University of Southampton

Faculty of Social Sciences

Southampton Business School

Economic fluctuations and policy uncertainty

by

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Abstract

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Economic fluctuations have an impact across society and have been a prevalent topic of analysis, most fervently since the Great Depression. This study is an empirical exploration of the role of economic policy uncertainty upon variations in economic activity. With an aim to draw insight into the more contemporaneous instability, through analysis of the interwar period experience, a phase of considerable global macroeconomic flux. The research considers prominent historical episode clusters comparing them with various components of economic policy uncertainty and subsequently the shifts in economic activity. Hence supplements the existing economic crises and uncertainty literature particularly relating to prolonged periods of recession. Advancing with the less covered yet significant role of sectoral imbalances. A specific focus of the study is a look into UK and US output fluctuations and uncertainty, with comparative as well as more global spill over analysis. The contrast of sectoral disparities linked with policy uncertainty provides intriguing insight, thus far given scarce treatment in prior studies. Overall findings indicate significance to the role of policy uncertainty upon economic fluctuations and that the interactions with sectoral shifts are topics worthy of further exploration. With pertinence to the understanding of the evolving currents in post financial crisis turbulence.

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Research Thesis: Declaration of Authorship

Economic fluctuations and policy uncertainty

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission

Date: June 2024

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Forever indebted to my family, for their longstanding support and well wishes.

Any omissions and errors in this research endeavour are my own, any originality emanates from the Divine.

For Bhai Sahib Baba Ji, for the chance to be in your world.

Overall introduction

The proceeding study seeks to provide an exploration of economic fluctuations and provide some insights into the field of macroeconomics. Given the post 2008 period of multiple shocks and recent pandemic events the study of a historical period which exhibits a number of similarities may aide the understanding into the current time.

Relevance of the study

Preparing for the future is something that is paramount for international organisations, policy makers, investors and citizens. As considered below an approach that can be taken, is to explore macroeconomic data and make forecasts. However as per Marks (2018) the 'macro future' is something very difficult to predict or if taking an investor mentality to be able to use forecasting to 'outperform' others. Such that basing decision making predominantly on such forecasts is a perilous endeavour for policymakers and investors alike. However there are 'tendencies' which can be objectively considered, Marks (2018) such as contemplating upon what may or should happen and the mechanism through which this may occur. Then the study of financial history, past cycles and crisis provides a context for contemplating upon the future, as the present environment is not the outcome of episodes occurring in isolation and there are patterns which emerge that are reoccurring. As covered further below cycles and fluctuations upon the economy are significant and considering previous occurrence provides a means of contextualising decision making for the future.

The alternative to studying the significance of past fluctuations could bring about the next major crisis sooner than expected. As Galbraith (1990) in a study of financial euphoria, elucidates that there are a number of factors that seem to bring about financial euphoria including, 'the extreme brevity of financial memory' with 'financial disasters quickly forgotten' in no uncertain terms the case is made that recurrence of these crises is in part due to the dismissal of past experience as a 'primitive refuge' for those unable to gain insights into a new 'innovative' financial discovery.

Objectives of macroeconomic research

Stock and Watson (2001) consider four primary objectives of macroeconomic research, the first is data description, to provide an overview and depiction of macroeconomic data; the second is forecasting, to provide a prediction of future macroeconomic outcomes; the third is structural inference, that is imputing quantitative estimation to provide insights into the 'true structure' of the macroeconomy; and lastly policy making. The research of the macro economy has developed over a substantial period of time, this includes theoretical, qualitative and quantitative methods. The post 1945 period was a time of economic growth for a number of regions and the approaches developed during this time included the more widespread use of econometric data analysis as a complement to theoretical explanations of the economy.

However, techniques used in the post war period became questioned during the global macro turmoil of the 1970s. The theories of inflation, unemployment and growth were challenged by the economic reality in this

juncture. At this time, Sims (1980) offered an alternative to the prevailing approaches bound by theory, the VAR (vector autoregression) techniques drew upon traditional autoregressive methods within a univariate framework, initially without the need to justify theories that were not converging with the events of the period and hence appeared to offer a viable research route.

Similarly, the 2007-09 global recession, which heralded the end of the 'great moderation' and also raised substantial questions over the prevailing forecasting models. Hence econometric approaches have emerged incorporating a more empirically grounded consideration of economic fluctuations. The study of such fluctuations is a primary of objective of this study.

Significance of fluctuations

Lennard (2018) considers the well-known theory of Lucas (1987) which disregarded the significance of business cycles (BC) given that they appeared to play a relatively minor influence upon on welfare in relation to consumption. The effect was quantified with an equation for the impact of fluctuations upon consumption such that with λ, representing the welfare cost; σ, representing consumption volatility; and γ, representing a 'parameter for aversion to risk' in the following formulation.

$$\lambda = \frac{1}{2}\gamma\sigma^2$$

Eq. 0.1: BC impact on consumption (based on Lucas 1987)

Lucas (2003) based estimates of consumption volatility upon post 1947 US time series data using a log of real per capital consumption for the period 1947-2007 and imputed the risk aversion parameter to have a value equal to one. Hence deriving the cost to welfare as being $\lambda = 0.0005$, such that the consumers preference for avoiding business cycles would be minimal, given that the implications is that the at most 'one -twentieth of one percent of average consumption' would be the preferred level of sacrifice to this end. Lennard (2018) estimates the same for the UK in the period between 1830 and 1938 and obtains a more significant result, imputing the welfare cost of the 'historical' fluctuations to be 0.3 per cent of the average annual consumption, a result six times larger than that obtained by Lucas (2003) for the post war period.

Based on the same formulation, an estimation for the welfare cost of US interwar period fluctuations is estimated with the same parameters as Lucas (2003) and Lennard (2018). So then using the conservative estimate of $\gamma = 1$, despite the recent literature finding the risk aversion factor being estimated to being closer to four. Then using a measure of the standard deviation log of US per capita consumption around a linear trend between 1929 – 1975, provides an estimate of the cost to welfare of fluctuations of $\lambda = 0.049$ or 4.9 percent of a year's average consumption. Given this is substantially of more significance than the result of Lucas (2003) for the post 1947 period. This as per the result of Lennard (2018) for the UK, reinforces the relevance of historical business cycles with respect to cost to welfare. Hence in this study consideration is

given to a significant period of historical fluctuations, the interwar period for which analysis of uncertainty and the business cycle is undertaken.

Research aims

The primary aims of the study are to make comparisons between interwar historical episode clusters and fluctuations in uncertainty, especially various components. Using these to supplement the existing literature and theories of crises particularly relating to interwar period which encompasses the great depression with incorporation of uncertainty perspectives. In particular to explore interwar business cycles and economic policy uncertainty for the UK and US respectively. Next then to consider the interwar business cycle spill over and economic policy uncertainty with both linear and nonlinear causality analysis. Proceeding this is an comparative investigation of the US and UK experiences during the same interwar period, in particular analysis of trade dynamics and capital flows with respect to uncertainty during a crisis period. With US and UK capital market data being analysed along with the respective historical economic policy uncertainty indices. Overall the main period of study is between 1920 and 1938, in essence the period in the aftermath of WW1 and the global Influenza pandemic and up to the point of WW2.

Rising macroeconomic uncertainty

> *Second only to its macro stability responsibilities is the central bank's responsibility to use its authority and expertise to forestall financial crises (including systemic disturbances in the banking system) and to manage such crises once they occur.*
>
> Alan Greenspan, former Federal Reserve Chairman (1997)

One of the primary functions of the Federal Reserve (the largest Central Banking institution on a global level) outlined by one its longest serving Chairperson's, was the prevention of financial crises. However, many within the economics profession had not foreseen the potential beginning of the last Financial Crisis of 2007-09 and subsequent Great Recession. Such that the Queen of England had remarked in reference to the escalating crisis, on a visit to the LSE (London School of Economics) for the opening of a new academic building at the university: '*Why did nobody notice it*?' HRH The Queen, November 2008

This question is a relevant motivation for the research thesis, which is an attempt to improve upon the understanding of the potential underlying causes and consequences of the financial crisis and the reasons for which it was not recognised. In order to answer the question an empirical approach has been taken in order to ascertain the prominent patterns which are apparent in the culmination of such seismic economic events. Intention is to gain a clearer perception of the past and of the possibilities for the future.

The recent financial crisis highlighted the many shortcomings and difficulties faced by researchers including some of the most experienced central bankers' having to admit that there was a 'flaw' in their perception of market operations, most famously Alan Greenspan the former Governor of the Federal Reserve. The crisis

bought forward various heterodox approaches to the study of the economy and as such this research attempted to redress the imbalances within the existing 'paradigm' Kuhn (1962), previously also Popper (1963) has indicated there have been various strategies to prevent rigorous evaluation of predominating theories. Thus, the assessment of methodological approach utilised in studying the economy is a key element of the thesis.

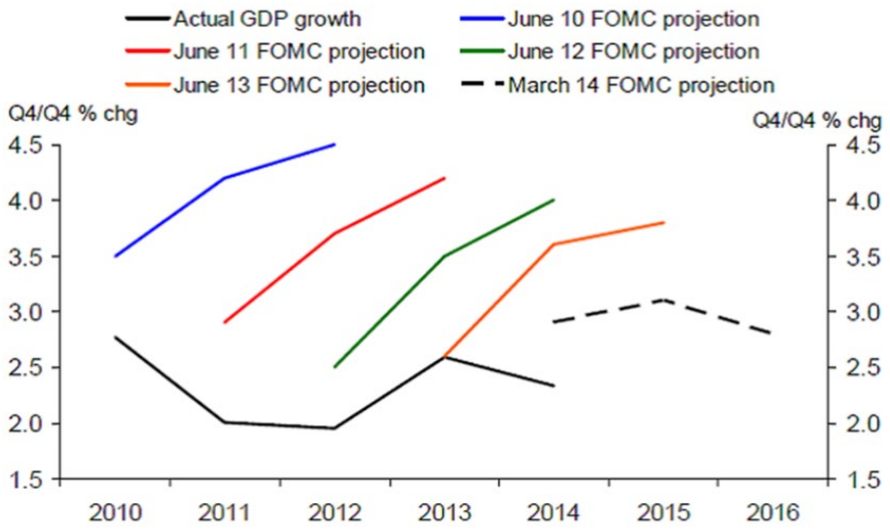


Figure 1: Breakdown of Fed's Forecasting model (Slok, 2014)

The above chart prepared by Slok (2014) shows the forecasting errors made by the Federal Reserve in the post 2009 period. The model of projected GDP growth at annual periodic intervals (2010-2014) has been significantly out of line with the actual GDP growth. This re-enforces the idea that there needs to be significant enhancements to the approach taken in the development of the existing models and in the paradigm being followed given that many Central banks were unable to foresee a major crisis, it appears the frameworks being applied to economic analysis are relatively stagnant and hence alternative approaches which are more empirical and reflective of the uncertain nature of the economy need to be applied. The modelling framework of central banks on a wider scale has also been analysed by Hendry and Mizon (2010) questioning the rationality of including 'rational expectations' into many of the Dynamic Stochastic General Equilibrium (DSGE) models and New Keynesian Phillips Curve approaches. The Hendry and Mizon (2010) study considers the mathematical basis of 'inter-temporal optimisation' and questions the validity given that 'conditional expectations' are not minimum mean squares nor unbiased in prediction. This analysis identifies the significance of incorporating the axiom of rationale expectations within many models and theories but furthermore questions the validity when faced with the actual market conditions being impacted in empirical reality with structural breaks and other significant events that are unanticipated. Blanchard (2018) also questions the suitability of variations of these approaches such as the FRB/US model which is less 'rigid' and attempts to allow the data more 'room to speak' than the theoretical confines of many traditional DSGE central bank approaches.

Context of the relevance of historical narrative

Hendry (2007) has noted that looking at a chart of unemployment in the UK mapped over a period of 130 years many of the significant structural events are explained by phenomena outside of the remit of traditional economic study. Such as wars, resource shocks and political events. Such that any attempt at analysis must attempt to incorporate the significance of such occurrences.

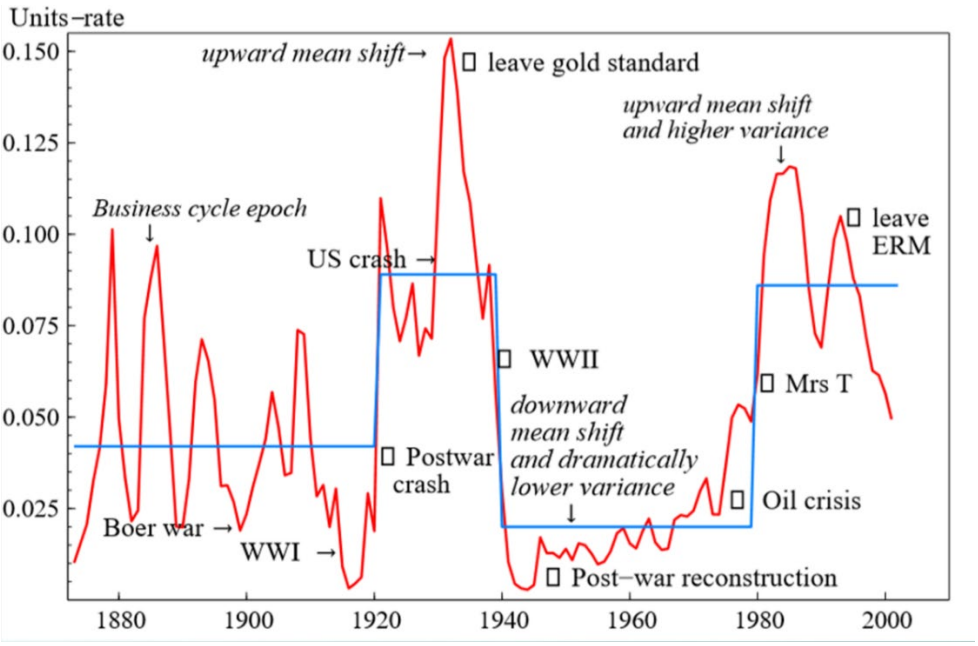


Figure 2: Historical unemployment levels UK with significant events (Hendry, 2007)

The interwar period was prominent on a historical level, due to the geopolitical change and also for the prolonged period of recession, which is most suitably described, when being considered from a macro economist's perspective by Bernanke (1994), 'to understand the Great Depression is the holy grail of macroeconomics'. Although, this study can only attempt to provide some prospective enhancements to the existing literature upon crises, here some novel approaches to explore underexplored facets of the interwar period which can support and enhance the most recent and insightful theories of crises.

The research into aspects of economic policy uncertainty with relation to business cycles and trade is relevant given the prevailing headwinds facing firms globally. There is a trend towards a potential return to protectionism. With the UK in a process of re-negotiating terms of trade post Brexit and subsequently requiring new trade agreements globally given EU unilateral terms applied to the UK up until the present. Further the US is attempting to renegotiate terms with its largest trading partner China. In relation to the UK there was a period of 3 years before even the initial terms of engagement for trade dialogue were agreed upon. The Financial Times 'Brexit Briefings' describe UK firms and consumers as being 'in the dark' and depict a Brexit timeline as 'a calendar of uncertainties', FT (2018). There is further uncertainty for business in relation to the future global terms of trade and the impact of restrictions to free movement of goods and services in addition to the restriction upon the movement of people which will has had a significant impact upon many industries

including financial and hospitality services as well as potentially most detrimentally upon heath care and agriculture. The UK and EU trade talks still face the possibility of a 'cliff edge' on the Northern Ireland protocol. In relation to the US China Trade deal the headlines and articles of the Financial Times describe the 'uncertainty over China-US trade deal', FT (2020) as impacting market prices in commodities and further Bloomberg News also indicates the significant amount of 'obscurity' over critical aspects of the present interim negotiation phase and the content of future aspects, Bloomberg (2020). The phase one talks have been completed, however there are many terms that are not in the public domain such as volumes of goods to be exchanged which are reportedly a very specific and detailed part of the agreement. There is further uncertainty in relation to the outcome of the forthcoming phases of negotiations. With much of the financial reporting and commentary still unclear about significant aspects, such that CNBC reports upon the latest updates with headlines such as ' US- China phase one deal brings some relief, but uncertainty' CNBC (2020) and also 'uncertainty remains on Wall Street about China-US phase one deal…' CNBC (2019). With CNBC (2020) and financial commentators such as Elrian (2020) describing the phase one as a 'truce' rather than completed negotiation, such that uncertainty is expected to remain. The current status of these negotiation for the UK and Europe as well as for the US and China has led to many commentators predicting the end of free trade with Fortune (2019) explaining the reasons 'why the era of free trade may be coming to an end' and further research by Faigelbaum et al (2020) depicting the reason for a return to protectionism. The potential forthcoming era of protectionism has clear parallels to the 1930s and hence the proceeding study has significant relevance to the current macroeconomic circumstance on a global level. Hence, further analysis into the impact of uncertainty fluctuations can provide insight into the perils and potential routes to stability in times of turbulence for the economy.

Furthermore the global pandemic fall out is currently apparent with respect to the global inflation and price movements. This has clearly apparent symmetry given the global Flu pandemic of 1918, Barro and Ursua (2020), further the post war period included an inflationary phase and price adjustments seen by the move away from and back to the Gold standard. Given the 2020 pandemic generated a large government intervention across nations which was the most significant increase in borrowing seen since the first world war and second world war periods respectively.

The following study utilises an empirical approach with reference to the way policy uncertainty can impact key macro fluctuations including the business cycle, business cycle spill over, trade under the period of turbulence which resulted in a major depression. The recent uncertainty literature has focused upon the recent financial crisis and periods after 1945. There is however a dearth of literature that explores the role of uncertainty, business cycles and trade during the interwar years.

Empirical approach and econometric analysis

As Stock and Watson (2001) note that two aspects of macroeconomic analysis 'structural inference and policy analysis' are the most difficult to approach even with statistically powerful tools such as VAR given there is

difficulty in identifying cause from correlation known as the 'identification problem'. Here Stock and Watson (2001) indicate that in order to address such issues 'economic theory and institutional knowledge' are required in order to arrive at suitable solutions. Lennard (2018) proposes the 'narrative approach' in which Ramey (2016) purports that the utilisation of 'historical documents' to build an identification series which can be used to analyse the 'reason and/or quantities' relating to changes for a given variable. There are a limited number of studies employing such approaches a selection noted by Lennard (2018) includes studies which use the narrative approach to "identify primitive shocks" across a number of macroeconomic variables such as relating to:

- oil supply shocks - Hamilton (1985)
- bank runs/panics - Jalil (2015)
- government spending/policy shocks - Ramey and Zubairy (2018); Ramey (2011); Ramey and Shapiro (1998)
- monetary policy - Cloyne and Hürtgen (2016); Romer and Romer (2004); Romer and Romer (1989)
- taxation / fiscal policy - Hayo and Uhl (2014); Cloyne (2013); Romer and Romer (2010)
- other transfers (policy related) - Romer and Romer (2010)

The narrative approach is considered within the relevant chapter 2 part e.

The empirical approach overall utilises the application of the relevant quantitative data techniques to explore relationships between the relevant variables, such as the link between trade uncertainty and crises. Working with the most appropriate approach to the study of the impact of policy making such as an inductive empirical approach which can be quantitative with the auto regressive distributed lag (also the general to specific method) and build a historical narrative through the exploration of archival material. The novel aspect is the application of the economic policy uncertainty index to the interwar period business cycle, business cycle spill over and trade in the context of crises.

However, when past crises are studied, this cannot possibly be carried out within the abstract, stylised and simplified neoclassical and deductive framework. Instead, a thorough understanding of the relevant institutions and decisions is needed. This can be utilised in the development of realistic micro foundations and understanding of market infrastructure, as Wade (1985) did in his exploration of the Taiwanese economy. This work highlights the relevance of the government in monitoring market activity and inevitably moves away from the free market hypothesis. At the same time, taking an empirical perspective, it is not a given that markets can be expected to be in equilibrium. As a result, disequilibrium economics, as for instance espoused by Barro and Grossman (1976), Malinvoud (1982) and Muellbauer and Portes (1978), may be found to be more relevant instead. Romer (2016) has even put forward a strong case to show that neoclassical approaches to macroeconomic study are a 'pseudoscience' that '… displaces objective fact from its position as the ultimate determinant of scientific truth' as depicted by Romer (2016).

