohistory database.[135] In other countries, large volumes of time series are available following institutional historical projects, such as the historical monetary data compiled by the Norges Bank and the Swedish Riksbank[136], or Swiss historical statistics which the University of Zurich is compiling[137].

This appendix presents the macroeconomic data that I compiled in the preparation of this thesis.[138] Data are presented on eighteen series which fall broadly within the categories of prices, output, labour market and money. Although not as comprehensive as, for instance, Hill *et al.*, (2015), this database includes most of the main macroeconomic variables, such as GDP, CPI, unemployment and interest rates. While it seems surprising that such data have not previously been presented in one place, to my knowledge this is the first compilation of such an array.

A2. Compiling long macroeconomic time series for Ireland

In this section I discuss the construction of the macroeconomic time series, beginning with some general information, and then focusing on the specifics of each individual series.

This database contains macroeconomic data over a 90-year period. While every effort has been made source data back to the founding of the Free State in 1922, when Irish data might reasonably be expected to be disaggregated from broader UK data, this is not always possible. Nonetheless, all series are available at least as far back as the 1940s.

Naturally, no single source provides all the data and it is therefore necessary to rely on a number of different sources, including the Central Statistics Office (CSO), the Economic and Social Research Institute (ESRI), the OECD, the IMF, the ECB, Moynihan (1975), Mitchell (2007), Homer (1963), Sherman (2015) and the website for the Maddison project.

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[135] These also provide data for other countries on a large number of series.
[136] See: http://www.norges-bank.no/en/Statistics/Historical-monetary-statistics/ and http://www.riksbank.se/en/The-Riksbank/Research/Historical-Monetary-Statistics-of-Sweden/
[137] http://www.fsw.uzh.ch/histstat/main.php
[138] Although not all data have been used in the thesis, the money, interest rate, GDP, inflation, import price and unemployment series have previously been described and used in Gerlach and Stuart (2014), Gerlach and Stuart (2015) and Gerlach, Lydon and Stuart (2015).

In the absence of objective criteria for constructing long time series by combining data from several sources, unless otherwise noted the current vintage of data is used as far back as possible under the assumption that it is subject to smaller measurement errors than older vintages. Older time series are then spliced in order to construct a single time series.

In many cases there are differences in the levels of the series. Such differences can arise for a number of reasons, including changes in the number of reporting banks in the case of monetary aggregates and base-year differences in the case of real GDP. Where more than one series was available, the decision was based on a comparison of growth rates in these series during any overlapping period with the more recent vintage of data, with the series which most closely matched the recent vintage chosen. The sources and construction of the individual series are set out below, the coding of variables is presented in Table A1 and the final series are in Table A2. All series in Table A2 are indexed to 100 in 2013, with the exception of the unemployment rate and interest rates.

A.2.1. Real and nominal GDP[139]

For real GDP, data from the Maddison website are used from 1933 to 1938. These data are reported on a per capita basis. To calculate the aggregate level of GDP, I use population data from the census provided by the CSO.[140] The Maddison data for Ireland are based on an estimate Maddison made for 1920 and data thereafter originated in papers by Duncan in 1940 and 1941. These data are available for 1926, 1929, 1931, 1933, 1936 and 1938, and Maddison therefore interpolates data for the years in between.

Data between 1938 and 1944 are sourced in a White Paper on National Income and Expenditure presented to the Oireachtas in March 1946, and data between 1944 and 1947 are taken from the Tables of National Income and Expenditure compiled by the CSO and presented to the Oireachtas in February 1951.[141] However, it is clear from the White Paper and the CSO's 1951 release that no data were collected in this period, and that these were

[139] These data were also described in Gerlach and Stuart (2014) and Gerlach and Stuart (2015).
[140] The Census was conducted every ten years between 1926 and 1946 and on a five-yearly basis thereafter. We interpolate the missing years using a cubic spline. The 1976 Census was cancelled as an "economy measure," with the result that one took place in 1979, and the 2001 Census was postponed until 2002 due to an outbreak of foot and mouth disease in Britain and Ireland.
[141] See White Paper (1946) and Central Statistics Office (CSO) (1951).

estimates made in retrospect.[142] In both cases, the data are for total national income, and are reported only in nominal terms. However, a price trend is also reported in both publications, and this is used to deflate the series. Real GDP data are available from the CSO from 1947 to the 2012.[143] [144]

The Maddison data are also available during the period 1938 to 1947. However, the growth rates differ dramatically between the White Paper and CSO (1951) publication and the Maddison data. In contrast to the other two sources, the Maddison data indicate that the growth rate of GDP was (almost exactly) zero throughout the Second World War, which suggests that no data were in fact recorded for this period. As a consequence, I prefer the data originally published by 'official' sources for the time period that they are available.

Nominal GDP is constructed in a similar manner. The Maddison data which are used for real GDP from 1933 to 1938 are not available in nominal terms. While these data could be deflated by CPI, it is not clear that this would be an appropriate deflator, and I instead use the series on nominal gross domestic expenditure in Moynihan (1975), Appendix 10, p. 528-529. Data from the 1951 CSO release and the 1946 White Paper are used for the period 1938 to 1947. CSO data are used from 1947 to 2012.

A.2.2. Personal consumption and income

Real personal consumption and real personal after tax (disposable) income are taken from official Central Statistics Office (CSO) sources. Data from 1944 to 1949 are taken from CSO

[142] The White Paper on National Income and Expenditure published in 1946, and containing data for the period 1938 - 1944, states that it *'inaugurates a series of official estimate of national income and expenditure… Heretofore the official statistical service has been unwilling to assume responsibility for statistics relating to national income through rough approximations have been made from time to time for departmental use'*.

[143] There are three breaks over this time period: in 1995 (data prior to 1995 exclude FISIM, the Financial Intermediation Sector Indirectly Measured), 1970 and 1959. Data from 1970 to 1995 are chain-linked annually and referenced to 2009; data prior to 1970 are at 1995 prices. Furthermore, there is no overlap in the two data vintages immediately before and after 1970. We therefore use growth rates of the real GDP series from the ESRI Databank for this year to splice the series. Data from 1959 to 1970 are at 1995 prices. Data prior to 1959 are estimates.

[144] Both real and nominal GDP data are also available from the OECD from 1970 onwards. The growth rates in the OECD data vary marginally from those of the CSO series. We do not use the OECD data as the CSO is the official statistics provider in Ireland.

(1951). This is the earliest CSO NIE publication that I have found.[145] For the period 1949 to 1970, the CSO published NIE tables annually which are available in hard copy and contain data for the period to 1947. In particular, the data are taken from the NIEs from 1968 and 1977 which contain extended appendices providing data back to 1947 and 1960, respectively. From 1970 to 1995, data are available from the CSO's historical NIE spreadsheet which is available online. Thereafter, the CSO's online database provides the data.

One important data issue arises from a difference in the level of consumption in the CSO's online historical spreadsheet and in the NIE hard copy publications. This appears to be due to an adjustment for depreciation which raises the level of consumption in the 1970 spreadsheet compared to the data for the earlier period. When the series are spliced together, the effect is to raise consumption in the earlier period. Since no similar level change occurs in personal income, the effect is to raise consumption above income in the earlier period, which is unreasonable. To address this, trend consumption-income ratio over the entire sample period is estimated using a Hodrick-Prescott filter[146]. The level of the filter in 1969 is then used to calculate consumption in that year, and the earlier data is spliced using this.

The data are made real using a consumption deflator, calculated from the original nominal and real consumption expenditure data, both of which are available from the CSO, to deflate the income series. The consumption deflator is preferable to a GDP deflator here, since a consumption deflator takes account of the impact of taxes on income, whereas a GDP deflator will not allow for this.

[145] Prior to this, a government White Paper in 1946, contained data for the period 1938 to 1944. However, it appears that the rubric of NIE tables was not established at this time, and some key data, such as personal income, is not available, even though private income (personal income plus corporate profits) and personal consumption are.

[146] Since the data are annual, $\lambda = 100$ is used in the filter.

A.2.3. Industrial production

Industrial production data are taken from White Paper (1946) from 1938 to 1942.[147] There after data are taken from Mitchell up to 1979. From 1980 to present, data are taken from the CSO.[148]

A.2.4. Unemployment rate[149]

Unemployment rate figures from 1923 to 1938 are taken from the ILO's International Labour Review. For the period 1939 to 1982, data are from Mitchell (2007). Finally, for the most recent period, 1983 to 2014, data are available from the Central Statistics Office (CSO). While the unemployment data at the very start of the sample may contain measurement errors (for instance, due to changes in social welfare eligibility criteria), which in any econometric estimation will tend to bias errors downwards, there is little that can be done to correct for this.