In the light of these shortcomings it is necessary to consider alternatives to the deductive-axiomatic methods. Instead of beginning with proclaimed axioms and assumed conditions, the inductive methodology proceeds by examining empirical reality and building and testing models that are entirely founded on empirically demonstrable facts. In terms of quantitative statistical analysis, this method is perhaps well represented by the general-to-specific econometric methodology, as developed by Hendry and collaborates, also known as the 'Hendry' or 'LSE' method such as seen in Hendry and Mizon (1978). This approach seeks to let the data teach us what the best possible representation of statistical reality (the 'data generating process', DGP) could be. In addition to the quantitative methods that can be applied in the pursuit of an empirical inductive approach, qualitative methods describing institutional realities and causal narratives play an equally important role. When examining phenomena and events, all records, including notes of meetings, correspondence and internal memorandums should be consulted and cross-examined with the other evidence to piece together as accurate and consistent a description of actual events as possible. Aside from the issue of access to sensitive documents, this could be potentially delivering unbiased insights. An important example in the literature of an approach that has been influential in the development of the methodology used in this dissertation is the innovative work of Geyikdagi and Geyikdagi (2011) on the political risk of foreign investments in the Ottoman Empire. This makes extensive use of newspaper archives in their investigation. Other scholars such as Natmessnig (1998), Teichova (1974) and Cottrell (1995) make use of archival materials in exploring a similar timeframe of the inter-war period.

Evolving economic and econometric methodology

As Pesaran and Smith (1992) identify there is a long standing debate within the economic field with regard to the optimum approach to the study of the economy with diversity in the character of theoretical perspectives and empirical 'observations'. Morgan (1990) refers to a well-known statement from Jevons, "the deductive science of economics must be verified and rendered useful by the purely inductive science of statistics'. Pesaran and Smith (1992) identify a conflict between the two aspects and further find that the purpose of economic modelling should be:

a. *Relevance* – depict the data, in a 'statistically adequate' way
b. *Consistency* – follow existing knowledge 'physical, institutional and historical'
c. *Adequacy* – utility for a progressive purpose such as forecasting, decision making or understanding

In particular Pesaran and Smith (1992) look at the evolution of statistical methods for econometric analysis which have evolved from the models of the Cowles Commission based on the original work of Tinbergen and later Haavelmo as identified by Hylleberg and Paldam (1991) in these models a wide variety of factors and variables are incorporated to produce 'estimators' consistent with the pre-existing theory. It was found later that the ARIMA 'univariate' models based on a single variable were more accurate at forecasting however theorists' complained that the models were unrepresentative and this led to the development of streamlined time series approaches which include the single equation based LSE methods producing ECM (error correction

models), the multivariate VAR (Vector Auto-regression) approach and the cointegration representations of both which led to the formulation of VECMs. Further analysis of the time series approaches is provided in the proceeding chapters.

Brief review of econometric approaches

There are multiple approaches to econometric analysis of time series data as well as numerous overall econometric methodological debates that have evolved over time, especially since the Cowles Commission was established as Rao (2007) indicates. As discussed above the approach taken in this study is the general to specific empirical approach which is seen to be more favourable for estimating short run and long run relationships in macroeconomic data. Pagan (1987) reviews three approaches of time series analysis which are based around a reductive approach to model development. These are analysed by the way of considering the work of the formative authors for each, in particular this includes the 'Hendry Methodology', exemplified in Hendry and Richard (1982), the 'Leamer Methodology' seen in Leamer (1978) and the 'Sims Methodology', within Sims (1980). Of these Pagan (1987) identifies the Hendy approach to be the most traditional and as Rao (2007) identifies least in conflict with the Cowles Commission given it is an 'alternative method of estimation for dynamic structural equations' whereas the other approaches are more direct alternatives especially the VAR models of Sims (1980) which are an 'atheoretical' alternative to the broader 'large scale models' which were used to coincide with more traditional economic theory, in combination with simultaneous equations methods and have been subjected to the Lucas critique. Lucas (1976) criticised the pre-VAR approaches with comments on the lack of coherence when factoring the relevance of behaviours of economic actors, such as under rational expectations, economic agents make behavioural adjustments due to policy changes. Hence, Rao (2007) identifies the prevalence of the VAR approach for forecasting due to the better performance compared to the Cowles large scale model approach.

The review undertaken by Pagan (1987) provides a thorough comparison of the main approaches, although there have been significant advances to the methodology of such time series approaches in more recent times, the points made are still relevant to better evaluate empirical analysis. In summary Pagan (1987) put's forward a view that a combination and clarification to these methods would be beneficial, such as with the reductive approach of Hendry, which could benefit with some bounds testing, which is part of Leamer's approach and furthermore both Leamer's and Sims's approaches could benefit from further focus on residuals to analyse the 'sensitivity of likelihood' aspect of variable inclusion. Rao (2007) further identifies the most prominent approaches to applied econometric analysis are all techniques based on an autoregressive (AR) framework which are in contrast to the ARIMA formulations which include moving average analysis. As depicted by Harvey and Koopman (1997) the ARIMA approaches are used mainly for forecasting as opposed to building 'structural models'. Many of these methods also utilise and ARDL set up for certain formulations, the methodology section of chapter 4provides a further overview of the ARDL Bounds testing approach, which is based on the work of Pesaran and Shin (1995) and Pesaran et al (2001).

An overview of the predominant autoregressive econometric approaches:

- GETS – LSE/Hendry method; Hendry (1987)
- VAR / VECM – Johansen approach; Johansen (1988)
- US VAR – Sims approach; Sims (1980)
- ARDL– Bounds testing approach; Pesaran and Shin (1995)
- Two step procedure – Engle-Granger method; Engle and Granger (1987)
- Fully modified OLS – Phillips and Hansen (1990)

An overview of the most prominent three AR econometric time series methods is considered in Rao (2007):

	GETS - [Hendry, 1987]	**VECM [Johansen, 1988]**	**VAR [Sims, 1980]**
Description	• Uses theory to formulate initial model and variables • Begins with a GUM and then reduces to parsimonious form through setting 'constraints on estimated coefficients'	• Identifies structure and theoretical basis for coefficients of a VAR • Tests for unit roots and cointegration	• Initially refuted need to discriminate between endogenous and exogenous variables (later work SVAR did consider this aspect) • Refutes need for 'constraints of traditional theory' which imposes restrictions with 'structural parameters'
Benefits	• Uses an adjustment structure which ensures consistency with the DGP • Formulate an ECM from the error correction term	• All variables treated as endogenous • Limits variables based on theory • Formulates an ECM based on reduction	• Can formulate an ARDL and reduce to parsimonious forms through optimal ordering of VAR through testing • Forecasting better than Cowles models if sufficient sample size
Detriments	• Does not pre-test for order of variables • Inadequacy of selected 'general model'	• More complex computation process if unit roots testing utilises 'break point analysis' and existence of seasonality	• Does not pass market usage test according to Evans (2003) • Incompatible with real business cycle long form models • Superseded with SVARs…

Figure 3: Time series methods summary (based on Rao, 2007)

Approaches used in this study

Granger (1997) puts forward a compelling perspective upon the choice of methodology, 'It is impossible to decide between models on purely intellectual grounds…' hence if possible the optimum approach could be a way that also enables the most confidence in the outputs to be derived. Hence '… little controversy if we agree to try several modelling methods and let competition decide between them.' The intonation of this perspective has been used to guide the approach taken in this study, which is to utilise a range of applicable approaches, a number of which are predominantly based around the ARDL equation formulation and all of which apply a variety of techniques to reduction, for a general to simple formulation.

- GETS - ARDL
- Granger causality
- Nonlinear causality

- Complimentary and robustness analysis:
    - Impulse response VAR
- Interwar period – Historical episode clustering
    - Narrative approach to compare with fluctuations in uncertainty components

In the chapter specific subsections below a further exposition of the methods/approaches used in this study is provided. As Hendry and Nielsen (2007) identify there are seven important components to an econometric based study:

1. Theoretical model of the topic of interest
2. 'Statistical model' of the data which is relevant
3. Selection of approach to estimate the 'unknown parameters'
4. Data sample which is to be analysed
5. Process to evaluate the 'fitted model'
6. Procedure to revise steps taken if misalignment of model
7. Review of the particular components ('properties') of the procedure

An attempt has been made to apply this framework when utilising the different econometric approaches although there a variety of ways the above steps can be worked through in practice, depending on the topic in question.

Overview of the proceeding chapters

The proceeding study is constructed as follows:

- Chapter 1 – overall literature review of the thesis, with summary evaluations of the literature and planned contributions of the thesis in tabular form
- Chapter 2 – first paper
- Chapter 3 –second paper
- Chapter 4 –third paper
- Chapter 5 – overall concluding remarks of the thesis (including avenues for future research)

Each of the Chapters 2, 3 and 4 are set out as complete papers with relevant Chapter-specific sections of Introduction, Literature Review, Research Gaps and Contributions, Empirical Analysis, Econometric Model, Results (with significance of the results), and then Concluding Remarks.

Chapter 1: Overall literature review

The two primary aspects of economic literature that are considered through this study are policy uncertainty and theories of crises. The proceeding chapter considers the present literature, motivating concepts and provides a succinct summary of tenkey theoretical contributions for each paper, which are further explored in the subsequent chapters.

a. Uncertainty conceptual framework and relevant literature

The subject matter of uncertainty and risk is of primary importance to economic agents acting in the 'real' world, subsequently researchers have considered several facets concerning uncertainty and its relationship with economic activity. The various approaches have been surmised in the work of Bloom (2016) and also in Choudhry et al (2020). These matters are given further consideration in the proceeding sections of this chapter. However, to begin, two fundamental questions which re-occur throughout the proceeding chapters are touched upon. The first is the definition of uncertainty and the second is the nature (and causal direction if any) of the relationship between fluctuations in economic activity (the business cycle) and fluctuations in uncertainty. Within Chapter 2 further analysis of uncertainty and the macroeconomy, including some approaches to measuring uncertainty is considered, wherein particular attention is given to the Economic Policy Uncertainty indices of Baker et al (2012). Chapter 2 also includes an analysis of fluctuations in uncertainty during the interwar period, which is undertaken using the approach of clustering historical episodes and comparing them with various components of uncertainty specifically identified using the Economic Policy Uncertainty indices for the US and the UK.

Concept of Uncertainty – Knightian uncertainty

The notion of 'uncertainty' has become more widespread with the increase in empirical studies since the Great Recession of 2008-10 such as Baker, Bloom et al (2012) and Choudhry et al (2020). However, the theoretical basis which is 'Knightian uncertainty' was espoused most clearly during interwar period with the work of Knight (1921). Before focusing on a refined definition of uncertainty it is worthwhile considering the context and underpinnings of the approach taken by contemporaneous interwar research work which also considered this topic, as within the Austrian School, exemplified within the work of Hayek (1932). Knight (1921) frames uncertainty as being part of the asymmetries of the 'real world' in which the theoretical assumptions of perfect competition and perfect knowledge or the existence of perfect foresight of economic agents are non-existent. Hence in the empirical dimension the inability of market participants to have perfect knowledge and inability to completely measure risk, especially for specific events or changeable 'economic conditions', brings opportunity for the entrepreneur, through taking advantage of the asymmetry they can earn a profit. Erstwhile, in the previous state of the economy, before the activity of the entrepreneur, competitive forces prevent or minimise excess profit. Hence, ex-post other market participants see the profits being earned after the entrepreneurial intervention and the subsequent emergence of competitive forces erodes this profit.

Thus the interwar conception of uncertainty which is most clearly seen in the work of Knight (1921) but also Hayek (1932), has a distinct framework relating to the place of the entrepreneur as being able to make real world profits due to an ability to take benefit from the existence of 'market imperfections' which create the opportunity. Deriving opportunity from changing 'economic conditions' the entrepreneur is able to engage 'productive services' for a fixed price such as labour, land, machinery, or other capital at a predetermined fixed cost and then realise profit ex-post when a sale price is determined. The changing 'economic conditions' create this differential between the costs of production and sale price before competition can 'equalise' the cost of production with the price of produced goods/services.

In summary there are perhaps two matters of significance, firstly there exists a subtle distinction between the interwar conception of uncertainty which was framed within the entrepreneurs ability to take advantage of 'failures of competition' and the post Great Recession research which has focused more on utilising the interwar definition of uncertainty to build empirical analysis of economic fluctuations. The second matter concerns the definition of uncertainty itself for which the Knightian approach was more universally accepted in the interwar period, as identified by Schliesser (2012), In the post 1945 period there has been a dichotomy between the work of Arrow (1951) which assumes that uncertainty is measurable and the work of Ellesberg (1961) which identified uncertainty as being an immeasurable component that is faced in the 'real world' by decision makers. This definition of uncertainty has been used in the work of Shackle (1949) and those using the concept to identify the significance for the activity of economic agents. This definition of uncertainty is identifiable in much of the aforementioned, post-Great Financial Crisis empirical studies exploring the impact of uncertainty, as can be clearly ascertained from the definition applied by Bloom (2016).

Definition of Uncertainty

As Pritsker (2013) notes that there are three concepts to clarify upon when giving consideration risk and they are 'risk, uncertainty and structural uncertainty'. Here risk is depicted as the notion that future events having a random outcome whereas under uncertainty the probabilities of 'random outcomes' are also unknown. In addition, a further aspect of uncertainty which is defined as structural uncertainty is not knowing complete 'structure of the economic environment'. This is an aspect that was apparent during the interwar period, although in a differing context the Rumsfeld (2011) depiction of '…known knowns, known unknowns and unknown unknowns…' perhaps has some relevance to the notion of uncertainty in particular regard to the interwar period. Given that there was a dramatic geopolitical shift taking place with new methods of production and the hegemony of the UK role in trade also shifting.

Henceforth in the proceeding chapters of this thesis the definition of uncertainty applied is that of 'Knightian uncertainty', or Immeasurable risk. Perhaps a novel approach to succinctly defining the notion, is to categorise the relevant elements contained within the definition of Knight (1921) using the framework (sic) of Rumsfeld (2011), Further here an introduction to another framing concept is introduced that of a *Risk-Uncertainty*

Expectation Spectrum this is another construct outlined within this thesis and is given more attention in Chapter 4.

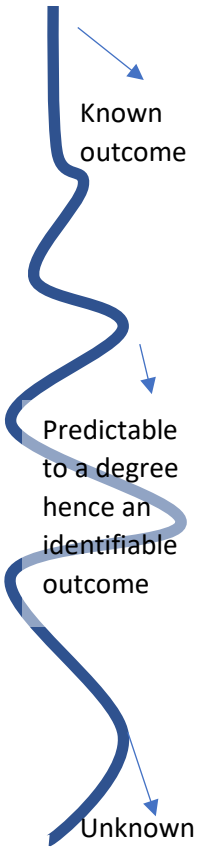
Knightian definition	***Explanation***	***Spectrum of expectation***	***Rumsfeld Lexicon***
1. *Priori* probability	**Homogeneous class of events** - Probability distribution of an assumed straight die is known for example		***Known knowns***
2. *Statistical* probability	**Measurable / quantifiable risk elements** - Can draw upon a probability distribution function from taking a sample of the population with some statistical assumptions such as independent errors and so on (for example from knowing the sample mean).		***Known unknowns***
3. Estimates	**Uncertainty - immeasurable element** - No systematic way of accurately quantifying/estimating risk – quasi fat tail risk vis. Black Swan events Taleb (2007)		***Unknown unknowns***

Figure 4: Uncertainty and risk summative definitions

Further consideration is given to the notion of the spectrum of expectation in Chapter 4, given there is certain nuance required in making a distinction between the second and third classification of the framework above. Here Knight (1921) distinguishes between an 'estimate of an estimate' and the ability of enterprises to construct for a relative level of confidence certain 'measurable uncertainties' which can be interpreted as measurable risk and hence this would not be a 'true uncertainty'. This classification of uncertainty should perhaps be clarified in relation to the post Great Recession literature which has developed 'measures' of uncertainty as in the work of Baker et al (2016a) and Jurado et al (2015). The distinction to be drawn here is that they identify *measurement of uncertainty* as the measurement of *proxies* for the prevalence of the 'true uncertainty' as opposed to Knight's conception of the second part of the framework of a measurable risk which Knight refers to a as a measurable uncertainty, which would be a lower form of uncertainty. Thus, future reference within this study to the 'lower form' of uncertainty, is as measurable risk.

Henceforth it is the 'higher form of uncertainty' identified as that element or outcome which cannot be measured and thus not possible to eliminate from consideration through risk measurement and identification

techniques. This is the definition of uncertainty utilised in the proceeding thesis, the true Knightian uncertainty, which results in asymmetry in market outcomes and the profit of the entrepreneur.

b. Key question - causal precedence of uncertainty and business cycles

The discussion of uncertainty cannot be undertaken without mention of the looming question of causality and precedence, as considered above Knight (1921) conceives that uncertainty must exist as a *priori.* This could be in the form of an informational asymmetry or another market imperfection, which at the level of the firm or economic agent creates an opportunity which is exploited by the entrepreneur for profit. This can be related to Schumpeter's (1939) concept of 'creative destruction' in which new methods of production or technology emerge displacing or creatively destroying the older forms and thus can be linked to the formation of business cycles and 'waves'. This matter is considered further in Chapter 4. However, certain elements of the more recent literature develop a conception with empirical analysis at the macroeconomic level, predominantly utilising the recently developed measures of uncertainty. Baker et al (2016a) propose and develop one such EPU (Economic Policy Uncertainty) index. A brief review of the existing approaches to considering this question of 'causal effects', all of which appreciate that it is clear that 'uncertainty moves with the business cycle' but there is a distinction between them hence leading to three separate approaches, which are covered by Bloom (2016).

Approaches	Description	Benefits	Detriments
1. Timing	Uncertainty shocks used to estimate movements in key variables, such as production, new employment, and investment	Can be effectual in the case of 'unexpected' shocks	Less effectual in cases in which the uncertainty is 'correlated to unobserved factors' or is predictable in other ways prior to the occurrence of the shock
2. Structured models	The effect of an uncertainty shock is quantified using micro and macro moment analysis and calibration techniques applied to structural modelling techniques	Theoretical basis of the approach is well established	The basis of the assumptions for the models is quite 'debatable' and hence weakens the strength of the results given that structural models are 'sensitive' to changes in these assumptions
3. Natural experiments	Utilising exogenous shocks such as natural disasters or political regime changes in additional to economic events such as price movements in key markets such as currency rates and energy or major political announcements on trade	These are often not predictable in advance and hence can provide an effective basis to analyse as an exogenous shock to the system	The derived results can have less 'generalisability' given that although at the micro level firm and consumer behaviour Is impacted by the uncertainty element of the shock, there remains the question surrounding other potential 'influence' which occurs as a result of the particular event in question.

Figure 5: Uncertainty analysis methods (based on Bloom 2016)

Timing based studies of uncertainty

The studies which explore the relationship between uncertainty and the economy include macro and micro level analysis. Novy and Taylor (2014) find that uncertainty has a negative impact upon trade across different sectors for US trade flows with data beginning in the 1960s and further more find that the Great Recession

global trade collapse can attribute around half of the decline as being due to uncertainty. Handley and Limao (2012) also find firm level impact upon trade with a positive impact from increasing certainty such as seen with Portugal's accession to the European Community in 1986. Bloom (2016) identifies that the macro level studies have mainly considered the short run impact, however Ramey and Ramey (1994) explore the long run effects of volatility a proxy for uncertainty upon economic growth for a global 92 country sample, 1960 to 1985 as well as a more focused 24 country OECD sample, 1950-1988. They formulate an equation to estimate GNP and construct a measure of volatility through divergence with the forecast. This study finds that there is a negative impact upon the business cycle and long run growth of nations with more volatility. This has been explored with alternative methods by Bloom (2009), Ramey and Ramey (1994) find that the results support the theoretical basis of studies by Ramey and Ramey (1991) which relates to 'planning errors' by firms due to uncertainty inhibiting growth as well as the studies which identify fixed or sunken cost limiting the ability to 'shift productive factors between sectors' as in the work of Bertola (1994) an Dixit and Rob (1994). In addition, Leahy and Whited (1996) also identify that 'irreversibility of investment' as limiting factor for US publicly traded manufacturing firms, for whom investment decision making is negatively influenced by stock price volatility. Guiso and Parigi (1999) obtain similar results from Italian firm data using their own expectations of demand as a proxy for uncertainty. More recent studies upon firm level effects such as Bloom et al (2007) find in the period between 1972-1991 for UK manufacturers corroborate these results. Furthermore Romer (1990) found that the 1929 stock market crash induced uncertainty to reduce consumer expenditure in durable goods, with evidence of a sustained impact from stock market volatility negatively impacting consumer durable expenditure during the interwar period.