A.2.5. Industrial wages

Data are taken from Mitchell (2007) from 1931 to 1953. Thereafter, data from the CSO is used. From 1954 to 1997 data are for average weekly earnings based on NACE Rev 2 classification. These are based on fourth quarter levels of wages. From 1998 to 2005 average weekly industrial wage data are from the Quarterly Industrial Inquiry survey and are based on NACE Rev 1 classification of industry. [150] For the most recent period, average weekly earnings are from the CSO's Earnings, Hours and Employment Costs Survey, and are again NACE Rev 2 and based on fourth quarter wages.

A.2.6. Consumer prices, import prices and export prices

The Consumer Price Index is available from the CSO from 1922. Import and export price indices are available from the CSO beginning in 1930.

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[147] The White paper includes both value and volume industrial production. The series here uses volume.

[148] CSO data are for Industries (05 to 35).

[149] These data were also described in Gerlach, Lydon and Stuart (2015).

[150] This is one of the few times when an older series is used when more recent data are available: the Quarterly Industrial Inquiry survey is available from 1984, but because the NACE categorisation of the earlier data is in line with the current series from the CSO, I use the older data up to 1997.

A.2.7. Short and long-term interest rates[151]

Irish interest rates bring with them several challenges. Most obviously, data on Irish interest rates appear not to be available as far back in time as data on interest rates in the UK. This may reflect the fact that Irish markets were much less important than UK markets and that there was less demand for information about Irish interest rates. Alternatively, it may be that there were no active markets for Irish debt.[152]

I use the annual average of the open-market rate of discount in London, quoted in Homer (1963, pp. 417-420) for the period 1933 to 1962 as a proxy for Irish short-term rates. This is the rate paid in London on three months' bankers' bills or three months' bankers' acceptances. I use this rate because short-term interest rate data for Ireland is either not available, or is not appropriate to this study. Data on Irish rates available during this period appear to be official rates that may have deviated from actual market rates: there is little or no movement in any available rate over the period to 1951, while it is likely that the fact that an increase in the UK Bank Rate in the 1950s was not matched in Ireland led to a deviation of official rates and markets rates for Irish banks.[153] Furthermore, it is arguable whether a money market existed in Ireland throughout much of this period to provide an 'Irish' market rate.[154] The London open-market rate which I use is both lower and more volatile in the period 1933 to 1951 than the official rates reported by a number of sources. However, it moves closely with data from the IMF's IFS database on the discount rate in the period after 1951.[155] The London overnight rate is therefore used for the period to 1962. The discount rate from the IMF is used for the period until 1984, and data on the short-term rate from the OECD are used for the most recent period.

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[151] These data were also described in Gerlach and Stuart (2014) and Gerlach and Stuart (2015).

[152] For instance, it may be that debt issued by the Irish government was held to maturity by Irish financial institutions.

[153] Indeed, data indicate that the official rate was unchanged at 3 per cent from 1932 to 1941. In 1942, the rate was reduced to 2.5 per cent, and remained at this level until 1951.

[154] Indeed, as late as 1969, Hoare (1969) debates the existence of an Irish money market, concluding that one does, indeed, exist.

[155] Data prior are also available from the OECD from 1922 to 1949. These also move very closely with the London rate that we use over the period 1922 to 1933. A further alternative would be to use the Bank of England "Bank Rate", but that is a posted penalty rate that provided a ceiling to market rates.

Long-term interest rates prior to 1952 are proxied using UK interest rates. Homer (1963) reports a high and low bond yield for each year in the period from 1922 to 1947. I take the midpoint of these yields in these years. From 1948 to 1952, the IMF's International Financial Statistics (IFS) data are available for the UK. Data are taken from the IFS from 1952 to the present. Data from other sources are available over this period, including from Homer (1963), the CSO and the OECD. However, as the IMF series is available for the full period and, as it evolves over time in similar ways to the data from other sources, I use it.