Structural models of uncertainty

Recent studies have attempted to identify the short run impact of uncertainty shocks, for example the Bloom et al. (2012) study attempts to build a general equilibrium model with 'heterogeneous firms' facing adjustment cost from both labour and capital with both micro and macro uncertainty acting in a countercyclical fashion. This model attempts to identify a scaled impact of uncertainty following a recession and finds that uncertainty can reduce total output by 3% they find this is due to firms limiting investment and also from the reduction on expansion from productive firms and continuation in production from unproductive firms limits productivity growth. In this model a reduction in uncertainty generates a V-shaped recovery due to 'pent up ' demand creating a rebound effect. Bloom (2016) identifies the sensitivity of assumption as critical given the differing results of Bachmann and Bayer (2012,2013) in which a similar general equilibrium model is applied with variation in assumption as they exclude 'labour adjustment costs' and emphasise the micro level uncertainty ahead of macro uncertainty shocks. The result indicates a lower impact of uncertainty upon growth. Kellogg (2010) utilise Texas oil drilling data with NYMEX future options market volatility for oil prices as a proxy for uncertainty and finds that the results indicate a reduction in oil drilling activity aligned to the real options theory, this is discussed in the proceeding subsections.

Natural experiments on uncertainty

There has also been an exploration of uncertainty through the utilisation of exogenous shocks such as Stein and Stone (2012) in which they proxy exposure of firms to energy and currency exchange volatility for uncertainty and find that this accounts for a third of the reduction in 'investment and hiring' during the 2008-10 period. Baker and Bloom (2013) utilise 'natural disaster, terrorist events and political shocks' with news and stock market data used to identify that the shocks were unanticipated, a definition was applied to each category of event such as 'minimum share of GDP lost or political regime change' undertaken over the 1970-2012 period for 60 countries. The procedure was to use the events to predict volatility in the stock market, then to use the predictable element of the stock market volatility from the shocks to generate a GDP growth forecast. The results indicated that 'half of the growth variation' was attributable to the rising volatility due to the shocks.

Hence it can be perceived that the analysis of this measure in the literature is unable to firmly identify a singular direction of causation. Each of the approaches identified by Bloom (2016) has merits to contributing towards the advancement of understanding but each is not able to provide a definitive answer to the question of precise causal effect. Here Bloom (2016) asserts that the short run impact upon investment, output and trade amongst other key variables of uncertainty is negative. Whereas the long run impact is not clear for which Bloom (2016) refers to the 'growth options effect' as a possible alternate explanation indicating the potential presence of a positive effect. However, reference is not made in the recent literature to the primary focus of Knight's (1921) thesis and exposition which was to explain the way the entrepreneur seizes the opportunity of uncertainty to introduce new methods or new goods and service to the market. Overall, Bloom (2016) considers that more empirical work investigating the potential causal impact of uncertainty, is highly beneficial.

c. Theories of crisis and relevant literature

The economic definition of a recession is two consecutive quarters of negative growth in gross domestic product (GDP), such as may arise during the course of a business cycle. An economic crisis can often be a trigger for a deeper recession, typically one in which the recovery from the fall in output is of a longer duration than in a *normal cycle.* A depression is one in which the fall in output, trade and employment is of an *abnormally* greater size again with a slow recovery which may take several years before economic activity reaches the level prior to the onset of the crisis.

In the following sub-sections, consideration is given to the literature upon the most prominent theories which depict the interpretations of crises including more recently the great recession and are also impacted by the past research on the great depression. The initial section considers two prevailing approaches, one side is the theories that give prominence to the non-systemic causes and the other is the literature which gives prominence to the systemic causes, as well as a summary of the asset bubble perspectives on crises. The next

section considers several approaches which relate to the theory of the business cycle. This is followed by recent research upon sectoral imbalances relation to the US economy during the interwar period.

Non-systemic causes of recession

An example of the non-systemic approach to considering the cause of a crisis is exemplified partially in the work of Bernstein et al (2011) which is placed in the historical context of the 1815-1925 period of US financial instability. This is in a similar vein to the work of Reinhart (2011) in a more recent 2008-10 context, which looks into the short-term measures that were applied to alleviate the liquidity declines experienced in financial markets. The policy advocated by the G7 and IMF revolved around the injection of liquidity through quantitative easing, at its core this policy eased conditions for institutional financial market participants. Primarily the result was a recovery in stock market prices but a lack of support for the real economy King (2016). The research which has focused on this narrower notion of falling liquidity as a primary cause of the collapse perceives the crisis as primarily a financial event. This is seen in the collapse of the UK bank Northern Rock which was unable to access interbank funding and the doubts raised, caused a run on the bank from depositors. This type of failure appears to lead to a contrary perspective, that of the markets essentially drying up due to the uncertainty surrounding the worthiness of assets and fear of failure surrounding large market participants, as opposed to falling liquidity causing market participants to lack funding for continuation of activities. This was seen in the US with the failure of two large investment banks. Bear Stearns and Lehman Brothers suffered due to being unable to fund an array of positions in a range of asset classes which was at a fundamental level not dissimilar to Northern Rock suffering from its extreme positioning of long term mortgage lending supported by short term interbank lending without enough 'sticky' depositors to prevent illiquidity during stress.

The example of Northern Rock is also a primary example of the facet which was perceived to be the primary cause of the crisis by some commentators, which was fundamentally an asset bubble in the mortgage market. In the UK, Mortgage lenders such as Northern Rock and Bradford and Bingley engaged in a somewhat Ponzi scheme Nesvetailova (2008). through the escalation of the loan to value ratios being applied, in contrast a sound bank would typically apply lend up to 75% of the value of the underlying property asset being used as collateral. However, during the 2004-2007 period many banks engaged in making loan contracts with loan to value ratios of 100% or even higher. The expectation was that the price increase in the value of the asset, would be apparent in a forthcoming period, which would lower the loan to value ratio and hence exposure of the lender in a short time period. Which as depicted by Minsky (1980) is fundamentally a form of a Ponzi scheme. In the US there was also a rise in financial disintermediation, non-bank financial intermediaries such as Countrywide would originate mortgage contracts with borrowers before selling the loan contracts onto banks and other financial institutions. Hence Countrywide itself would not bare the risk of default and they were thus prepared to undertake more sub-prime lending. That is loans to less than prime credit worthy borrowers, in extreme cases some intermediaries made an excessive number of, so called 'Ninja' loans, which

were loans to borrowers with 'no income and no job'. These practices were supported through the quasi-governmental institutions such a Freddie Mae and Freddie Mac which effectively allowed financial institutions such as Merrill Lynch to take loan assets off the balance sheet. Furthermore the investment banks would purchase the assets in the form of a collection of securities known as mortgage backed securities and they would either be funded through short term money market or interbank funds as well as asset brokers such as Goldman Sachs selling these securities of loans to foreign investors. Many such investors were totally unaware of the precise composition of the securities themselves.

Some prominent commentators such as Crotty (2009) consider the periodic escalation of this problem due to de-regulation of the market participants. This aspect put into question the ability of regulators such as the then FSA (Financial Services Authority) in the UK and US Securities Commissions in the US in having misaligned incentives to allow expansionary activity and an inability to identify the level of risk. Such as comments by Moorad Choudhry (2014) that Northern Rock underwent a regulatory review and submission in June/July and was then facing a bank run in September 2007. This was partly a focus of the Turner review (2009) following on from this Turner chaired investigations into the market practices of participants. With activists in the US arguing that the repeal of the Glass-Steagall Act of 1933 was a primary factor in fuelling unchecked profit seeking without any separation between the retail and investment division within the banking sector. Some commentators such as Gorton (2009) attribute the blame toward the misplaced 'free market' ideology of policy makers such as Alan Greenspan, believing in the 'invisible hand' hypothesis that markets are self-correcting.

This aspect of de-regulation occurring within the financial services sectors links into the literature which gives credence to the rising 'financial innovation' and increase in the number of OTC (over the counter) unregulated bespoke transactions which were occurring within derivatives markets. The regulators and even the executive boards of institutions were essentially either unable to ascertain the level of risk as explored by Crotty (2009) or compliant in allowing the innovation to occur. As Engel et al (2008) observe the belief of participants was that the development of the securitisation of loan contracts into mortgage backed securities, with each offering comprising a portion of an underlying loan contract of varying risk (prime to subprime) to leave the overall level of risk in the security as low but with a higher potential return. The trading strategies of firms such as Goldman Sachs were enabling of such transactions, by utilising collateralised debt obligations (CDOs) to refinance the mortgage backed securities for re-sale to clients. Many of the offerings were supported with large insurers such as AIG further enabling the perception of low risk. Boz (2014) explores the modelling mechanisms relied upon to monitor the underlying assets and securities, which became increasingly complex to measure.

The level of risk attributed to the securities being sold, often to foreign investors was enhanced through the credit ratings agencies, which was identified by Stiglitz et al (1999) as being unsuitable. The ratings agencies had adverse incentives in the grading of the assets and securities due to the commissions they received from

the banks and stock trading firms. The system employed was also at fault as Hunt (2009) explores the banks had an opportunity to show the securities in the 'best light' given as Partnoy (2002) also identifies the agencies relied upon the banks to provide the basis of the risk identification in the assessments undertaken and hence undermining the reliability of the assessments. A further observation is the lack of competition amongst the agencies undertaking the ratings, with three agencies, Moody's, S&P along with Fitch dominating the market.

The risk pricing approach undertaken by the banking sector itself was further put into question by King (2016) and Greenspan (2009), the Governor of the Bank of England and the Federal Reserve respectively. Honohan (2008) and Altunbas et al (2018) both consider that the pricing of risk was not suitably assigned, and the traditional approaches were undermined. Diamond and Rajan (2009) further highlight the internal risk measures were undertaken with a highly fallible methodological approach.

Systemic causes of recession

There is another aspect to the literature upon the causes of recession and crises which takes an approach to giving consideration of the wider system under which market participants operate and hence influence the decision making of the respective actors. One such critique is undertaken by Strange (2015), and the basis of the analysis is that the increased influence of financial firms over the economy has skewed incentives for these firms. The term used to describe this evolution is casino capital, due to the drive to extract profits, the increased risk taking was permissible due to the ability of the technology allowing the banking sector to operate at an increased distance to the real economy. An example of certain markets operating outside of the primary work hours of users, is another example given by Strange (2015) of the increasing distance between borrowers of funds and the ultimate lenders of the funds.

The increase in fragility caused by the actions of lenders is depicted by Minsky (1980). In this hypothesis the fragility is due to the changing composition in the type of borrowers in the economy. The three-core type of borrowers range from those able to repay the interest and capital of a loan from the return they earn on an investment project. The next type of creditor is one that can only repay the interest due to lower returns being earned. The lowest ebb is the 'Ponzi' level at this point the repayments are only possible with further extensions of loan credits. Under the hypothesis the crisis point occurs when the level of Ponzi finance rises above all others. The boom period in the business cycle can give rise to the advancement of Ponzi finance. Palma (2009) further explores the inevitable impact of globally rising debt to GDP ratios.

Asset bubbles

The role of credit expansion in fuelling asset bubbles has been a recurring theme in capitalist economies. Kindleberger (1987) has analysed several historical asset bubbles which ultimately burst due to factors of social nature and institutional design. Galbraith (1954) identifies the 'irrational exuberance' as a cause of bubble formation amongst other concepts such as herd mentality driving up the price of assets, the price of which is inflated through excessive credit granting. The recent crisis was attributed to the rise in house prices in the US

in particular and in the UK although the UK did not see such a drop in market prices on the same level as seen in the US. Perez (2009) explores the notion of the asset price inflation being due to the long term structural technological cycles and a form of 'creative destruction' in which the last vestiges of an old technology is subject to a bubble prior to a significant shift in paradigm. The 1929 stock market crash is identified by Eichengreen (1992) and many others as they highlighted the role of the price bubble as a key aspect of the great depression.

d. Summary evaluations of literature and planned contributions

The following sub sections consider for each topic / thesis paper, a summary of the 10 key papers, as well as the research gaps to identify the areas covered and any other aspects without treatment in the literature. Hence this leads to the planned contributions of this thesis under each topic / paper.

Uncertainty fluctuations (chapter 2 – paper 1)

The table below highlights the ten key papers of interest within this chapter.

Uncertainty literature				
#	**Author**	**Summary**	**Selected contributions**	**Potential gaps / further work**
1	Knight (1921)	Concept of uncertainty	Incalculable risk in which the probabilities are unknown	Beyond the notion of uncertainty itself the underlying concept of Knight with regards to the role of the entrepreneur is perhaps somewhat lacking in many recent policy uncertainty index based studies
2	Leland (1968)	Precautionary savings	Declining to spend in the face of uncertainties surrounding future income	Theoretical approach to consumption and determination of the level of uncertainty required for 'dissaving' could be investigated
3	Bernanke (1983)	Real options effect	Reduction of investment based on irreversibility of certain projects hence a waiting approach is taken	Consideration of the applicability to exiting or established firms vs new enterprises
4	Romer (1990)	Consumer spending	Reduction of consumer expenditure upon durable goods in the face of stock market volatility	Could consider the precedence of whether consumer demand shifts preceded firm decisions to reduce investments and vice versa
5	Bloom (2009)	Adjustments costs	Supply side constraints generated through irreversibility - reluctance to hire, fixed disruption - cost of new hiring process, quadratic interactions - implicit cost due to adjustment rate	Essentially this is building on the real option effects theory to consider firm level components of decision making with respect to investment in resources and so could be extended with consideration of the decision making of new enterprises inn comparisons.
6	Alexopolous and Cohen (2009)	Macro uncertainty greater in recessions	Uncertainty is attributable to significant impact on business cycle fluctuations	Causal precedence is a question that could be further investigated as well as the claim that other shocks in the literature such as productivity are generated through uncertainty
7	Gilchrist et al (2014)	Financial frictions effect	Uncertainty leads to an increase in credit spreads increasing the hurdle to obtain financial for investment and f deleverage	Question the significance of the wait and see or real options effect in light of the results - hence challenge the view on the role of uncertainty this could be a point to analyse further
8	Mathy (2016)	US post 1929 uncertainty	Narrative approach to the identification of uncertainty	Consider only the post 1929 US period hence the pre 1929 period is potential area to further explore as well as trade and other global macro events
9	Bloom (2016)	EPU index	identifies four facts regarding micro and macro level uncertainty during rescissions and the interaction with wages/income and the higher level faced by developing countries	Identifies the limitations of the evidence being suggestive rather than exhaustive and the approximations applied in the existing literature of the impact. Further also the question of causal precedence is again a further area.
10	Lennard (2018)	UK interwar uncertainty and UK historical EPU index	Takes a narrative approach to consideration of UK uncertainty in the interwar period	Focus is on UK domestic policy and hence extension could be to consider wider global macro polys changes and trade dynamics as well a capital flows

Figure 6: Uncertainty fluctuations – key papers

Business cycle fluctuations and uncertainty (chapter 3 – paper 2)

The table below highlights the ten key papers of interest within this chapter.

Business cycles, uncertainty and spill over literature				
#	**Author**	**Summary**	**Selected contributions**	**Potential gaps / further work**
1	Hansen (1938)	factor endowments limits / secular stagnation	growth reaches 'natural' limits which are determined by the supply of factor endowments and labour	defining factor endowments and there limits as a quantity is not readily discernible hence the direct application of the theory is difficult
2	Kydland and Prescott (1982)	real business cycle	time periods and lags in production phases with relevance of employment fluctuations and supply of capital goods leading to the business cycle as well as the predetermined savings assigned by consumers for future purchase	Number of assumptions required limits the utility in empirical investigations such that in particular during greater periods of fluctuations the models explanatory power is severely diminished, also ignores a number of the shocks that are included in other business cycle studies
3	Zarnowitz (1984)	Zarnowitz rule / balance sheet recession	large drop in output results in a steep recovery, notion of balance sheet repair being required in a recession in which firms pay ay done debt	The work of Koo (2011) develops the balance sheet recession role of firm deleveraging between the duration of a rescission although in long recessions it is apparent a number of firms are in a positive cash position
4	Minsky (1992)	Minsky hypothesis	Prevalence of credit generates Ponzi finance schemes in which the underlying output is no longer a source of the credit repayment hence a asset bubble develops and ultimately collapses	Exploration of the distinguish / unique features of the internal dynamics of an economic and policy interventions combining to generate fluctuations
5	Friedman and Schwartz (1963)	Monetary policy and federal reserve approach prolongs crisis	role of monetary shock and the weakness of Federal Reserve policy in extending the depression through inadequate countercyclical measure to prevent deflation through increase in money supply	Consideration of causation is potentially weaker and stronger on the prolongation of crisis period and recession turning into a recession
6	Bernanke and James (1991)	Gold standard and bank panics	Compare 24 countries based on being on/off gold standard and/or incidence of banking panic - linkages between gold standard and credit constraints	Significance of Gold standard in pre-crisis period could also be considered for example UK mad an earlier departure from UK
7	Diebold and Yilmaz (2013)	Transmission of US domestic shocks	Connectedness across economies sis time varying across business cycle for US and Japan - significant influence	Covers the post 1962 period and hence the level of connectedness pr 1962 is a potential avenue
8	Colombo (2013)	US EPU and Euro impact	US EPU has a macro impact on Euro area greater than Euro Elu has on US macro	Focus on Euro area collectively - there may distinctions between countries within EU and over other time periods
9	Apostolakis and Papadopoulos (2014)	Sock and uncertainty spill over	Following the herd during a crises induces cross country contagion a common lender effect	Uses a financial stress index as an indicator for uncertainty using an alternate index such as EPU would also provide a supplementary evidence base for the role of uncertainty
10	Choudhry et al (2020)	US EPU spill over in great recession	US EPU has an impact on business cycle of EU countries with more impact during crises periods	Considers the post war period and hence a complementary study could be undertaken for the interwar period

Figure 7: Business cycle fluctuations – key papers

Uncertainty and global market distortions in the US and UK (chapter 4 – paper 3)

The table below highlights the ten key papers of interest within this chapter.

Market distortions, uncertainty and crises literature				
#	**Author**	**Summary**	**Selected contributions**	**Potential gaps / further work**
1	Schumpeter (1943)	Creative destruction	New means of production emerge to replace previous methods and in this process there is a period of adjustment in which some firms make the transition and others may be unable too. Function of credit is to facilitate the transfer by the entrepreneur	Could explore the linkage with Knight's conception of the entrepreneur acting in a period of uncertainty and whether the entrepreneur activities play a role in generating further uncertainty. Further whether the entrepreneur benefits mots from uncertainty or whether there is any difference acting outside of the uncertainty.
2	Greenwald et al (2012)	Sectoral imbalances	Sectoral imbalances developed in agricultural sector with rising productivity but lack of labour mobility leading to sectoral imbalances which extenuated the depression and were resolved only through wartime intervention to move labour into industry	Focus of the article is on the domestic supply and demand constraints. The international context and build up prior to 1929 is given light treatment and hence the significance of foreign demand and capital movements is an area of further study.
3	Galbraith (1954)	Great crash	Provides insightful narrative of key events surrounding the 1929 great stock market crash including events in the build-up in the UK stock markets which may have provided triggers to the eventual collapse	Consideration and focus is on the events closely surrounding the great crash so the period of 1928 and 1929 are given the most detail in terms of historical episodes and events. This could be extended with consideration of the earlier period in the 1920s and to consider quantitative dimension of the potential UK and US spill overs.
4	Kindleberger (1986)	World in Depression 1929-1939	Provides insightful synopsis of the global context and immediate build up to the 1929 great depression period and considers the context of capital movements, trade dynamics and policy events.	Contextualisation of the 1929 period could be given with respect to the 1920s period and significant events as well as building on the historical narrative with quantitate analysis and consideration of the role of uncertainty
5	James (2009)	End of Globalisation	Detailed account of the collapsing international capital and trade position in the 1930s after the 1929 crash	The insightful descriptive dated provided could be extended with further econometric analysis to test some of the potential relationships between key macro economic variables.
6	Svennilson (1954)	European agricultural demand	Considers the international market for agricultural goods and the significance of the European market in particular being the largest net importer.	The insightful descriptive dated provided on pricing and demand could be extended with further econometric analysis to test some of the potential relationships between key variables.
7	Ritschl (2012)	Policy shifts and financial transmission	German transfer problem in the Dawes plan period 1924-9 German borrowing to pay for reparations and the subsequent negative impact on US with financial distress.	Another aspect to consider is the role of export dynamics and impact on the US producers of export goods.
8	Harris and Todaro (1970)	Sectoral shifts in two sector model	Consider how unemployment can persist given increased productivity in rural region given that rural migrants are utility maximisers	The policy implications reflective of a closed economy more than a n open economy hence trade dynamics can be considered as well as wages and taxation.
9	Accominotti and Eichengreen (2013)	Capital flow stops + stock volatility	Compilation of data on new foreign issues in the global market and the impact of sudden stop to capital flows which occurred between 1928-31 considers relevance of stock market volatility in country of issue as potential factor alongside degradation of borrowers	The analysis could be extended through consideration of stock volatility spill over and policy uncertainty
10	Stuart (2017) & Stuart (2018)	Stock market spill over 1900-20	Considers co-movement between Irish, UK and US stock markets	UK and US analysis is considered up to 1925 and hence considering the more extensive period may provide insights into the events of 1929 and beyond

Figure 8: Market distortions and uncertainty – key papers

Chapter 2: Fluctuations in uncertainty during the interwar period

The only thing more uncertain than the future is the past.

Soviet Proverb

a. Introduction

In the following chapter consideration is given to the fluctuations in uncertainty which may have an impact upon economic activity. Initially an overview is given of the measures of uncertainty which utilise a time series of economic policy uncertainty (EPU) this is based on identification of the uncertainty narrative within media records. This proceeds a review of the fluctuations within the respective EPU series for the UK and US, which are considered through an approach to analyse significant shifts from the mean. Then consideration is given to the historical narrative as undertaken by Mathy (2016), as well as Romer and Romer (2004) and Lennard (2018) all of whom incorporate a variation of the narrative approach to identification. In these subsections significant historical episodes are clustered for various time periods. Then a comparison is made between the historical episode clusters and the fluctuations in uncertainty, especially various components.

b. Literature review

Impact of uncertainty upon economic activity – theoretical basis

As per Choudhry et al. (2020) three key channels can be identified in relation to the theoretical relevance of uncertainty which are also considered in a number of other recent uncertainty research contributions (Bloom, 2009: Baker et al., 2013; Colombo, 2013; Born and Pfeifer, 2014; Jurado et al., 2015) through which there is a negative impact upon 'employment, investment and output'. The three major elements to the theoretical basis for the negative impact of uncertainty upon economic activity are:

- Real options effect, (Bernanke,1983)
- Precautionary savings, (Leland, 1968)
- Financial frictions effect, (Gilchrist et al., 2014)

In addition, there is also a theoretical basis for the potential positive impact of uncertainty upon economic activity, which is based on the following concepts:

- Interwar entrepreneurial theory, (Knight, 1921; Hayek 1932)
- Growth options theory, (Bar-Ilan and Strange, 1996; Paddock, Siegel, and Smith 1988; Kraft, Schwartz, and Weiss, 2013)
- Oi-Hartman-Abel Effects, (Oi, 1961; Hartman, 1972; Abel, 1983)

These relative concepts are given further consideration in Chapter 4, these may have a positive impact which is confined to an individual firm or specific sectoral level in the short run at least. However, within the following subsections consideration is given to the theoretical impact of uncertainty in relation to negative

consequences on the micro level, which is compounded across many firms and consumers, thus impacting negatively upon the macroeconomy.

Uncertainty and the Demand side

Real options effect

The consequence of uncertainty can be significant due the impact on the perceptions of economic agents. Hassler (1996) explores the role uncertainty plays in investment through the study of commercial real estate data. Comparing the neoclassical model which postulates uncertainty is included within asset prices and valuations almost intrinsically this is tested through a structural model against the option-based model. The results indicate that the options model is a stronger predictor which implies that 'irreversibility and delay' are significant parts of the investment decision making process. The results further indicate the potential for asset price uncertainty to be 'positively related' to policy conditions such as changes to the regulatory, tax or monetary policy environment. Hence the significant impact uncertainty can take upon macroeconomic growth. Scarf (1959) was one of the first authors to show the relevance of decision making rules in respect of minimising the cost of holding a depreciating asset which was again in contrast to neoclassical theories of asset pricing.

Bernanke (1983a) puts forward a theory of investment which bridges the divide between the short run and long run divergence that can occur in perceptions of optimal decision making, by exploring the role of uncertainty and the consequences of irreversible investment decisions. Bernanke (1983a) considers that timing is important due to the availability of more information. The work of Dixit (1989) follows that of McDonald and Siegel (1986) in that they put forward the notion of timing within the decision making process with an 'irreversible project'. They identify the 'option value' of holding can be a more suitable approach than simply investing when the returns exceed cost. They find that with certain 'parameter values' the most benefit is derived when waiting until the returns from the investment are twice the costs. Pindycek (1990) explores the combination of two key aspects of the investment making process which are that sunken cost can create irreversibility of a decision and that the decision can be put on hold. The waiting time is utilised for more information to be gathered to reduce uncertainty regarding the cost implication or other factors such the market environment. The findings have significant implications for policy makers in as much as that reductions of uncertainty can be more beneficial than fiscal or monetary policy being made more favourable. Hence economic policy uncertainty can outweigh other factors in certain instances.

Romer (1990) further corroborates that uncertainty faced by consumers leads to disinclination to spend upon goods of a durable or partially durable nature. Romer (1990) postulates the 1929 stock market crash created uncertainty and that the link to consumer spending is seen in a trend between the production of durable goods and fluctuations in the stock market. This derives a consumer-based perspective upon Bernanke (1983a) depiction of firm behaviour towards irreversible investment. Romer (1990) identifies that durable goods purchase such as that of a car have element of irreversibility due to the nature of future market value and

price depreciation. Romer (1990) further explores the role of Financial information agencies such as Moody's and Standard's as well as news agencies such as Business Week change perspective and increased inclusion of uncertainty in being influence in further creating consumer perceptions of uncertainty about future market conditions

Precautionary savings

As Romer (1990) identified during the Great Depression period the uncertainty and volatility following the 1929 Stock market crash induced consumers to restrict expenditures on durable goods essentially choosing to purchase only non-durable or the most essential goods. This choice of declining to spend was theoretically explored in the work of Leland (1978) and modelled as the 'precautionary demand for saving' with a two period model with certainty of income (i.e. income is known) in the first period and whereas in the second period there is a 'subjective probability distribution' as in the consumers second period income is partially dependent on the choice made in the first period, the choice is between saving for the second period or consumption, as in 'dissaving'. The model explores the change to the level of uncertainty of income, as in income in the future period become more unknown for the second period. Leland (1978) finds that 'risk aversion' alone is not a sufficient condition for the rise of demand for savings instead 'additional assumptions on certain risk properties' are required to induce a 'guarantee' of the positive impact of uncertainty. The assumptions are based on intuitive reasoning which have some basis from an empirical perspective. The two assumptions applied are 'Pratt's principle of decreasing absolute risk aversion' when modelling with additive utility functions or without such functions then an assumption upon 'decreasing risk aversion to concentration'. The results imply that a level of uncertainty is required to induce a positive impact for demand for savings more than a merely having risk aversion to future outcomes. Hence this provides theoretical support for Romer (1990) analysis of reduction in consumption upon durable goods and the analysis of Bernanke (1983a) which indicates a similar reduction to demand at the firm level due to reduction in investment given the irreversible nature of certain projects.

Uncertainty and the Supply side

Employment opportunity

In relation to the supply side impact of uncertainty there is both theoretical and empirical exploration within the literature which finds that uncertainty negatively effects the opportunities for employment with firm's reluctant hire. Bloom (2009) considers the employment decision alongside the investment decision of firms, identifying three components that a 'adjustment costs' for any decision to hire such as:

- *Partial irreversibility*
    - A decision to hire new employees has an inevitable training cost associated in addition to a cost of releasing employees
- *Fixed disruption*

    - A decision to increase employees requires certain upfront costs such as advertising, application procedure and induction
- *Quadratic interactions*
    - Likewise hiring or releasing employees could also have an expense due to the 'rate of adjustments' which is amplified in the case of accelerated adjustments

Bloom (2009) builds a model based upon uncertainty shocks and the impact of 'time varying second moments' this models the impact upon the adjustments cost for the decision to invest and employ new workers. Numerical solutions to the models are used to set up a parameterised model with firm level data used to estimate the model parameters which is then used in a simulation of a 'macro uncertainty shock' this produces an initial significant decline followed by a *V* shape recovery, with higher *V* causing short term restrictions upon hiring an investment with medium term volatility creating an 'overshoot' impact over longer periods. The estimated real effects appear to a show a 1% drop in employment. Fundamentally this is an extension of the real options effects. The employment decision making 'pause' can then lead to a reduction in the supply of goods and services. Bloom et al. (2015) also utilise firm level data to find that 'employment growth and investment rates' decisions are adversely impacted upon by uncertainty, in particular policy uncertainty in the US and Europe has a negative and 'materially harmful effect'.

Financial frictions effect

As Choudhry (2019) indicates the influence of uncertainly upon creditor expectation of returns is adversely impacted and hence the hurdle to obtain finance restricts the firm in obtaining the necessary capital required to finance new project investment, Gilchrist et al. (2014) identify this as a 'financial frictions effect' they indicate that the finding that the increase in 'credit spreads' due to uncertainty has a 'strong effect' upon investment whether or not the 'level' of the uncertainty innovations is large or small and hence question the precedence of the real options or 'wait and see' impact of uncertainty. Overall, the 'quantitative general equilibrium model' which includes similar parameters to other studies such as Bloom (2009) including adjustments cost which are irreversible and time varying uncertainty shocks along with the inclusion of financial frictions. Hence, they proffer that in combination with adjustment shocks financial distortions offer a more robust explanation for business cycles. As they are perhaps more closely related to credit spread cyclicity than only technological innovations.

Output and macro uncertainty

In considering the overarching macroeconomic impact to growth and output, Kose and Terranes (2012) identify the significance of 'manifold uncertainty' during times of recession. Overall, they note a distinction between the 'intrinsic' uncertainty which is seen over the duration of a normal business cycle for which they find there is limited scope for countercyclical policies to 'alleviate' the effect. Whereas the relative significance of policy uncertainty to macroeconomic uncertainty during recessionary periods, means that there is the

potential for institutional policy makers to make a direct impact which can alleviate some macro uncertainty and induce growth if applied in a 'bold' and timely manner.

Uncertainty and policy

Friedman (1968) implies that policy should be directed towards creating some policy certainty through a setting a monetary growth rate, hence avoiding inflationary instability and thus more likely to improve the 'basic forces of enterprise'. Rodrik (1991) goes further a to show that 'policy uncertainty can act as a hefty tax on investment'. Higgs (1997) brings forward the case that the duration of the great depression was a result of regime uncertainty. Hassett and Metcalf (1999) theorise upon the negative implications of an uncertain tax regime for investment. These studies all allude to the overriding negative consequences that a rise in uncertainty can take upon the actions of economic agents and collectively lead to a significant detriment to the growth of the economy with more severe events such as the economy operating below capacity and underutilisation of resources. There have been some recent studies which seek to explore the interaction of uncertainty with the recent financial crisis and great recession. These studies have utilised the development of an emerging measure of policy uncertainty developed by Baker, Bloom and Davis (2016).

Political factors can lead to significant policy uncertainty such as during elections or instability within governmental decision making procedures. Bernhard and Leblang (2008) find that market participants react to perceptions of government adherence to certain policies, as such they find that a 'cabinet collapse' can lead to an increase currency speculation. Alesina and Roubini (1992) study the impact of election cycle and governmental changes upon significant macroeconomic variable including inflation, unemployment and GNP they find no significant relationship. Heckelmen and Berument (1998) find similar results thus implying that change is not a significant component of uncertainty but rather uncertainty surrounding policy making and market conditions is more significant than actual policies being pursued. Brogaard and Detzel (2015) use a 'search based measure of uncertainty' which indicates that a relatively small change to economic policy uncertainty of 1% can lead to a reduction in returns by 2.9% and further to cause volatility to rise by 18%. Thus, there they find that uncertainty can have long term significance for market conditions. This more recent research can perhaps also reveal further aspects regarding the impact of uncertainty during the Interwar period such as the global uncertainty that may have been caused during the period in which the Dawes Plan was being replaced with the revised terms of the Young Plan this transitionary period for war debt renegotiations, covered the timing of the Wall Street crash and the 1931 Credit Anstalt crisis. Hence in our study we further consider the significance of policy uncertainty during the interwar period.

Uncertainty during a period of crisis

Bloom (2016) identifies four key facts regarding micro and macro level uncertainty and the interaction with the business cycle.

Facts on uncertainty	Description	Evidence	Literature
1. Macro uncertainty is greater in recessions	• Volatility of key economic measures rises during a downturn • Stocks, bonds, currencies, and GDP growth	• VIX, S&P 500 30-day implied volatility spikes • EPU newspaper index • Forecaster disagreement	• Baker et al (2012) • Alexopoulos and Cohen (2009)
2. Micro uncertainty is greater in recessions	• 'Fractal' impact of uncertainty at the disaggregated level of analysis • 'Plant level shocks to total factor productivity' increases	• 152% rise in variation in rate of growth of manufacturing plant sales • 50% rise in variation of 'cross firm stocks' • Consumer price change, 50% increase in volatility	• Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012) • Campbell, Lettau, Malkiel, and Xu (2001) • Vavra (2013)
3. Countercyclical wage and income adjustments	• Unemployment rises • Household income volatility increase • Volatility of employed worker wages also increases	• Panel data studies on lifecycle of labour earnings	• Guvenen, Ozkan, and Song (2015) • Meghir and Pistaferri (2004)
4. Developing countries face higher uncertainty	• Lower income nations have higher volatility over all aspect of the economy • Stocks, bonds, currencies, and GDP growth	• World Bank Development Report 2014, *Risk and Opportunity* • Households face multiple micro and macro risks	• *World Bank Development Report 2014*, World bank (2013)

Figure 9: Stylised facts on uncertainty (based on Bloom 2016)

Furthermore, policy makers appear to find that uncertainty reduce the rate of growth of a recovery from a recession such as during the Financial Crises. Such as the IMF Director Christine Lagarde stating, 'there is a level of uncertainty which is hampering decision makers from investing and is a level of uncertainty which is hampering decision makers from investing and from creating jobs', (IMF 2012) and the International Labour Organisation stating 'indecision of policy makers in several countries led to uncertainty about future conditions and reinforced corporate tendencies to increase cash holdings or pay dividends and reinforced corporate tendencies to increase cash holdings or pay dividends rather than expand capacity and hire new workers', (ILO 2013). However Bloom (2016) finds that the empirical evidence can only be described as 'suggestive', for example the impact of uncertainty can approximates such as taking the fact that there was a 9% drop in GDP in the Financial Criss due to 3% decline against the 6% growth that was predicted to occur over 2008 and 2009. The marginal impact of uncertainty is estimated to be 3% of this total 9% change, given that Bloom (2009) through a vector autoregression and Bloom et al (2012) through a structural model estimate that an average

uncertainty shock generates a 1% reduction in GDP given the Financial Crisis uncertainty shock was three times the magnitude of a typical shock this equates to a 3% impact of uncertainty upon GDP which correlates to Stein and Stone (2012) instrumental variable analysis based on micro data finding a similar 3% reduction due to uncertainty. These measures are approximations and hence further empirical studies are required to enhance the existing literature.

c. Research gaps and contributions

The following areas have been identified as potential research gaps and contributions that can be made through the proceeding analysis and future investigations.

- Notion of uncertainty – considering the context of Knight in terms of the role of the entrepreneur is often not covered in many studies
- Causal precedence – between policy uncertainty and fluctuations, also in addition to test the claim that shocks such as relating to productivity are generated through uncertainty
- Consider pre 1929 period – given the significant policy shifts and the dynamics of capital flows, trade and other global macro events

In summary this chapter attempts to make relative comparisons between policy or other interwar historical episode clusters and the fluctuations in uncertainty, in particular using the relevant EPU indices for the period. Which complements current studies in particular providing analysis on the 1920-40 period.

d. Empirical analysis

Measuring Uncertainty

Baker et al (2016a) develop an index of economic policy uncertainty (EPU) that is based upon newspaper media coverage frequency. They further collate several sources evidence to provide a significant indication of the suitability of the index as a proxy for economic uncertainty which is related to policy. In support of the value of the index, their measure of certainty has a relationship with stock market volatility (VIX) and 'foreshadows' declines in investment unemployment and output. The index is taken back to 1900 for the US and UK and begins in 1985 for other major European and G7 economies. There have been comparative developments to the measure of uncertainty with Jurado, Ludvigson and Ng (2013) developing an estimation of 'time varying macroeconomic uncertainty' with a large data set of economic variables to provide a view of 'common volatility in the unforecastable' components. This builds upon Bloom (2009) work on the countercyclical impact of uncertainty upon real economic activity. This work proxied stock market volatility for uncertainty. Such measures of volatility can have components unrelated to uncertainty and hence Jurado et al (2013) develop alternative measure. Other research approaches such as tested by Bachmann, Elstner and Sims (2013) find that using firm or analyst expectations indicates uncertainty is a result rather cause of recessions. Hence the Jurado index uses a large macroeconomic dataset to forecast uncertainty and uses a diffusion index forecasting approach a comparatively limited number of factors are estimated from a relatively large number

of data series. This offers a distinct approach to common proxies of uncertainty which can have limitations due the confluence of the other factors which create the volatility. Such a methodology is more applicable to comparative more recent episodes of uncertainty such as post 1960, for such time periods there is more abundant and diverse range of economic timer series available.

Juardo et al (2015) delve further into the problems of measuring the 'behaviour of uncertainty' and look beyond proximate measure such as volatility in stock market returns or firm level profits given that such fluctuations can occur independently of uncertainty at the macroeconomic level. Instead they seek a measure of the predictability of the economic behaviour at the aggregated level across measures as opposed to consider whether a singular measure becomes more volatile. They attempt to remove the forecastable element prior to estimating conditional volatility. Then they compute a forecast based on an array of predictors then find the conditionality of errors and finally they estimate macroeconomic uncertainty from a combination of separate uncertainty measures. The measure they develop appears to indicate a stronger role for overall uncertainty during recessions that in more normal periods. The measure they develop is valuable in a data rich period of study however our focus upon the interwar period entails difficulties of having less data measures at hand and thus limitations as to building alternative indices. Instead we can utilise the valuable work of Bloom et al (2015) and in the recent work of Lennard (2018) which enhances existing EPU indices with an interwar EPU index for the UK. Lennard builds an index based on contemporaneous newspaper information and finds evidence for the reduction in output and higher unemployment to be attributable to the level of uncertainty. The UK faced its worst recession since the 1700s in the early 1920s and had more volatility in output growth than in any other period when comparing over 300 years of data. Hence, we utilise the EPU indices of Baker Bloom et al (2015) and of Lennard (2018) (both available online) as measures of uncertainty for the US and UK respectively in the period between 1920 and 1938.

Economic Policy Uncertainty index

Hence the utilisation of the Economic Policy Indices is an innovative tool which can bridge between the study of qualitative economically relevant data and quantitative economic variables. One promising facet of the economic policy uncertainty index is that it provides a quantification of uncertainty that is experienced by economic agents. This is achieved through a count of the coverage of 'uncertainty' within mainstream media, namely newspaper articles. There has been other heterodox economic research which has attempted to incorporate the relevance of newspaper media coverage to provide valuable economic insight but through a more qualitatively grounded approach. Studies of crises and the role of institutions have significant relevance, as seen in the work of Wade (1992) in looking at Taiwan and East Asian economies. Such qualitative approaches include the search for data sources, be they in archival material, yet untapped statistical compilations or a thorough analysis of unused secondary sources, such as professional news coverage for example. In relation to economic history Geyikdagi and Geyikdagi (2011) utilise newspaper archives to develop a further understanding of the political risks facing investors in Eastern European economies during the late

19th and early 20th centuries. Bloom et al (2007) use the stock market as a proxy for uncertainty and explore the delaying of investments caused by the market fluctuations postulating that high uncertainty at the firm level can reduce responses to alternative stimulus given the circumstances of a major shock. Baker et al (2013, 2015) develop an uncertainty index which is built upon the mentions of uncertainty in relation to the economy and economic policy as key indicators of volatility and develop a quantitative measure to forecast level of uncertainty. They use six major newspapers to develop an index of Uncertainty within the US spanning back to 1900. They test the measure of policy uncertainty which could be unreliable due to bias and consistency with other measure such as stock market volatility and the Federal Restress 'Beige Books' for inclusion of term policy uncertainty they further look at the political dimension comparing 'right and left leaning' news agencies.