A.2.8. Private and personal sector credit

Private sector credit data are collected from Moynihan (1975) for the period 1932 to 1969. Thereafter, data are taken from Sherman (2015) which collates information from Central Bank of Ireland Quarterly Bulletins. There are no data for 1970 when there was a bank dispute, and no data could be collected. Half the change in the level of lending between 1969 and 1971 is therefore assumed to have occurred in 1970, so that the increase is the same in each of 1970 and 1971.[156] In addition, it is important to note that the Moynihan data report a growth rate in excess of 50% in 1947.

Personal sector credit data are collected for the personal sector from Central Bank of Ireland Quarterly Bulletins. The earliest sectoral lending data available are from 1948. At that time, lending to the 'personal and professional' sectors were categorized together. Only in 1968 was personal sector credit split out separately. Data on lending by building societies for residential mortgages is available from 1959 onwards, and these are added to bank lending from when they become available until 1996 when building societies were re-classified as banks. From 1971 onwards, the data are taken from Sherman (2015). There are two years in the series for which growth rates are not available. The missing data in 1970 as a result of the bank dispute are dealt with in the same manner as for private sector credit.[157] The second year for which there is no growth rate is 1967, since there is no overlap between the old and new series when personal and professional lending are split. Here, the 1968 growth rate is applied to 1967.

[156] However, it is possible that credit growth in 1970 accounted for less than the full increase between 1969 and 1971. Other assumptions, such as that growth in 1970 was zero or negative, could therefore also be made.

[157] As per private sector credit, alternative assumptions over the allocation of credit between 1970 and 1971 might reasonably be made.

A.2.9. Money Supply[158]

Data from Moynihan (1975) for both M1 and M2 are used from 1933 to 1950. Moynihan defines M1 as cash plus deposits at the Associated banks, and M2 as cash plus current and deposit accounts at the Associated banks. Data from Mitchell (2007) are used for M1 for over period 1950 to 1980, and for M2 over the period 1950 to 1971. Mitchell defines M1 as currency in circulation plus demand deposits (other than those of the central government). M2 also includes time and savings deposits and foreign currency deposits of residents.[159] Data from 1980 for M1 and from 1971 for M2 are available from the Central Bank of Ireland. Prior to 1999, the data that I use for M2 were classified as M3, however, since M3 was then defined as currency outstanding and Licensed Banks' current and deposit accounts[160] it is consistent with the earlier definitions of M2. The current definition of M2 is M1 (currency in circulation and overnight deposits) plus deposits with agreed maturity up to 2 years, deposits redeemable at notice up to 3 months and post office savings accounts.

There is a break in both series in 1999 when data collection under Eurosystem definitions began. As the new definitions did not run concurrently with the old ones, no growth rate is available for 1999. However, monthly data for 1999 is available. I therefore annualise the 11-month growth rate (January to December) to proxy an annual rate for 1999.[161] Joining a currency union also affected how Irish money supply was defined. From 2000 onwards M1 and M2 data were collected on the basis of both "Irish contribution to the euro area" and for "Irish residents". The "Irish contribution" data include deposits in Irish resident credit institutions by other euro area private-sector residents. The "Irish resident" definition more closely represents money held by Irish citizens, and it is therefore used here. A further break in the series occurred in 2003 when, in line with

[158] These data were also described in Gerlach and Stuart (2014) and Gerlach and Stuart (2015).
[159] Unfortunately, it is not clear from Mitchell what sample of banks is used for these data.
[160] Precisely, this definition applies from 1972-1981. Accrued interest of resident private-sector entities is included. This is likely due to the introduction in 1982 of consistent rules (including on the residency of the customer, the treatment of accrued interest and bad debts) which were compiled using international statistical and accounting standards were adopted.
[161] The series are also seasonally adjusted before calculating the changes using the Census X11.2 method used by the U.S. Bureau of Census. The annualised growth rate is 31.5% for M1 and 17.3% for M2.

Eurosystem requirements, securities issued to non-euro area residents were excluded from M2, while holdings by credit institutions of debt securities up to two years' maturity issued by euro-area MFIs are netted off debt securities issued in this category.