The EPU index developed by Baker et al (2016a) for the US and for the UK extends back to 1900 which enables coverage of the interwar period and great depression as well as covering the more recent great recession. In relation to the US indices it is based on three components, the first is based on newspaper articles from 10 of the largest newspapers, a search of these newspapers is used to build a 'normalised index of the volume' of news articles which mention or discuss the relevance of economic related policy uncertainty. This is supplemented with a second component of Congressional Budget Office information provides information on federal tax codes that are due to expire in the proceeding 10 years and hence allows the construction of a 'dollar weighted number of (expiring) tax codes' metric which gives an indication of the relevant level of uncertainty upon tax provisions. The third element of the EPU index is based upon professional forecaster differences in expectations for key macroeconomic indicators which include the Consumer Price Index, Federal Expenditure and State and Local Expenditure. The data source is the Federal Reserve Bank of Philadelphia Survey of Professional Forecasters.

Summary view uncertainty measurement indices

In order to contextualise the relevance of the EPU index in relation other measure of uncertainty Baker et al (2016a) also give consideration to a comparison with the US stock market measure of uncertainty the VIX is a measure on 30-day 'option-implied volatility' for the S&P 500 stock index. This comparison indicates that the correlation of 0.58 indicates some element of similarity between movements however there are specific points during which the VIX shows higher levels of volatility. Hence an attempt was made to compare an adjusted Economic uncertainty index which replace the policy terms for terms relating to 'stock price', 'equity price' or 'stock market' and this modified index show more similarity with a correlation between the VIX of 0.73. This provides some indication of the applicability of the methodology and suitability to explore uncertainty through textual analysis. There are a number of studies which have developed text-based search analysis which relate to newspaper indication g the relevance of this approach for earlier periods during which alternative data measure were lee pervasive. Studies such as Alexopoulos and Cohen (2015) make an application of this approach in relation to uncertainty shocks and further in a study spanning back to 1909, Alexopoulos and Cohen (2016) utilise a measure of technology titles to consider employment dynamics and find that there is

some positive correlation but are unable to explain the puzzle of 1934 stagnation in employment given the level of technological change which in parts could be attributable to the alternative Greenwald (2012) regarding the trapped labour in the agricultural sector and subsequent lack of demand. Further there is a literature which give prominence to policy matters that includes Friedman (1968) and Rodrik (1996).

The interwar period developed with significant geopolitical change and the transformation of the global balance of economic investment during the early 20th century saw the rise of new global trade and industrial powers of the US and Germany. They were now in direct competition with the UK, but they saw respective disturbances in the path of more industrial growth in this period and there was a rise of other industrial economies emerging in places such as Japan as depicted by Parrini (1969). The work of Mollan, Smith and Tennent (2016) highlight the significance of the first world war upon 'international business' and thus upon global trade and investment. Hence in undertaking this historical economic study quantitative measures of macroeconomic variables and archival data sources for policy measures are relevant to the investigation. The uncertainty index developed initially by Baker et al (2016a) provides a relevant tool to transforming such qualitative data into a computable quantifiable index which can be analysed with real economic variables. Following this development other works such as Lennard (2019) have made refinements through additional data such as the development of a specific UK interwar EPU index. Furthermore, there has been diversification in the breadth of such indices being developed to aid the analysis of economic events. The use of textual analysis in the creation of such indices has seen a significant recent increase. There are more specific indices for certain aspects such as trade policy Baker et al (2016), trade and stock market volatility Baker et al (2019) and also a World Uncertainty Index formulated in the work of Ahir, Bloom and Furceri (2019) which encapsulates 143 countries. There are also new indicators developed for Firm level political risk developed by Hassan et al (2019), in addition there is work on Geopolitical Risk index is developed by Cladara and Iacoviello (2018). These new indices are targeted towards more recent sources of data. The merits of historical analysis are also being utilised with the advancement of the Geopolitical Risk Index this spreads back until 1899. Also seen in the work of Puttmann (2019) in the formation of a Financial Stress Indicator based on methodology of firstly defining 11 topics which are composed of 120 words related to financial markets. In which Puttmann (2019) finds that the ten words account for 41% of all articles relating to financial markets within the chosen criterion. The second stage of the process is to identify negative sentiments with the article titles and if there is a net negative sentiment, more than positive, this is taken as a relevant indication. The value is thus derived through a multiplication of the number of articles referring financial markets by the proportion of the articles with a 'net negative connotation' which is divided by the 'number of all titles'. This raw indicator is standardised by taking a mean of 100 and a 'unit data deviation from 1899 to 2016' to develop the indicator. This recent work adds credence to the approach of this study to integrate historical qualitative analysis to enhance the quantitative data analysis to develop a clearer picture of the nature of events and pertaining factors of relevance.

EPU Index measure methodology

Formulation of the index through text base search on three category levels

The basis of the economic policy uncertainty index as depicted by Baker et al (2016a) is to conduct a text search of leading newspapers, utilising digital archives and carrying out a search based on specified criterion. For example, the US index procedure is conducted as a search based on the following three categories:

1. Uncertainty terms: 'uncertainty' or 'uncertain';
2. Economy terms: 'economic' or 'economy';
3. Policy terms: 'congress', 'deficit', 'Federal Reserve', 'legislation', 'regulation' or 'white house' (inclusion of variants such as 'uncertainties', 'regulatory' or 'the Fed')

To meet the criterion, the article must contain one of the terms in all three of the categories relating to uncertainty, the economy, and policy. An audit procedure is utilised to identify and select appropriate terms relating to policy. Due to the potential difficulty of having a variation between the number of articles in each newspaper for each month there is a concern of having only a 'raw count' of articles hence the monthly index of each newspaper is 'scaled' by the number of articles for each month. The next step is to 'standardise' each 'newspaper level series' to a unit standard deviation for the period. The last step is to 'normalise' the respective series for the number of newspapers and period to a mean of 100.

Aggregation of index average articles and standardisation

A formal representation of the approach is the following:

X_{it} represents the EPU frequency counts scaled for newspapers $i = 1,2, \ldots, n$ in month t

and T_1 and T_2 represent the time intervals used in the standardisation and normalisation

The steps for computation are then as follows:

(1) Calculate the variance of the time series for each paper i in the period T_1 denoted as δ_i^2

(2) Divide through X_{it} by the standard deviation δ^2 for all t to standardise

The above generates a series Y_{it} for each newspaper which has a standard deviation in the interval T_1

(3) Calculate over the newspapers Y_{it} the mean to generate the series Z_t

(4) For the interval T_2 calculate the mean value of Z_t represented by M

(5) To generate the normalised EPU time-series index, for all t multiply Z_t by $(100/M)$

This procedure is utilised to generate the EPU indices for all the respective countries and indices and in this study and extract of the historical indices for the UK and US is utilised. The extract represents the interwar period, for the period between 1920 and 1938 monthly.

Historical indices for the UK and US

The analysis of the historical index for the US shows that the prevalence of uncertainty has increased over time such that as depicted by the below chart in which key policy events can be related to spikes in the index. Comparing the US and the UK historical index for the interwar period indicates that the US was more significantly impacted upon in the 1930s period whereas the UK was somewhat less impacted by the Great Depression but more significantly impacted with higher relative uncertainty during the outbreak of both the first world war and second world was as depicted in the below charts.

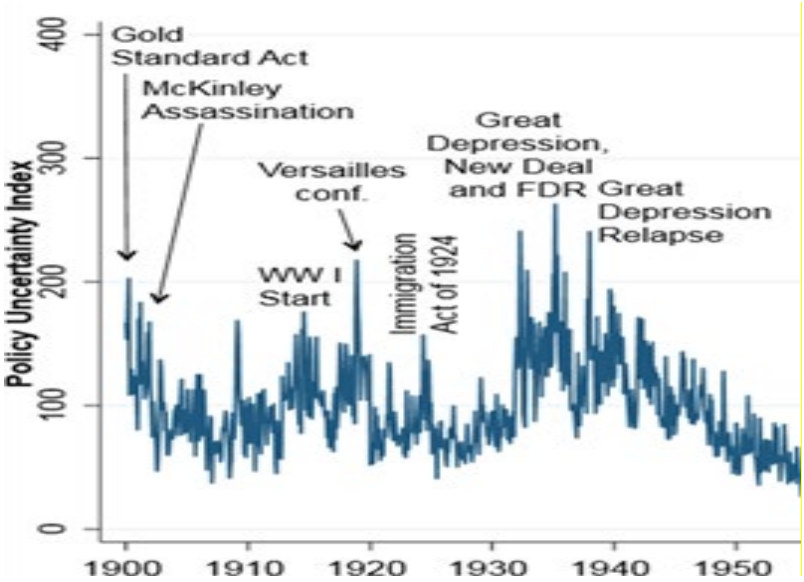


Figure 10: Historical Index of US EPU ''All Scaling'' (Baker et al. 2016)

The above chart shows that in the same way that Hendry (2007) depicts that economic variables such as unemployment may be related to unquantified non-economic events , the EPU indices is perhaps a mechanism to explore the relationship of such events and association with significant economic variables.

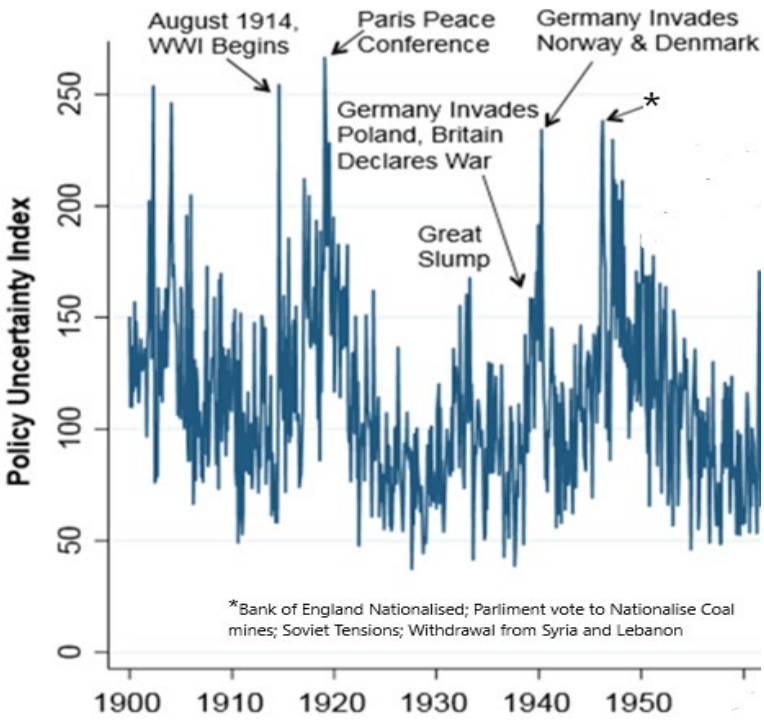


Figure 11: Historical Index of UK EPU (Baker et al. 2016)

The EPU index on a historical basis includes the US and the UK newspaper data from 1900 with the mention of the word 'uncertain or uncertainty' which forms one category with the inclusion of the following terms in the second category 'economic', 'economy', 'business', 'commerce', 'industry', and 'industrial' and the third category of terms includes 'congress', 'legislation', 'white house', 'regulation', 'federal reserve', 'deficit', 'tariff', or 'war'. To be included within the search an article must contain at the minimum one term from each category. Baker et al (2016a) in order to account for the fluctuation of total volume of articles within each newspaper over the course of different time periods, they create the index on a proportionate basis by dividing the number of articles related to policy uncertainty by the total number of articles which relate to business or the economy in general within the given newspapers. Following this procedure, a normalisation is undertaken for each newspaper series to a 'unit standard deviation prior to December 2009'. The US historical indices from 1900 to 1985 includes the following newspapers, 'Wall Street Journal, the New York Times, the Washington Post, the Chicago Tribune, the LA Times, and the Boston Globe'. A similar procedure is conducted for the UK historical indices, which relies upon The Guardian and Times of London newspapers. The UK index is based on a similar procedure to account for changes in volume of articles and a standardisation for a 'unit standard deviation from 1900 to 2008' and then an 'average across the two papers' on a monthly basis. A further normalisation over the 1900-2008 period for the two papers is undertaken for a mean of 100. The terms that are included in the third category for inclusion vary slightly compared to the US due to different terminology and institutions, so the third term category for the UK includes the following, 'tax', 'policy', 'regulation', 'spending', 'deficit', 'budget', 'Bank of England', 'war', or 'tariff'. Again at least one term from of the three aforementioned categories of terms is required in order to be included within the search. An

enhancement to this historical series in the UK has been developed specifically for the interwar period by Lennard (2019). This index is further discussed in the proceeding data and results section below, some of the key differing factors between the Bakers et al (2016) index for the UK include firstly the incorporation of the Daily Mail newspaper which at this time, the interwar period was the most circulated newspaper on a global level and in addition some refinements to the terms for inclusion have been made. For the second set of terms the 'policy terms' the search includes "Bank Rate" and "duty" as these were prevalent during this period in relation to monetary policy and trade or tariff policy related matters in UK in particular.

Evaluation of the index for relevance

In order to overcome potential issues in the application of the text based search analysis of newspapers in terms of 'accuracy and bias', Baker et al (2016a) develop an audit process to compare for a given sample the difference between a human generated EPU index against an automated EPU index generation process. The large-scale audit study was conducted for eight newspapers spanning from 1900 until 2012. The audit process was developed through an initial pilot study of 2,000 randomly selected articles and this led to the development of a 65-page guide for the human search invigilators as a refence manual and training tool. The human evaluation related to the policy element of the search given that only 0.5 per cent of articles in the selected newspapers contained the terms economic and uncertainty this reduced time wasted upon irrelevant articles for an 'expensive' procedure. Overall, the reviewers audited 12,009 articles for the policy related terms given the two-step reduction in the universe of articles to be audited.

The audit process was undertaken as follows to select the Policy set ('P' set) term:

(1) Human auditor codes and article as EPU = 1 (EPU^H =1) and records the policy terms which relate to the relevant text on economic policy uncertainty
(2) 15 terms significant terms identified (for the 1985-2012 period):
    - "regulation", "budget", "spending", "policy", "deficit", "tax", "federal reserve", "war", "white house", "house of representatives", "government", "congress", "senate", "president", and "legislation" (and variants like "regulatory", "taxation", etc.)
(3) Then 32,000 'term set permutations' were considered which contain four or more of the above policy terms
(4) A computer assignment was generated for each permutation
    - EPU^C = 0 or 1 for each article in extracted sample
(5) Comparison between the human and computer coding is made for each permutation to generate the following sets:
    - Set of false positives [$EPU^C = 0$, $EPU^H = 1$]
    - Set of false negatives [$EPU^C = 1$, $EPU^H = 0$]

(6) Selection of the **P** term set which minimise the 'gross error rate, (which is the sum of the false positive and false negative error rates)
    - Generates the 'baseline policy term set' of the EPU index
    - "regulation", "deficit", "federal reserve", "white house", "congress", and "legislation"
(7) Alternate EPU indices are developed which remove one of the above (six) base line terms
    - The behaviour of the EPU index time series does not indicate sensitivity to any single particular term
(8) Analysis of 'compound text filters' such as "government AND tax"
    - "Tax" is an example of a term which lowered the relative false negative rate compared to the base line set
    - No 'simple compound text filter' which generate lower error rate compared to the baseline set of terms
(9) Procedure repeated for the Historical Index which generates the same base line six terms (above) with the addition of "tariff" and "war"
    - Indication of the significance of tariffs and also political concerns regarding revenue generation from tariffs.
    - Significance of the major conflicts and impact upon the respective economies
(10) Time series analysis of the **P** set term which minimises the gross error rate as computed above for the automated EPU index
    - Comparison against the human and automated EPU indexes
    - Fraction of EPU^{H} = 1 articles in each quarter multiplied by EU rate for the selected newspapers and normalised to 100 for the period
    - Fraction of EPU^{C} = 1 articles in each quarter multiplied by EU rate for the selected newspapers and normalised to 100 for the period
    - The historical index shows a correlation of 0.93 (modern variant has a 0.86 correlation)

Further observations of further analysis based on the above audit process indicates that there is no significant correlation with GDP growth rates, the correlation with the automated EPU index is -0.02 and for the human generated index the correlation is 0.004. This is relevant to the application of the uncertainty index for econometric analysis and provides an indication of the respective 'time series properties' of the computer generated EPU index.

In relation to the textual content of the EPU^{H} = 1 articles:

- 5 per cent of articles relate to declining uncertainty (reports show less concern for declines than for rising uncertainty)
- 10 per cent of articles relate to decision makers (*the who*) of future economic policy
- 68 per cent of articles relate to the content of policies (*what and when*)

- 47 per cent of articles relate to economic 'effects' of policy action over time
- Election periods triple discussion of the decision makers of economic policy
- 32 percent of articles refer to foreign policy matters in combination with domestic policy discussion

In order to verify as to whether there was any potential bias related to 'political leanings' of the newspapers being considered, Baker et al (2016a) utilise the 'political slant index' of Gentzkow and Shapiro (2010) to explore as to whether the political leanings of a given newspaper may impact the depiction of economic policy uncertainty within the content. The of Gentzkow and Shapiro (2010) approach to classification of US newspapers if to identify the terms used most often by one of the two major US political parties. The Republican party is deemed to be 'right wing' or 'more conservative' and the Democratic party is deemed to be 'left of centre' and they search the words or common phrase used most frequently or 'preferentially' by each within Congressional speeches or newspapers. An example of words used to depict the same topic by either party is shown below:

Republican *terms – right of centre politics*	**Democratic *terms – left of centre politics***
Death tax	**Estate** tax
Personal accounts	**Private** accounts
War on **terror**	War on **Iraq**

Figure 12: Political terms US Political parties (based on Gentzkow and Shapiro 2010)

In comparing 10 major US newspapers utilised for the economic political uncertainty index, Baker et al (2016a) find that segregating each newspaper into either left leaning or right leaning, according to the Gentzkow and Shapiro (2010) political slant identification and then comparing the two indices finds no significant impact upon the political uncertainty measure. Such that the two segregated indices with 5 newspaper in each, have a correlation 0.92, indicating that political bias does not skew the relative uncertainty measure.

e. Methodology

Narrative approach

As Stock and Watson (2001) note there is difficulty in identifying cause from correlation known as the 'identification problem'. As well as using economic theory and institutional perspectives, narrative identification method can be used for the identification of shocks as well as for size and timing of such shocks. Ramey and Shapiro (1998) utilise the news journal *Business Week* in relation to government expenditure, another example is Hamilton (1985) exploring the historical origins of post 1945 oil shocks. Further Romer and Romer (2004) use the approach in relation to monetary policy analysis.