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Table A1: Coding of variables

Variable	Code
Nominal GDP	NY
Real GDP	RY
Nominal personal disposable income	NPY
Real personal disposable income	RPY
Nominal personal consumption	NPC
Real personal consumption	RPC
Industrial production	IND
Unemployment rate	UNR
Wages	W
Consumer prices	CPI
Import prices	IMP
Export prices	EXP
Short-term rates	STI
Long-term rates	LTI
Private sector credit	PSC
Personal sector credit	PERS
Narrow money	M1
Broad money	M2

Table A2: Final Series

	NY	RY	NPY	RPY	NPC	RPC	IND	U	W
1922	0.096	6.697							
1923	0.095	6.636						5.960	
1924	0.095	6.622						5.890	
1925	0.095	6.632						5.510	
1926	0.095	6.628						4.010	
1927	0.097	6.838						3.330	
1928	0.100	7.055						3.450	
1929	0.104	7.279						3.260	
1930	0.106	7.468						3.380	
1931	0.108	7.660						3.810	0.397
1932	0.104	7.436						9.490	0.393
1933	0.101	7.218						10.740	0.393
1934	0.110	7.428						15.370	0.393
1935	0.111	7.645						18.000	0.393
1936	0.113	7.867						14.490	0.393
1937	0.117	7.621						11.770	0.397
1938	0.119	7.868					1.754	12.370	0.421
1939	0.127	7.867					1.725	14.280	0.430
1940	0.138	7.867					1.665	15.500	0.430
1941	0.150	7.867					1.542	14.600	0.439
1942	0.167	7.867					1.324	14.200	0.439
1943	0.186	7.867					1.339	12.500	0.466
1944	0.194	7.867	0.334	11.252	0.321	10.823	1.393	11.300	0.484
1945	0.212	7.782	0.362	11.916	0.343	11.277	1.589	10.600	0.492
1946	0.222	7.867	0.378	12.358	0.366	11.949	1.893	10.600	0.510
1947	0.243	7.970	0.415	12.404	0.438	13.092	2.089	9.300	0.609
1948	0.269	8.327	0.449	13.085	0.460	13.404	2.375	9.400	0.663
1949	0.290	8.775	0.481	14.102	0.472	13.851	2.714	9.000	0.725
1950	0.295	8.900	0.499	14.310	0.495	14.199	3.109	7.500	0.725
1951	0.310	9.135	0.536	14.235	0.535	14.205	3.158	7.300	0.725
1952	0.356	9.389	0.580	14.237	0.556	13.652	3.158	9.100	0.815
1953	0.392	9.658	0.630	14.765	0.601	14.096	3.356	9.600	0.821
1954	0.394	9.779	0.632	14.742	0.614	14.308	3.553	8.100	0.877
1955	0.413	10.105	0.670	15.223	0.662	15.042	3.652	6.800	0.924
1956	0.420	10.045	0.675	14.899	0.663	14.646	3.504	7.700	0.958
1957	0.434	10.089	0.705	14.945	0.678	14.372	3.356	9.200	1.011
1958	0.450	9.974	0.712	14.531	0.724	14.778	3.455	8.600	1.050
1959	0.481	10.409	0.758	15.411	0.735	14.936	3.751	8.000	1.117
1960	0.503	11.038	0.798	16.093	0.782	15.772	3.997	6.700	1.178
1961	0.542	11.621	0.864	16.978	0.825	16.219	4.343	5.700	1.311
1962	0.586	11.950	0.928	17.547	0.889	16.808	4.639	5.700	1.364
1963	0.630	12.428	0.977	18.020	0.949	17.499	4.935	6.100	1.537
1964	0.717	12.851	1.119	19.290	1.057	18.235	5.330	5.700	1.591
1965	0.764	13.021	1.177	19.375	1.114	18.343	5.577	5.600	1.731
1966	0.805	13.095	1.234	19.577	1.180	18.727	5.823	6.100	1.858
1967	0.879	13.795	1.322	20.340	1.253	19.282	6.268	6.700	2.026