Lennard (2018) notes that application of the narrative method of identification can be distilled into the following three approaches:

Approach A – narrative record

Step 1 – search of the narrative record

- Reports, newspapers, speeches are searched in the relevant time period
- Identification of the *reason; timing; size* of an innovation/shock

Step 2 – classification as endogenous or exogenous

- Requires judgement and separation of change to the independent variable
- So that the change is not 'contemporaneously' correlated with the dependent variable
- Formulate a 'new series of exogenous shocks'

Step 3 – regress variable of interest on a series of exogenous shocks

- Regress the independent variables upon the formulated series of shocks

Approach B – quantitative narrative

Step 1 - estimate of equation based on forecast

- So, for $G_t = \gamma Y_t + \varepsilon_t^G$ **Eq. 2.e.1a: Gov. expenditure narrative approach (based on Lennard 2018)**
- here Y_t is the forecast and not 'final vintage' of the time series for GDP or output
- and G_t is the planned budget for government spending
- regression yields residuals X_i

Step 2 – derived error terms to estimate the parameter of interest

- So, for $Y_t = \beta G_t + \varepsilon_t^Y$ **Eq. 2.e.1b: GDP narrative approach (based on Lennard 2018)**
- here G_t is replaced with residuals X_i
- derive β as an unbiased estimate of the parameter of interest

Approach C – proxy SVAR

Step 1 – find suitable proxy SVAR or external instrument

- The identification of a shock with the narrative approach is imperfect
- As being an accurate measure of the actual shock

Step 2 – nature of the external instrument generates suitability

- The proxy measure is not correlated to 'other structural shocks'
- Although at the same time it is correlated to the actual shock
- Hence it is suitable as having both 'instrument relevance and exogeneity conditions'

Romer and Romer (2004) further explain the method in relation to monetary policy by utilising the historical record for the identification of episodes which generate large or significant shifts in policy or sectoral behaviours. Through searching the descriptive narrative of the procedures followed in decision making and the 'reasoning' used in order to make decisions by the authoritative regimes and other 'accounts' of monetary shocks. The key aspect is to find the disturbances which were generated outside of innovations to the 'real economy'. The test procedure for the relevance of monetary shocks is to then ascertain whether output is depressed more than expected by a negative innovation or output rise more than expected with a positive shock. Furthermore, two key aspects or difficulties in the narrative approach are identified by Romer and Romer (2004) are shown as follows.

Challenges of the narrative approach

Challenge 1 – Isolation of a shock

- Determinations of a shock from the historical record – no prescribed formulation or rule
- Shock discovery is undertaken posthumously hence bias could lead to selection of innovations which are linked to large fall sin money and output of example
- Thus, shocks can be misclassified and also false implication upon outputs are generated

Challenge 2 – assessment of unusualness of movements in dependent variable

- Determination as to whether an unexpected change to the dependent variable has occurred as a result of the innovation to the independent variable of interest.
- Some formal statistical test could be highly beneficial to identify 'systemically unusual' movement in the dependent variable
- An absence of a test weakens the significance, with alternative assumptions such as:
    - Ruling out statistical testing due to irregular impact of the shock or long lag time
    - Invalidates any inferences that are drawn
    - Significance of shock is overemphasised
    - and the bias in the initial section of shocks is compounded

Hence Romer and Romer (2004) in relation to the utilisation of the narrative approach for exploring the impact of monetary shocks upon output develop the following schemes to formalise the test of relevance:

- identification of class of disturbances
- process for the identification is defined
- test for the significance of the shock upon the dependent variable

f. Model approach to time series analysis

EPU Time series analysis

In order to gain insight into a time series, a number of approaches can be taken, consideration is hence given below to the predominant existing approach within the literature with respect to the EPU index. However, as per Harvey and Jaeger (1993) there are weaknesses to drawing inferences from 'mechanical detrending' such as the filter proposed by Hodrick-Prescott (1980) as well as 'limitations' of ARIMA models when a single break and deterministic trend is applied. Harvey (2007) states that making application of structural time series models can provide a route to direct interpretation through consideration of trends, seasonals and cycles. This leads to decomposing the time series through the method of 'signal extraction' Hence prior to the analysis of fluctuations within the EPU index, application of the unobserved components filters approach is undertaken within Chapter 2g below.

The setup of a structural time series model consists of components that have 'direct interpretations' see Harvey and Jaeger (1993). In which the following model is postulated to be the most appropriate.

$$y_t = \mu_t + \psi_t + \varepsilon_t,\ t = 1, \ldots, T$$

Eq. 2.f.1: structural time series model (based on Harvey and Jaeger 1993)

in which y_t is the observed series, μ_t is the trend, ψ_t is the cycle, and the ε_t, is the irregular component. Furthermore here the trend is a 'local linear trend., which is presented as

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \qquad \eta_t \sim \text{NID}(0, \sigma_\eta^2)$$

$$\beta_t = \beta_{t-1} + \xi_t \qquad \xi_t \sim \text{NID}(0, \sigma_\xi^2)$$

Eq. 2.f.2: structural time series trend (based on Harvey and Jaeger 1993)

in which β_t is the slope and the white-noise disturbances are η_t and ξ_t these are normal and independent of each other. The generation of the stochastic component is represented by

$$\psi_t = \rho \cos \lambda_c \psi_{t-1} + \rho \sin \lambda_c \psi_{t-1}^* + \upsilon_t$$

$$\psi_t^* = -\rho \sin \lambda_c \psi_{t-1} + \rho \cos \lambda_c \psi_{t-1}^* + \upsilon_t^*$$

Eq. 2.f.3: structural time series stochastic component (based on Harvey and Jaeger 1993)

Here ρ is a damping factor with $0 \leq \rho \leq 1$ with λ_c being the cycle frequency in radians. In addition both υ_t and υ_t^* are NID(0, σ_υ^2). The irregular component is also NID(0, σ_c^2) and further the disturbances in all three components depicted above are also independent of each other. As per Harvey (2022) given the local linear model is a state space form, it can be handled by the Kalman filter, with the parameters estimated by means of maximum likelihood and the one step ahead prediction errors being used to form the likelihood function.

Hence once undertaken the smoothing algorithm generates the estimates of trend, cyclical and irregular components. Further information on seasonal components can be extracted without distortion of the seasonal pattern structure, hence no need for a deterministic structure to be imposed.

Method of fluctuation analysis

In the proceeding sections of this chapter the approach taken is to identify various historical episodes and to cluster them in order to compare the episode clusters with fluctuations of uncertainty, especially various components. The stages of the approach are as follows:

Stage a

Here the in initial stage, as per the literature, the aim is to identify the significant spikes in uncertainty with the application of the Hodrick-Prescott (1997), **HP filter** using the setting suggested by Ravn and Uhlig (2002) such that $\lambda = 129600$. This filter de-trend's the natural logarithm of the historical EPU indices. A major shock is identified as one occurring with a 1.65 deviation above the mean, under one tail at 5 percent significance level.

The approach taken follows the procedure of Bloom (2009) and Lennard (2018) applied to identify shocks to volatility in the stock market and with respect to the EPU index. Although Hamilton (2017) makes a characterisation of the **HP** filter which implies it is unsuitable if the true data generating process is identifiable as a random walk and suggests an alternate approach. This **H cycle** approach utilises the comparison between values at the time period $t + h$ in comparison with the expected value given the 'behaviour' followed until time t. Hodrick (2020) compares the outcomes of applying alternate approaches with a number of simulations, the results indicate the **H cycle** approach is highly suitable for less complex time series models including random walks and for example with a ARIMA (2,1,2) model. In contrast the Hodrick and Prescott (1997), **HP filter** and Baxter and King (1999), **BK filter**, methods have 'flaws' in such circumstances, especially given that these were intentionally designed with forecasting. However, when there is more complexity in the time series models such as for unidentified cyclical components or with a slow 'growth component' the **H** cycle approach is ineffectual whereas the **BK filter** and **HP filter** approaches yield a more representative 'underlying cyclical' component, as indicated by the simulation testing undertaken in the Hodrick (2020) study.

Stage b

The second stage is to consider the historical narrative and identify the relevant clusters of historical episodes which could perhaps have a relation to fluctuations in policy uncertainty or other forms of uncertainty. Here an attempt is made to align and structure the episode clusters into levels, this includes the global macro relevant events (given US and UK had a number of trade and capital flows including in Europe, and in other regions), as well as domestic US and UK specific events respectively and third specific events which relate to trade relations between the US and UK. Lennard (2018) considers economic policy uncertainty in the UK during

the interwar period, here identification is also made of levels of causation for uncertainty including overseas events, domestic politics and stabilisation policy, the emphasis is placed upon domestic events. In this study consideration is given to global macro events as well as domestic events and trade which is hitherto unresearched directly for this period. Mathy (2016) considers the period from 1929 onwards for the US, whereas here in this study consideration is given to the build-up of uncertainty during the 1920's which is again unresearched in the existing literature. In this study we give some consideration as to the whether the episodes were endogenous or exogenous as undertaken by Lennard (2018) as well as the significance of the differing macroeconomic factors such as undertaken by Mathy (2016) exploring the relevance of 'monetary policy, banking crisis and wars' etc.

Stage c

The third stage is to compare the fluctuations in the Economic Policy Uncertainty indices against the clusters of historic episodes or events. Furthermore the possible macroeconomic impact of fluctuations is considered within the context of the recent literature. Through analysis in chapters 3 and 4 in which statistical testing is undertaken in relation to the relevance of uncertainty fluctuations in relation to macroeconomic fluctuations, as well uncertainty spill over and comparatives of prolonged crises. Using the analytical methods described in the respective methodology subsections, as well as incorporating the theoretical underpinnings of the existing literature relating to uncertainty and economic crises.

g. Analysis

EPU component fluctuations

As depicted in the above sections the measure of uncertainty for the study is estimated through the economic policy uncertainty historical index of Baker et al (2016), in particular for the US economy between 1920 and 1938. This is supplemented through the utilisation of the Lennard (2019) UK interwar economic policy uncertainty index which enhances the UK historical index developed by Baker et al (2016). The monthly depictions of the indices are utilised. This approach to the measure of uncertainty is beneficial given it allows for a 'continuous' measure of uncertainty with respect to time as opposed to prior approaches to the modelling of uncertainty which may include the incidence of elections both reginal and national. In addition some research has used the 'passage of legislative bills' as a proxy measure for political uncertainty as in the work of Bernhard and Leblang (2006) which is of a 'discrete nature' which revealed an increase in exchange rate volatility due to the timing of such events. However, there has also been consideration given to endogeneity issues with this approach as it has been shown in some instances within OECD countries that the nature of economic conditions is a determining factor for the election to be called Heckelman and Berument (1998) explore this aspect in particular. As mentioned in the prior chapters there has been a range of investigation into the role of uncertainty upon financial markets such as Boutchkova et al (2012) and also upon firm level investment Julio and Yook (2012). The approach of Choudhry et al (2020) in exploring the impact of uncertainty upon trade consider the notion of Juardo et al (2015) perspectives of uncertainty in respect of

economic actors being unable to forecast the 'conditional volatility' of the stochastic processes impacting the economy. Bloom (2009) indicates that uncertainty as being unable to 'know' the future status of the economy with 'certainty'. This feeds into the development of the Baker et al (2016a) index which incorporates three levels of primary data to build a continuous measure over time. Lennard (2019) puts a focus on UK interwar period uncertainty by additional primary material to the Baker et al (2016a) interwar index newspaper and text search criterion.

EPU interwar data

The below charts depict the EPU historical indices for the inter war period respectively for the US and UK. They show the spikes of uncertainty occurring and also although there was uncertainty faced in both countries the US experienced higher peak levels of economic policy uncertainty during the period.

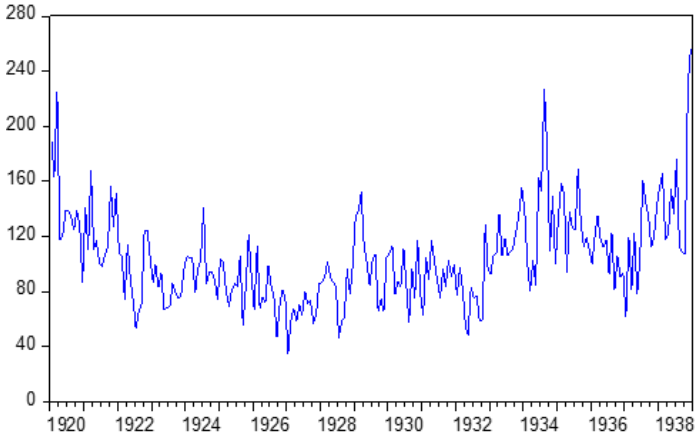


Figure 13: US EPU Index (NBER)

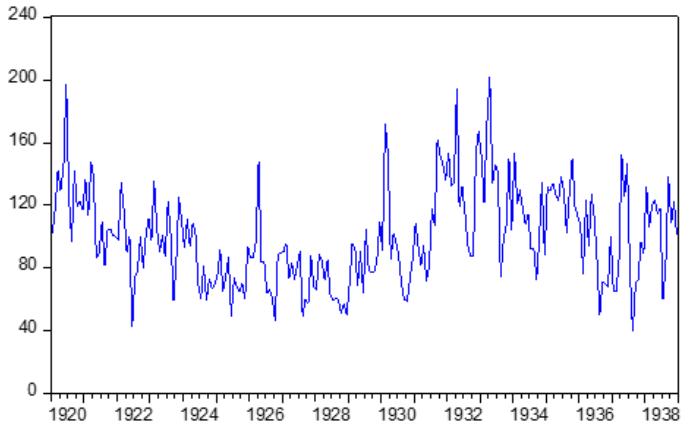


Figure 14: UK EPU Index (NBER)

Economic Policy Uncertainty time series components of uncertainty fluctuations

The below charts depict the outputs of the EPU monthly time series models in terms of trend, cycle, seasonal and irregular components. They provide some relevant insights into the structure of the series, which is dynamic in nature and also indicates the cyclical behaviour that is apparent.

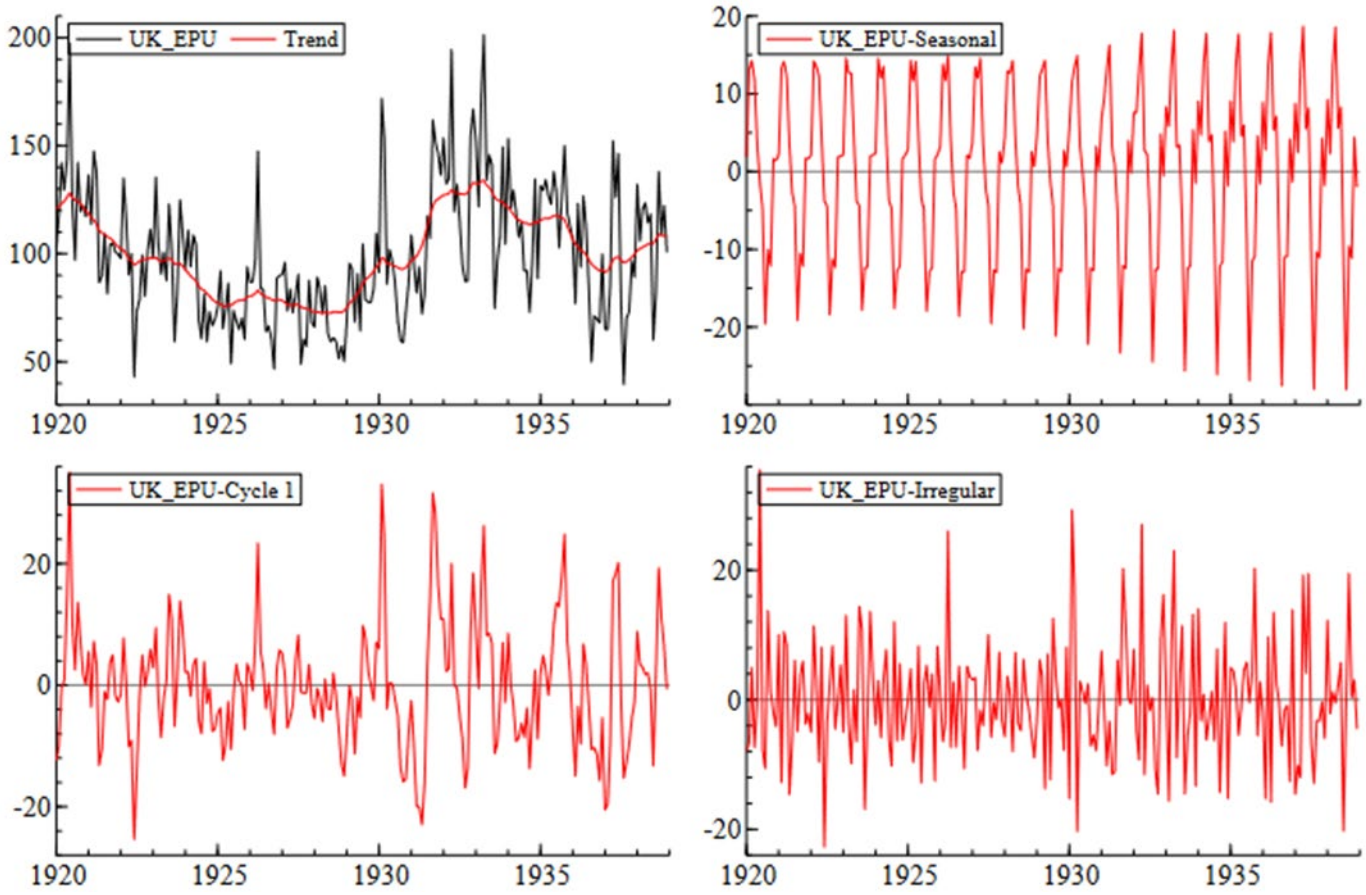


Figure 15: UK EPU Index components

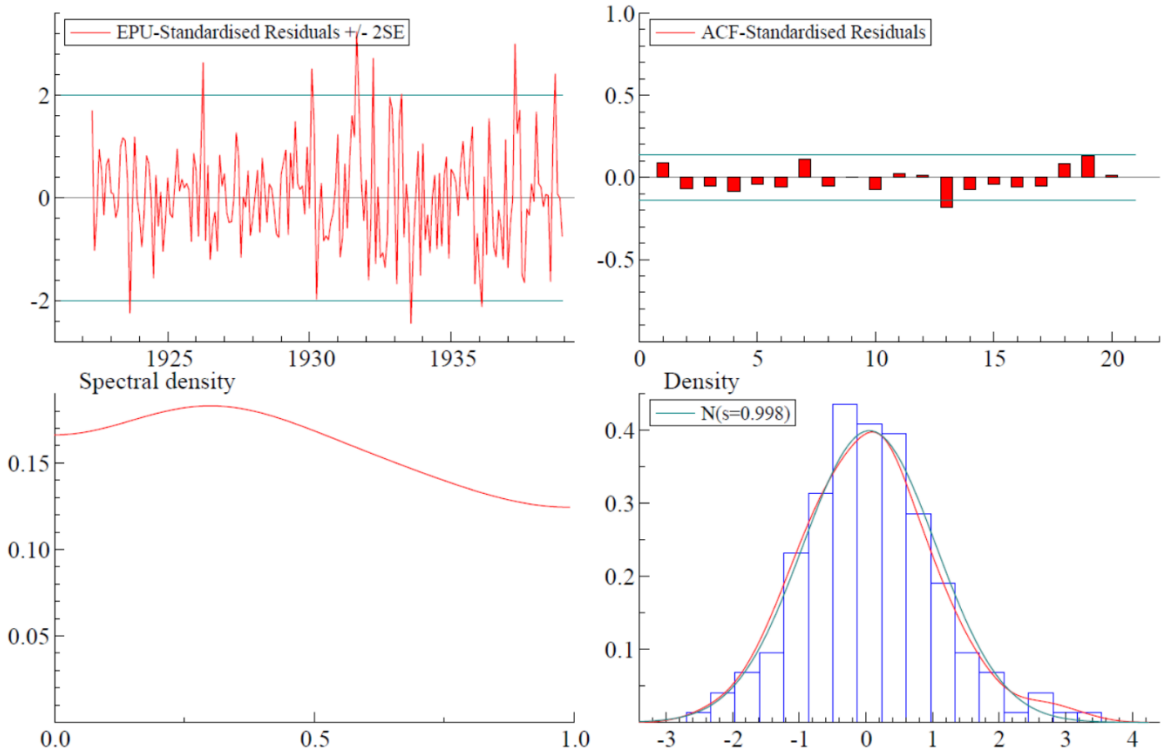


Figure 16: UK EPU Index irregular component analysis

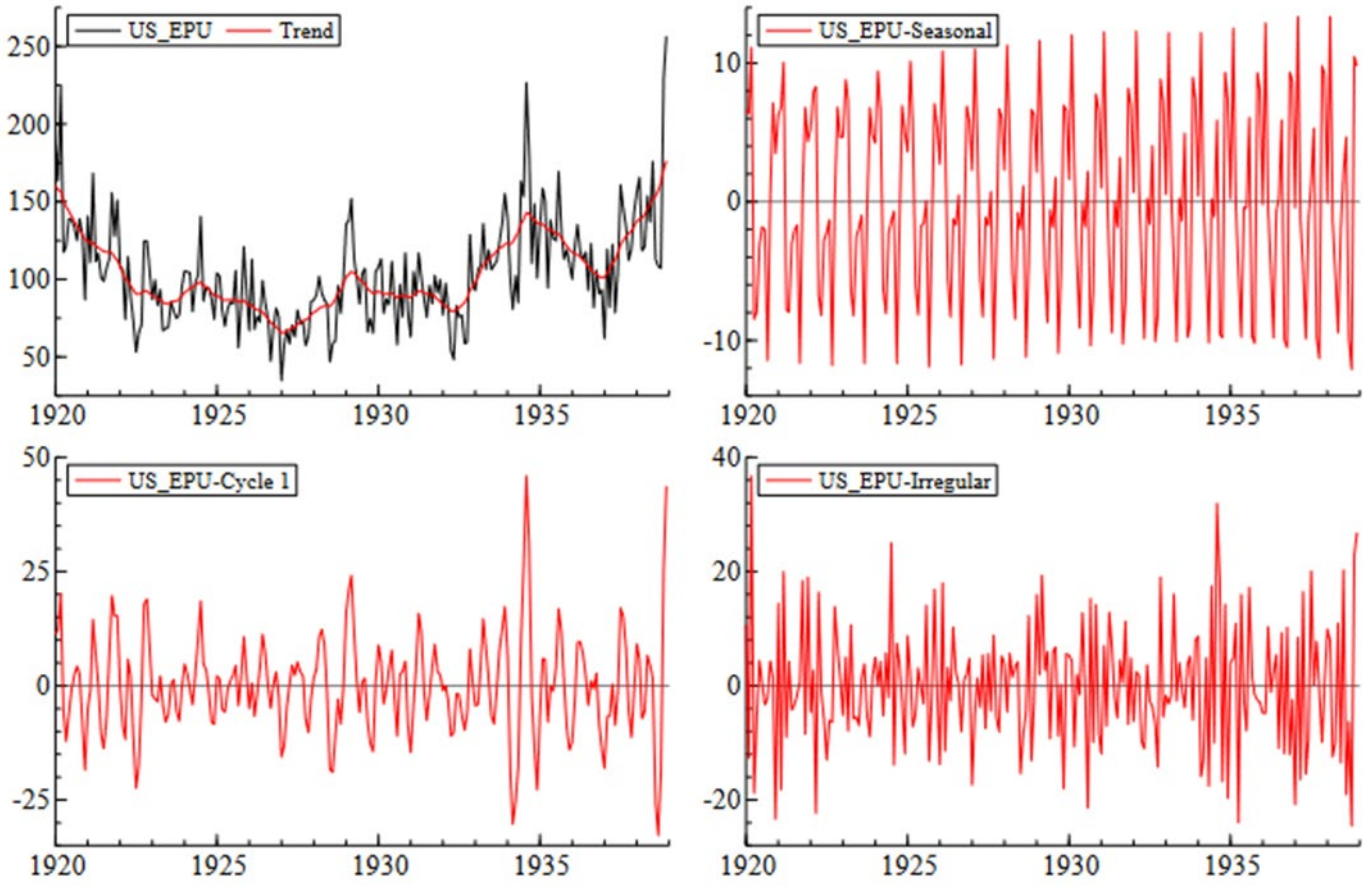


Figure 17: US EPU Index components

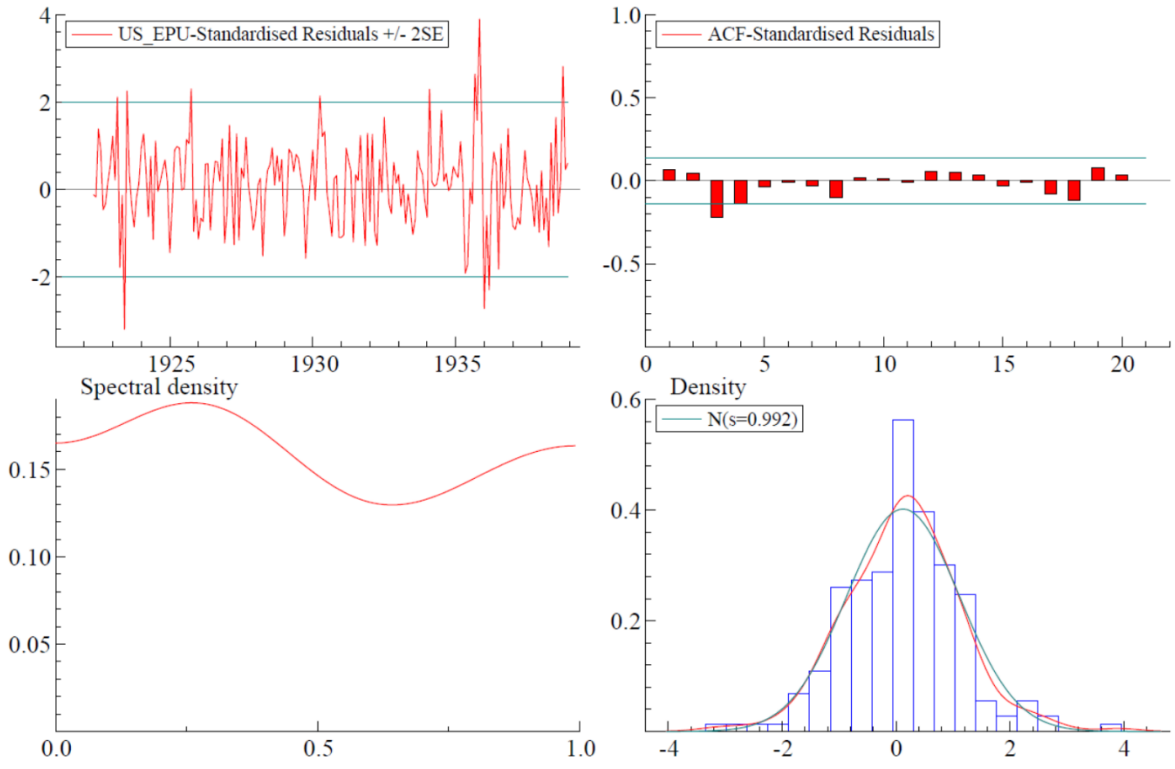


Figure 18: US EPU Index irregular component analysis

The above charts displaying the irregular component analysis for the UK and US EPU indices respectively show that for both the model is a reasonable fit given that the residual variation is within bounds and indicates normal distributions. The spectral density is relatively smooth and hence further indicates that there are no major disruptions.

The inference from the cycle components of both time series indicate the fluctuations which are in congruence with the HP filter analysis depicted below.

Economic Policy Uncertainty time series filter

The below charts present the HP filter analysis output for UK and US EPU index time series.

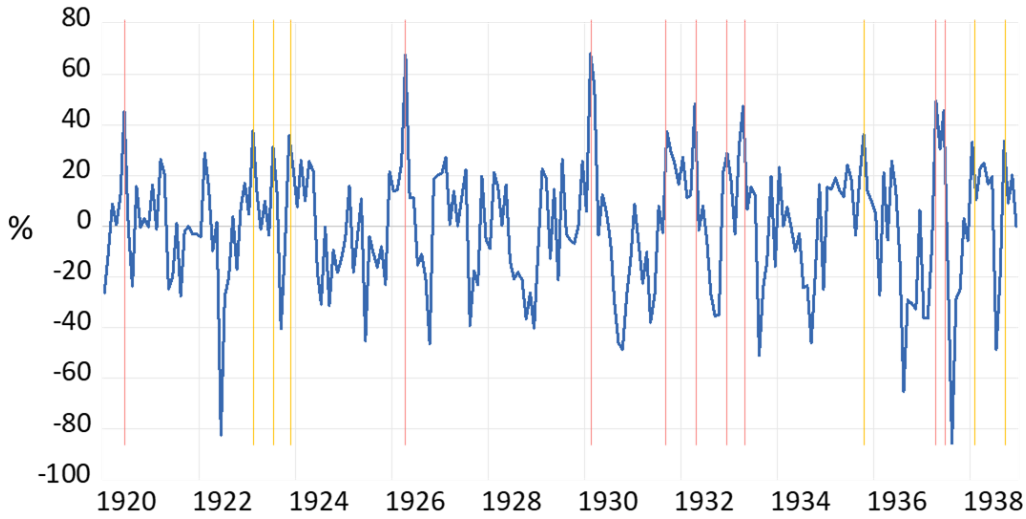


Figure 19: UK De-trended (HP filter) Log EPU Index

The above chart depicts the major uncertainty shocks marked with red vertical lines for those identified by Lennard (2018) as significant episodes given, they are more than 1.65 standard deviations above the de-trended natural logarithm of the UK EPU index mean. Further the yellow vertical lines are identified in this study as relevant uncertainty shocks which can also be compared to the clusters of historical episodes identified through the narrative approach in the subsections below.

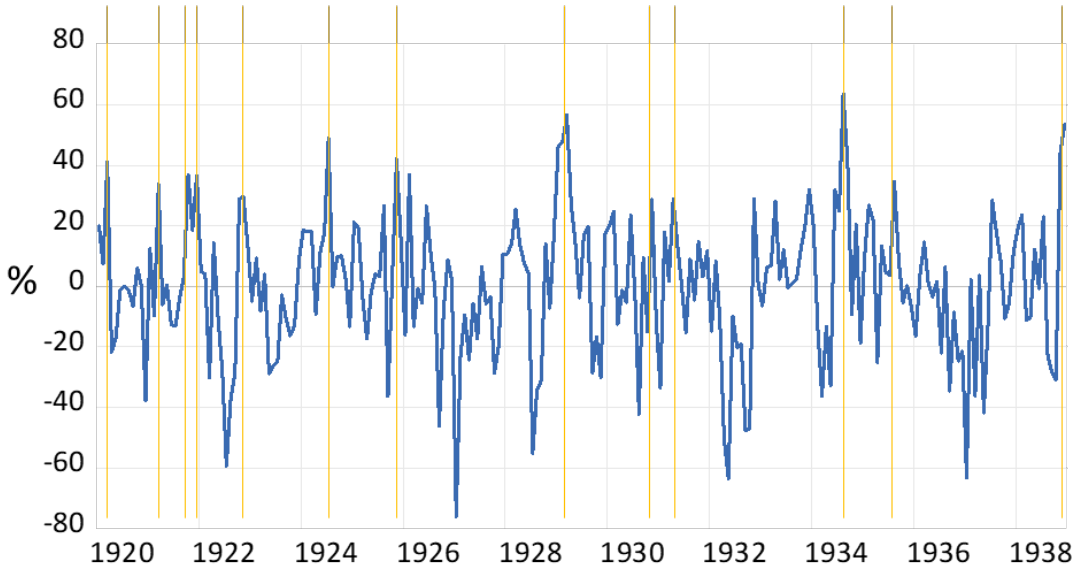


Figure 20: US De-trended (HP filter) Log EPU Index

The above chart depicts the uncertainty shocks marked with yellow vertical lines identified as significant episodes given, they are 1.65 standard deviations (or close to this level) above the de-trended natural logarithm of the US EPU index mean. As such they are relevant uncertainty shocks which can also be compared to the clusters of historical episodes identified through the narrative approach in the subsections below.

Historical episode narrative

An exploration is made of the historical episode narrative of relevant events considered in the literature, which in turn draws upon selected newspaper source materials and as well as this study which considers selected historical archival report material such as from LoN and BoE archives. These are classified into the following levels as considered development upon the previous work of Lennard (2018) and Mathy (2016). The local refers to either UK or US related polices and episodes, hence global refers to external related clusters to the UK and US respectively:

- **Level 1 (L1) global episodes -** global episodes and structural shifts which may generate underlying impact and potentially on going drivers to other episodes (at Level 2-5) which may have an impact upon the UK and the US
- **Level 2 (L2) global policies -** global agreements and major foreign government policy which are expected to have an impact on the major economies respectively
- **Level 3 (L3) local episodes-** UK and US macro events, financial and monetary episodes which are expected to have a domestic impact on the UK and US economies respectively as well as potential spill overs with relation to capital and trade flows
- **Level 4 (L4) local policies -** related with government policy which are expected to have a mainly domestic impact on the US and UK economies respectively related with government policy which are expected to have a mainly domestic impact on the US and UK economies respectively, as well as potential spill overs
- **Level 5 (L5) trade episodes** - trade related episodes and policy shifts which may have relations to US and UK bilateral trade or their respective trade with other nations

Level 1 - Global episodes

GLOBAL TRANSITION

Towards the later 19th century the UK's industrial superiority was faced with competition from the United States and Germany. The early 1900s were a critical period for the financial interests of the UK and arguably the most acute crisis was faced in 1914 according to Morgan (1952) with a potential financial crisis averted before the outbreak of the war. Subsequent post war problems of inflation and unemployment according to Morgan (1952) can be linked to the decline in competitiveness of UK industry and the need for rationalisation of many sectors. However, ingrained mostly within but often without the domestic organisations involved in the manufacturing process through factories; foundries; mills; and shipyards. the UK had established a network of distinctly 'invisible' economic agents operating across the world which were ingrained into the very heart of the more visible industrial activity. The role of UK firms in bill discounting, capital issuance, money market operations, the gold market, trading and issuing securities and insurance, is the realm of a broad-spectrum research literature. This activity when viewed collectively, could arguably be a form of 'modern economic imperialism' as depicted by Feldman and Hertner (2008), a question of debate for future exploration is the functioning and structure of such financial empires.

The pre-1914 and post War era saw the development of a second wave of industrial development a move to mass production and the rise of major rivals to UK industrial supremacy. The strongest of these USA, Germany and Japan. According to Andersson (1990) there was a broader global economic shift occurring with the progress of industries in other nations such as Sweden and other European nations. New methods of production required upgrading machinery and the benefits of economies of scale were further accelerated, this period saw the emergence of large conglomerates (in US Ford, in the UK BCM) Germany was a leader of the Rationalisation process, partly from the necessity of circumstance and the emerging resources at the countries disposal. The German meaning of Rationalisation from Board of National Efficiency as explored by Meakin (1930), 'Rationalisation encompasses general economic situation, technical and systemically planned organising increases standard of living by the production of better and cheaper goods in larger quantities. Demands a common effort by all classes of the community.' This depicts a much broader economic and social objective and this aspect was perhaps absent from the UK industrial and political leadership in its pursuit of rationalisation. The objective in the UK was much more limited orientation applied through certain measure for individual firms or regional supply chains.

The emergence of new competitors resulted in the inevitable decline of UK export markets as countries began developing industrial strategy to compete with the UK. In response the UK began to attempt to consolidate the Empire; seen in the policy of Imperial Preference pursued by Joseph Chamberlain. There was also a global increase in protectionism after the 1929 US Stock Market Crash.

A further consideration is the loss of other markets, which occurred as a result of inevitable socio-economic movements occurring before and accelerating during, the war. the UK's position as the workshop of the world,

was under pressure from the rapid rise of US industrial capability, Japan's increasing development and the productive capacity of Germany. An example would be the cotton textile industry, during the period 1910-13, UK exports were three times larger than the next six largest producers combined, however within 20 years Japan the weakest of the competition would overtake the UK. As the UK Consul in Osaka stated the war provided the circumstances for Japan to operate in its primary market in China without facing any competition. Further advantage was gained through entering new markets in which they could supply goods that they were unable to receive from the previously dominant UK and other producers, Robertson (1990). So now that the War had stunted German expansion, the UK had an unmissable opportunity to introduce or re-establish itself in those markets which had been closely tied to German interests. Alongside this political turbulence further afield in places like Russia meant that UK firms were compelled by their very nature to seek alternative markets to replace those that were now closed. The region of East Central Europe was an ideal place to begin this process of market creation. Another aspect highlighted by Peteri (1992) was that the UK needed to reinvigorate the European economy for its own economic revival to proceed. the UK's clear aspirations to this end are highlighted by some of the projects which were undertaken at this time such as the 'International Corporation for the Trade in Eastern Europe and Russia'. Such endeavours have relevance considering the American threat in Europe.

	1914		1928	
	Amount	%	Amount	%
UK	18,300	41.6	18,100	36.3
France	8,700	19.8	3,500	7.0
Germany	5,600	12.7	1,100	2.2
USA	3,500	8.0	17,200	34.5
Other	7,900	17.9	10,000	20.0
Total	44,000	100.0	49,900	100.0

Figure 21: International Investments ($000,000's) (Woytinsky, 1955)

After the initial turmoil there were some broad issues to address, aside from the pressing peace time economic reversion required at home there was also a need to address long standing decline of competitiveness of domestic industry. Further outlook was needed to address the key losses of export markets and partners, most substantially in Russia. The threat to UK involvement and trade routes through Europe to the East after the Ottoman Empire had been overturned. In terms of the focus of our study the end of the Austria-Hungarian Empire bought a further convolution for financial interests. As there was a substantial pre-war investment structure inter linked between London and Vienna (the regions financial centre) which was now under threat

as the formation of new states would disrupt the established Universal Banking networks. The changing circumstances of new leadership also provided an opportunity to replace the old ties to the German Empire.

Beyond the internal disruption the war had instigated a new entrant into European affairs. The United States (US) provided resources which had enabled the Allied powers to prevail, but this had unleashed the shackles of expansionary investment and the capacity to expand exporting industries was a prime motivation for the interest in Europe In the broader context of UK global financial integration there was a group named by Baster as the 'Anglo-International' banks, with territorial areas of interest outside of the immediate 'Empire'.

Great Influenza Pandemic (Spanish Flu)

Barro and Ursua (2020) identify the potential significance of the Great Influenza Pandemic (Spanish Flu) of 1918-20. They find data for 43 countries revealing 39 million deaths which was 2% of the global population. Their model for the impact controls for the impact of the First World War and finds that for a 'typical country' there was a pandemic relate decline in GDP of 6% and decline of consumption of 8% furthermore there was a 'meaningful' impact on real returns for stock markets and yields on short term government bonds.

They construct the below for Flu death rates during the Great Influenza Pandemic (sum 1918-1920).

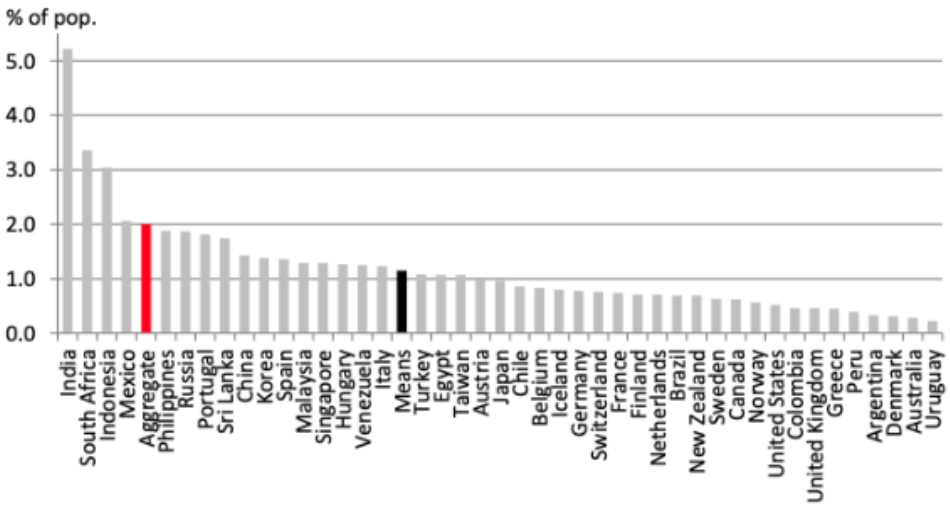


Figure 22: International population impact from Influenza 1920 **(Barro, et al. 2020)**

Further Barro and Ursúa (2008) find that there may have been a significant negative impact of the influenza pandemic through studying macro 'disasters' in 12 countries with respect to GDP and 8 countries for consumption. The Barro and Ursua (2020) update expanded the analysis to more countries and consider the variations in flu death rates over a longer period.