Table A2 continued

	CPI	IMP	EXP	STI	LTI	PSC	PERS	M1	M2
1922	1.953			2.630	4.615			0.090	0.163
1923	1.912			2.710	4.575			0.083	0.151
1924	1.933			3.440	4.505			0.080	0.145
1925	1.974			4.140	4.710			0.075	0.138
1926	1.922			4.460	4.690			0.072	0.133
1927	1.818			4.240	4.570			0.072	0.133
1928	1.808			4.160	4.515			0.065	0.119
1929	1.829			5.260	4.760			0.071	0.131
1930	1.777	3.267	4.042	2.560	4.355			0.071	0.131
1931	1.662	2.812	3.657	3.610	4.820			0.070	0.130
1932	1.631	2.736	3.080	1.870	3.495	0.046		0.075	0.138
1933	1.569	2.432	2.599	0.690	3.425	0.045		0.071	0.133
1934	1.579	2.432	2.406	0.820	2.870	0.047		0.077	0.127
1935	1.621	2.508	2.406	0.580	3.005	0.047		0.076	0.123
1936	1.662	2.584	2.599	0.600	3.065	0.047		0.079	0.124
1937	1.766	3.040	2.984	0.590	3.400	0.050		0.082	0.125
1938	1.797	2.888	3.369	0.630	3.590	0.050		0.084	0.123
1939	1.849	2.888	3.850	1.220	3.710	0.051		0.085	0.124
1940	2.130	4.103	4.909	1.040	3.345	0.052		0.097	0.134
1941	2.348	5.015	5.775	1.030	3.110	0.050		0.108	0.144
1942	2.597	6.079	6.545	1.031	3.105	0.051		0.131	0.161
1943	2.920	6.231	7.122	1.030	3.185	0.048		0.150	0.180
1944	3.065	6.383	7.218	1.030	3.125	0.051		0.172	0.201
1945	3.055	6.459	7.218	0.950	2.825	0.050		0.189	0.221
1946	3.013	6.307	7.603	0.530	2.600	0.058		0.209	0.240
1947	3.190	7.371	7.988	0.530	3.025	0.089		0.228	0.257
1948	3.294	7.447	9.336	0.560	2.780	0.097	0.045	0.234	0.262
1949	3.304	7.143	9.528	0.600	2.880	0.101	0.045	0.255	0.273
1950	3.346	7.827	10.106	0.670	3.000	0.112	0.049	0.265	0.282
1951	3.616	9.574	11.550	0.920	3.640	0.130	0.052	0.285	0.293
1952	3.927	9.726	11.838	2.700	4.971	0.126	0.050	0.298	0.300
1953	4.135	9.043	11.935	2.780	5.026	0.130	0.049	0.315	0.318
1954	4.148	9.119	11.742	1.840	4.850	0.141	0.050	0.330	0.331
1955	4.256	9.422	12.031	3.755	4.905	0.156	0.055	0.335	0.331
1956	4.436	9.574	11.453	5.050	5.805	0.157	0.055	0.335	0.330
1957	4.619	10.182	11.646	4.980	6.134	0.164	0.052	0.359	0.337
1958	4.824	9.726	11.935	4.750	6.156	0.168	0.053	0.357	0.353
1959	4.825	9.498	12.416	3.490	5.596	0.186	0.058	0.370	0.365
1960	4.846	9.650	12.223	5.050	5.980	0.204	0.064	0.440	0.405
1961	4.980	9.802	12.031	5.280	6.628	0.215	0.068	0.474	0.437
1962	5.192	9.802	12.127	4.410	6.650	0.236	0.076	0.522	0.473
1963	5.320	9.954	12.416	3.980	6.013	0.257	0.091	0.602	0.509
1964	5.677	10.030	13.090	6.810	6.507	0.297	0.108	0.622	0.534
1965	5.963	10.258	13.282	5.880	6.847	0.302	0.117	0.646	0.561
1966	6.140	10.258	13.474	6.870	7.637	0.320	0.124	0.682	0.609
1967	6.333	10.182	13.474	7.780	7.670	0.344	0.139	0.739	0.680

	NY	RY	NPY	RPY	NPC	RPC	IND	U	W
1968	0.992	14.872	1.505	22.017	1.422	20.790	6.959	6.700	2.269
1969	1.145	15.696	1.711	23.299	1.592	21.677	7.501	6.400	2.596
1970	1.291	15.980	1.949	24.565	1.923	24.237	7.847	7.200	3.022
1971	1.475	16.713	2.196	25.493	2.159	25.064	8.143	7.200	3.481
1972	1.793	17.868	2.678	28.549	2.501	26.655	8.538	8.100	4.427
1973	2.165	18.877	3.271	31.529	2.973	28.649	8.488	7.200	5.021
1974	2.406	19.368	3.824	31.735	3.496	29.012	9.722	7.900	6.535
1975	3.025	19.634	4.926	33.535	4.208	28.643	9.327	12.200	7.819
1976	3.727	20.277	5.788	33.244	5.271	30.272	10.166	12.300	9.169
1977	4.536	21.551	6.956	35.213	6.241	31.592	11.005	11.800	10.526
1978	5.361	23.098	8.171	38.309	7.247	33.975	11.894	10.700	12.125
1979	6.351	24.070	9.712	39.867	8.911	36.580	12.634	9.400	14.331
1980	7.537	24.767	11.401	40.004	10.709	37.575	12.437	8.100	16.721
1981	9.145	25.390	13.917	40.809	12.891	37.800	13.202	10.100	18.871
1982	10.849	25.769	15.711	39.563	14.365	36.173	13.106	12.100	21.085
1983	11.957	25.581	16.959	38.560	15.625	35.527	14.063	14.000	23.654
1984	13.242	26.401	18.396	38.558	17.096	35.832	15.498	15.550	25.539
1985	14.385	26.915	19.523	38.690	18.576	36.812	15.880	16.908	27.489
1986	15.321	27.029	20.867	39.834	19.824	37.842	16.167	17.025	28.771
1987	16.372	28.013	21.990	40.661	20.888	38.623	17.602	16.750	30.256
1988	17.487	28.853	23.201	41.613	22.309	40.012	19.516	16.108	31.428
1989	19.396	30.473	24.907	42.720	24.110	41.352	21.812	14.600	32.700
1990	21.027	32.822	27.047	45.090	25.605	42.686	22.577	13.200	34.162
1991	21.877	33.361	28.738	46.114	26.886	43.143	23.247	14.583	35.475
1992	23.299	34.555	30.306	47.200	28.499	44.386	25.447	15.167	37.469
1993	25.092	35.355	32.761	49.985	29.860	45.560	26.882	15.500	38.505
1994	26.967	37.439	33.588	49.800	32.023	47.480	30.039	14.033	39.313
1995	30.549	41.030	36.745	53.357	34.347	49.876	35.875	12.125	40.460
1996	33.545	44.855	41.155	58.085	37.997	53.628	38.744	11.517	41.741
1997	38.656	50.011	44.626	61.409	41.557	57.187	45.537	10.300	43.544
1998	44.759	54.409	48.811	64.788	46.612	61.869	54.625	7.375	58.388
1999	51.619	60.421	53.158	68.407	52.584	67.669	62.661	5.550	62.229
2000	60.385	66.910	59.300	72.792	60.957	74.827	71.558	4.242	67.188
2001	67.927	70.454	68.970	81.092	66.681	78.400	79.307	3.908	71.546
2002	75.758	74.426	75.384	84.306	72.907	81.536	85.812	4.425	76.429
2003	81.238	77.317	80.667	86.653	78.122	83.918	90.691	4.608	80.000
2004	87.031	80.690	86.469	91.472	82.353	87.117	92.030	4.483	82.869
2005	94.723	85.431	93.998	98.094	89.598	93.502	95.665	4.408	85.769
2006	103.051	90.048	98.358	100.434	97.757	99.820	98.535	4.500	89.519
2007	109.811	94.952	107.316	106.363	107.575	106.620	103.701	4.667	94.615
2008	104.513	92.949	117.361	114.041	109.821	106.714	101.214	6.442	98.654
2009	94.418	87.878	111.049	113.275	98.931	100.914	96.813	11.958	99.327
2010	92.593	87.204	102.929	107.391	97.469	101.694	104.275	13.842	98.269
2011	96.931	88.452	100.458	103.597	97.994	101.056	103.858	14.608	97.115
2012	97.435	98.586	100.840	102.275	98.917	100.324	102.294	14.700	98.846
2013	100.000	100.000	100.000	100.000	100.000	100.000	100.000	13.100	100.000
2014	105.349	105.199	103.335	101.849	103.561	102.072	122.941	11.200	102.404

	CPI	IMP	EXP	STI	LTI	PSC	PERS	M1	M2
1968	6.634	11.018	14.437	7.170	8.076	0.410	0.160	0.789	0.778
1969	7.125	11.474	15.303	8.250	9.700	0.446	0.186	0.843	0.857
1970	7.709	12.234	16.362	7.310	9.850	0.462	0.236	0.899	0.938
1971	8.400	12.994	17.613	4.810	8.471	0.477	0.286	0.953	1.019
1972	9.123	13.602	19.923	8.000	9.450	0.613	0.450	1.122	1.165
1973	10.165	15.350	24.447	12.750	12.317	0.778	0.593	1.239	1.464
1974	11.890	22.416	30.221	12.000	16.843	0.903	0.649	1.352	1.759
1975	14.372	27.052	35.804	10.000	14.625	1.020	0.766	1.620	2.124
1976	16.957	32.219	44.177	14.750	15.474	1.304	1.047	1.896	2.428
1977	19.269	37.766	50.914	6.750	11.288	1.556	1.393	2.322	2.825
1978	20.740	39.590	54.283	11.850	12.817	2.067	1.870	2.961	3.635
1979	23.486	44.909	58.999	16.500	15.055	2.785	2.162	3.204	4.324
1980	27.766	52.964	64.196	14.000	15.334	3.310	2.567	3.581	5.150
1981	33.432	62.918	74.495	16.500	17.244	4.161	3.092	3.834	6.047
1982	39.157	67.553	82.772	14.000	17.040	4.713	3.531	4.131	6.830
1983	43.263	70.745	90.087	12.250	13.884	5.380	4.004	4.486	7.209
1984	46.977	77.584	97.690	13.231	14.600	6.064	4.546	4.896	7.937
1985	49.533	79.407	100.385	11.925	12.629	6.606	5.115	4.970	8.359
1986	51.420	70.593	93.070	12.521	11.058	7.144	5.593	5.224	8.277
1987	53.034	70.517	92.974	10.833	11.263	7.666	6.203	5.777	9.178
1988	54.169	75.152	99.711	8.046	9.478	8.467	7.037	6.318	9.761
1989	56.381	80.015	106.352	10.035	8.936	9.715	8.690	7.116	10.251
1990	58.252	75.988	96.246	11.307	10.083	10.747	9.745	7.691	11.835
1991	60.113	77.736	95.573	10.428	9.211	11.337	10.471	7.742	12.399
1992	61.989	76.140	92.974	14.318	9.070	12.079	11.446	7.803	13.849
1993	62.862	80.091	100.000	9.119	7.701	12.947	12.664	9.533	16.105
1994	64.336	82.143	99.904	5.930	7.921	14.282	13.988	10.796	17.751
1995	65.955	85.638	101.732	6.248	8.255	16.453	15.824	12.287	19.959
1996	67.070	84.650	101.155	5.418	7.289	19.374	18.347	14.296	23.126
1997	68.044	85.106	102.310	6.092	6.293	24.717	22.192	18.074	28.226
1998	69.689	87.082	105.005	5.426	4.797	30.509	26.463	22.766	33.115
1999	70.832	89.666	105.390	2.964	4.711	42.122	33.356	29.943	38.831
2000	74.774	97.264	110.683	4.392	5.513	50.774	39.732	33.600	43.573
2001	78.416	100.152	116.362	4.262	5.012	59.231	46.177	39.501	47.641
2002	82.053	96.277	114.052	3.319	5.010	65.251	57.124	41.368	51.215
2003	84.909	88.222	103.946	2.333	4.133	70.256	69.214	46.186	55.837
2004	86.772	86.246	100.096	2.106	4.077	88.146	92.204	52.532	62.355
2005	88.882	86.930	100.577	2.185	3.329	114.951	116.664	62.342	73.856
2006	92.383	89.438	100.481	3.079	3.765	140.696	135.326	74.151	87.597
2007	96.877	89.134	98.075	4.278	4.306	166.911	150.029	79.203	97.847
2008	100.804	90.957	94.321	4.634	4.526	164.331	140.083	68.825	96.085
2009	96.288	86.550	95.188	1.228	5.225	150.788	137.455	88.107	102.842
2010	95.378	90.578	97.401	0.811	5.739	119.907	122.805	85.753	94.927
2011	97.843	96.049	95.958	1.391	9.602	110.421	101.233	79.535	91.353
2012	99.499	101.596	101.829	0.573	6.172	107.462	103.250	81.382	92.059
2013	100.000	100.000	100.000	0.220	3.790	100.000	100.000	100.000	100.000
2014	100.196			0.210	2.370	81.813	92.110	102.247	94.004