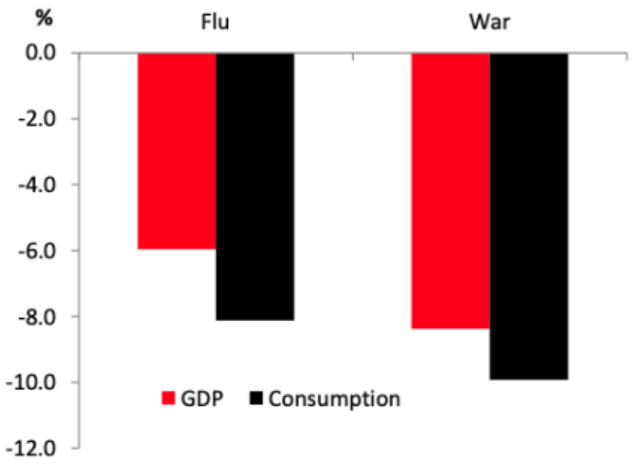


Figure 23: Economic impact from Influenza vs War 1920 (**Barro, et al. 2020**)

The analysis finds statistically relevant detrimental impact of the death rates induced by the pandemic and war. The above chart shows the macro impact upon 'typical country'. In addition they find that the increase in inflation rates related to the pandemic and war contributed to the following impact on financial returns, shown in the table below.

Negative effects (% points)	Stocks	Bill returns
Pandemic	26	14
War	19	13

Figure 24: Financial market from Influenza vs War 1920 (based on **Barro, et al. 2020**)

CREDIT ANSTALT 1931 & US – GERMAN CAPITAL/TRADE FLOWS

Uncertainty with Germany was heighted further by the onset of a Banking crisis which was triggered by the collapse of the Credit Anstalt in 1931. Schubert (1991) argues that 'a confused public' led to the developments and spread of panic that was born out of 'inconsistencies in policy'. The collapse of one of the largest central-eastern European banks spread into Germany. Kindleberger (1986) highlights the spread of the collapse as bank runs occurred in Hungary, Czechoslovakia, Roumania, Poland and Germany. Further despite a moratorium on payments of intergovernmental debts by President Hoover there was rapid withdrawal of foreign claims on German Banks. Eichengreen and Portes (1987) note the rapid decline in loans to Europe from $600 million in 1928 to $142 million as a precursor to the 1931 collapse. Eichengreen and Portes (1987) indicate that the reliance upon short term indebtedness of German financial institutions combined with the imperfect information of investors heightened the level of uncertainty and increased the rapid banks runs, Between mid-1930 and mid 1931 approximately 50% of the gross short term ;inabilities were withdrawn from the largest 28 banks. In a period of six weeks the Dramstadter lost 30% of deposits forcing the closure of all German financial institution. The Bank of England was not in a position to help and in the US, congress was facing a significant deficit of around $1.6 billion. The French were in a position to support but unable to agree upon the amount with a purported $1 billion required, The Wigston Committee working through the Bank of

International Settlements agreed to a standstill agreement which froze foreign claims on Germany the initial six month period was continually extended.

Level 2 - Global policies

CAPITAL FLOWS

The war had precipitated a new phenomenon of capital flows from across the Atlantic to Europe. London had formerly been the centrifugal point for capital to flow across the world. Kindleberger (1986) describes how despite the significant size and impact of the 1924 Dawes loan, this was not the point from which foreign lending from the US was 'set in motion'. During the war foreign governments had already borrowed funds initially through JP Morgan and then from the US government. By 1924 the annual amount had reached $900 million dollars and by 1927-28 this had reached $1.25 billion. Lending to Europe and South America increased by 'sensational' levels the rise in lending to Canada, Asia and Oceania was more moderate. Between 1924-1929 foreign lending from the UK totalled $3.3 billion and from the US the total was $6.4 billion (League of Nations, Balance of Payments Data 1932). The capital flowing to Europe was the most significant within this period the US amount totalled $3 billion and comparatively only $700 million from the UK. James (2009) looks at a wider perspective arguing that the pre 1945 era had larger capital flows to developing nations whereas the post war data is skewed by the 'peculiar' German borrowing which creates a significant imbalance. The German case is 'peculiar' in regard to the traditional theory of development economics that capital flows from developed to developing nations hence more funds should have been flowing into Asia and Africa which was not the case. The wide pool of capital flows is postulated to be up to $11 billion between 1924-1930 with 60% from the US in the form of long-term capital bonds. The peak for both the UK and US was 1927 there was a further sharper decline in 1931 from the US although the UK was still active within the Commonwealth nations. On an average 1.1 billion in long term capital flowed from the US from 1924-1930. (UN Department of economic affairs, 1949)

Short term indebtedness showed a reverse of the long-term flows as James (2009) explores Britain and the US were the large debtors for short term debt, Germany was the largest. A BIS estimate for global short term indebtedness in total was $13.5 billion of this figure Germany accounted for $3.9 billion and the US 2.7 billion. Of the world total only $4.3 billion was related to 'commercial transactions'. The UK and US partook a similar position of converting the short term liabilities into long term credits in terms of considering only banking liabilities the UK exceeded the US. Feinstein and Watson (1995) explore the data on capital flows and private international capital during the interwar period. Following the 1931 crisis $3.5 million in capital went to the UK and US, Short term capital had been flowing into the UK during the 1920s, but the onset of crisis saw an unprecedented scale of 'capital flight'. The crisis in Europe was followed by contagion in Latin America, the UK had been a major creditor across the world for railroads and related municipal lending through the period and UK commonwealth orientated bonds amounted to $5.3 billion and $1.6 billion to Latin America. The US followed a similar pattern arguably with a heightened spread of public issues, with $2 billion flowing into Latin

America. An estimated 1.5 million individuals held foreign securities and the securities and exchange Commission estimated in 1937 around 650,000 investors were holding bonds that had defaulted. Potentially the case of the short term capital flows and crisis period capital flight is indicative of the reverse of the traditional theories with capital flowing back to the most developed nations.

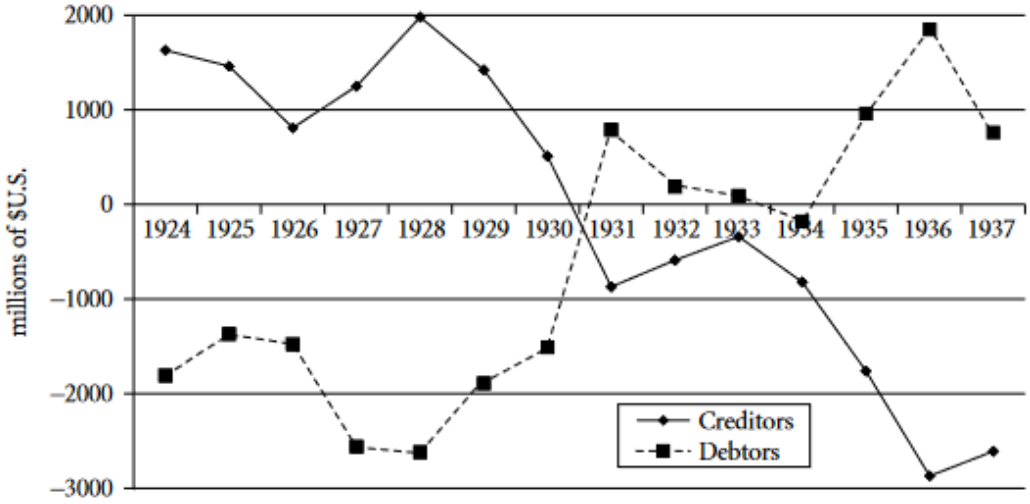


Figure 25: Capital flows, 1924–1937 (James 2009)

The above chart demonstrates the boom-bust cycle of capital flows, in which an increase of capital to debtor nations was proceed by a decline on confidence which would effectively reversed the flow. The UK and US were the main capital exporters the peak in 1927 saw a dramatic drop and after 1931 the US effectively halted all capital exports with UK focusing on the imperial preference for capital and trade.

James (2009) identifies the adverse impact upon the US government budget deficit through the combination of the collapse of the commodity prices in 1929 combined with the external debt build up in many Latin American nations for example Bolivian debt was 237% of exports and Chile faced debt of 121% of exports. The reliance on commodity exports meant the price collapse greatly impacted confidence and subsequent financial collapse. James (2009) looks into the global capital flows among financial institutions and ownership of significant banking assets in the Middle East and Latin America. For example, in Turkey there were runs on Deustche Bank branches and collapse of Banque Turquce pour le Commerce et l'Industrie. The Deutche Orientbank in Egypt were forced to close offices. Banks in Eastern Europe with German associations faced runs or collapse including in Romania and Latvia. At this point, the City of London came under a crisis due to the $4.86 gold standard exchange rate which was fixed in 1925 criticised by Galbraith (1954) as causing 'along series of exchange crisis… now an established part of the British scene'. Kunz (1987) identified the 1925 -31 period as a being one of 'traumatic experiences of the British economy'. The uncertainty levels were raised further to the 1931 difficulties in Europe when news of the Latin American crisis arrived. The report of the Echo de Paris in October 1931 read "the news that the Brazilian coupons would not be paid on 1 October increase the disarray. England is the largest creditor of Latin America". Although Britain faced difficulties in

the years up to 1931 but the process under which sterling was devalued 'contributed to the economic progress of the 1930's' as Kunz (1987) states. Whereas for the US 1931 was the beginning of a much longer period of depression. In 1931 the US bank crises began in the Midwest, but it was in 1932 that the New York banks faced the consequences of the withdrawal from Europe. Liabilities to Europe declined by $550 million and gold reserves were depleted by $535 million. In May 1932, the US Treasury announced the deficit for the 10 months of the fiscal year to be $2,2 billion whereas the previous deficit had been $886 million.

The US involvement in the Dawes Plan and Young plan with respect to trade uncertainty

As James (2009) identifies there was as significant impact from the capital flow going from the US to Europe which supported a return flow in trade with US exporters able to sell goods to Europe however with the changing dynamics of the recovery in major European economies including the UK as well as Germany and France the exports were also impacted alongside the adjustments to capital flows. The evolution of the Dawes Plan into the Young Plan which secured funds from US financial institutions into Europe was a significant policy factor. As depicted by Kindleberger (1986) the German economy recovered following the stabilisation of the currency and there was a mini boom in terms of economic output and production, with the Dawes plan and financing of bonds in New York. Although inter European relations such as with France and Germany were heavily strained the French economy also performed relatively well in comparison to the UK. Eichengreen (1992) depicts that the US and French held 30% of world gold reserve by around 1930. The French economy had returned to the gold standard in 1926 and had proceeded to increase reserves of Gold and Sterling in support of its currency valuation. The French domestic economy was more insulated than other nations to trade dynamics and experienced a longer run of stability until the mid-1930's. As described by Schuker (1976) and Feis (1950) the Dawes Plan and earlier JP Morgan bond raises had led to an increase of foreign bonds raised in the US to Germany and other parts of Europe including France. The Young Plan conferences commenced in 1929 and led to the formation of the Bank for International Settlements to collect the finalised reparations agreements. There was also an agreement for further loans for Germany offered in the form of bonds raised in the US in the second Hague conference in 1930, The conference took place over the course of increasing uncertainty and a final agreement at the Lausanne conference in 1932 was held to reduce German liability for reparations by up to 90%. This was under the extreme circumstances given the 1929 stock market crash and subsequent 1931 Credit Anstalt crisis, the German banking system was also under strain at this time.

YOUNG / DAWES PLAN & END OF REPARATIONS

Kindleberger (1986) further indicates global events may have created more significant long-term impact than the Hatry Crisis and led to the lack of confidence of US investors. These include global policy issue relate to the Dawes Plan and then the Young Plan which was meant to bring a "final and definitive settlement" to governments for reparations. The discussions resulted in an agreement for reduced amount of reparations and $300 million loan with $100million available to Germany, During the discussions a dispute between the French and British representative may have led to a withdrawal of £240miilion of gold as a result with further

withdrawals to New York and finally forced the Bank of England to raise the discount rate which was a trigger for the collapse of the stock market in New York. The final plan of the Allies was rejected in 1932 by congress however by that time the global system had collapsed. Ritschl (1998) discusses the Borchardt hypothesis that in the late 1920's wages constraints were a major reason for the decline in growth and that the Young Plan which had effect during the depression created limitations upon the public budget with credit retractions forcing austerity and dampening any prospect of recovery. Broadberry and Ritschl (1995) argue that the UK and German economies had similar patterns of labour cost, investment and demand but German restraints on foreign credit following the Young Plan were a key factor. Ritschl (1998) that the balance payments were more volatile in Germany than in the UK and this was attributable to the foreign credit restriction imposed by the Young Plan limiting any form of devaluation. This led to more restrictions and accelerated the impacts of the depression upon Germany experienced more significant uncertainty and volatility compared to the UK.

Level 3 - Local episodes

UK CHALLENGES IN GLOBAL ECONOMY

The below chart depicting annotated economic policy uncertainty during the interwar period for the UK as developed by Lennard (2018) which indicates significant peaks which occurred in relation to significant policy events. Some of the peaks can be less well explained through the consideration of events limited to the remit of parliamentary votes or large-scale protest such as strikes. The peaks and turbulences less well explained by such events have been marked with A1, A2 and A3 are hence further considered in subsection g below.

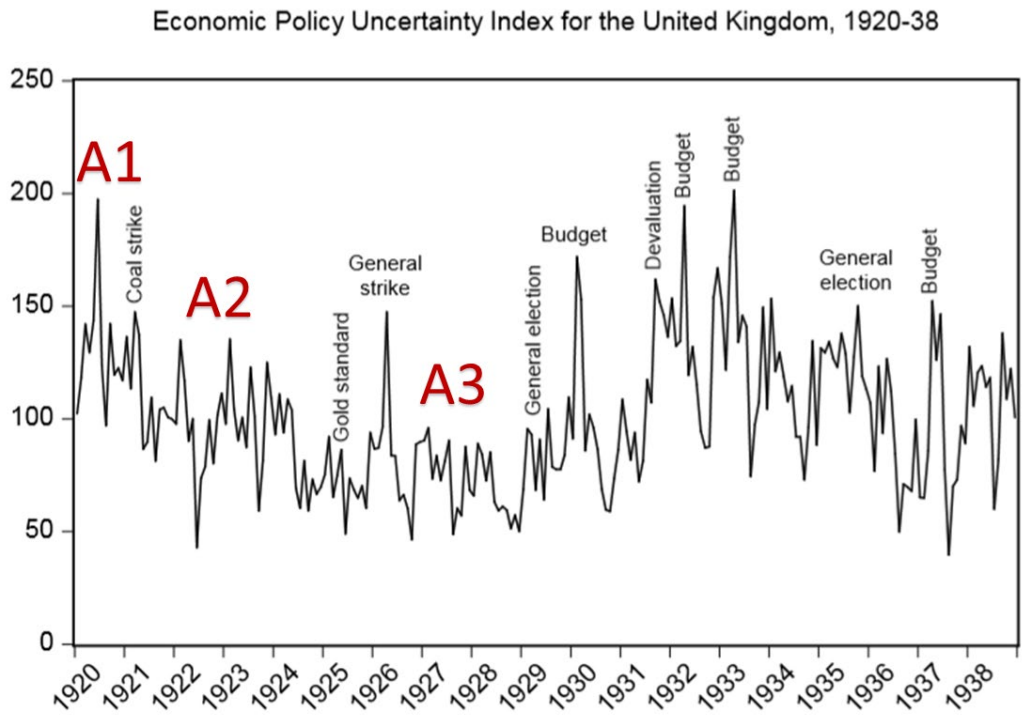


Figure 26: UK Interwar EPU index (based on Lennard 2019)

The periods less well explained by the more domestic parliamentary orientated approach to policy uncertainty as labelled in the chart above:

- A1 -> post war spike relating to the Treaty of Versailles
- A2 -> 'rationalisation' and export disruption
- A3 -> Bank lending constraints…

US POST WAR RECESSION

Based on the NBER dating of business cycle expansions and contractions there were four recessionary periods post 1918 and prior to 1929. As shown in the table below.

Peak month (Peak Quarter)	Trough month (Trough Quarter)	Contraction	Expansion	Cycle	
		Duration, peak to trough	*Duration, trough to peak*	*Duration, trough to trough*	*Duration, peak to peak*
August 1918 (1918Q3)	March 1919 (1919Q1)	7	44	51	67
January 1920 (1920Q1)	July 1921 (1921Q3)	18	10	28	17
May 1923 (1923Q2)	July 1924 (1924Q3)	14	22	36	40
October 1926 (1926Q3)	November 1927 (1927Q4)	13	27	40	41
August 1929 (1929Q3)	March 1933 (1933Q1)	43	21	64	34
May 1937 (1937Q2)	June 1938 (1938Q2)	13	50	63	93

Figure 27: Business Cycle Dating for US (NBER)

The 1918/19 contraction according to Goldberg (1999) was a result of the war production coming to an end as well an increase in unemployment partially due to the military troops returning. The 1920/21 decline has a wider variety of attributing factors. The other two contractions prior to the 1929 crash were of a milder nature. According to the work of Zarnowitz (1996) in compiling composite indices, the decline in business activity for each was as follows:

Recession	Business activity decline (%)	Potential Factors	Sources
1918-19	24.5	*Inflation in Europe and decline in US output*	Goldberg (1999)
1920-21	38.1	*Price deflation; labour adjustments; Pandemic - Spanish Flu; Monetary Policy*	Vernon (1991); Barro and Ursua (2020); Friedman and Schwartz (1963)
1923-24	25.4	*Changes to industrial production*	Zarnowitz (1996)
1926-27	12.2	*Ford plant closure*	Kindleberger (1987)

Figure 28: Business Activity Declines US (based on Zarnowitz 1996)

The below chart depicts the Dow Jones Industrial Average from January 1918 to January 1923. The index peak was at 119.6 on November 3, 1919, and troughed at 63.9 on August 24, 1921, a decline of 47%.

Figure 29: The Dow Jones Industrial Average (NBER)

UK STOCK MARKET AFFAIR 1928 -29 HATRY CRISIS & 1929 US STOCK MARKET CRASH

Galbraith (1954) alludes to the potential significance of exchange rate fluctuations which occurred following the Sterling return to the pre-war Gold parity and partly led to a 1926 strike. The fluctuations and circumstance led to gold leaving the UK and Europe and into the US. Hence in 1927 Norman (Governor of the Bank of England, Schact (Governor of the Reichsbank) and Rist (Deputy Governor of the Bank of France) requested the Federal Reserve to lower rediscount rates from 4 to 3.5% and this encouraged the purchase of Government securities leaving US banks and market participants with excess funds a dissenting member of the Federal Reserve, AC Miller described the event as " the greatest and boldest operation ever undertaken by the Federal Reserve and resulted in one of the most costly errors… by any banking system in the last 75 years…". Galbraith (1954) further indicates a significant event in September 1929 in a British financial promoter Clarence Hatry had been forging bearer scrip certificates and given them as security to multiple banks in exchange for loans to cover a shortfall in his dealings the London Stock Exchange suspended dealings in shares and the subsequent consequences have been cited as potential contributory factors for the US Wall Street crash which occurred in the preceding month. In addition, there were further events to put doubts into investors' minds including the refusal of the Massachusetts Department of Public Utilities to refuse a stock split of Boston Edison from four to one. The sentiments of the market began to shift with advertisements for a "overstaying Bull Market", and "investors make money in a bull market, and loose even more… in the readjustment…".

Level 4 - Local policies

GOLD STANDARD AND UK CRISIS

Britain was not immune to the German crisis with accepting houses having extended credit lines to German businesses. Kunz (1987) highlights the uncertainty created with the publication of the Macmillan Report in 1931 given the dearth of information on reserves which typified the era the publication was quantified the exposure to German borrowers and the near-term shortfall in Bank of England Gold reserves. There was a

drain on sterling prior to the report being published both French origin and from the other European central Banks attempting to raise gold reserves as a brace against the events in Austria and Germany. The Dollar and Franc occupied stronger alternatives to sterling as an international reserve currency. However, Kunz (1987) further notes that sterling was remained an important reserve currency for those countries that remained on the Gold standard. In addition, the Bank of England was undertaking closed discussions with both France and US for credit in order to maintain Sterling under the Gold Standard however there was an attempt mad to prevent wide scale discussion given this may induce further panic from investors and banks in New York. PM Ramsay Macdonald was forced to seek funds from the French Government and coalition of Investment and Merchant Bankers headed by JP Morgan. The creditors were adamant that the government must produce a balanced budget with a s significant 20% reduction of welfare spending for the unemployed. Uncertainty levels were raised due McDonald's Labour party resisting and such cut to welfare expenditure. However, to maintain Sterling without the access to credit was inconceivable and hence MacDonald was led to form an all-party coalition "National Government" with only a minority Labour MPs. The 'National Government' approved the condition of a reduction in welfare spending and off the Gold Standard. The policy uncertainty continued due to the subsequent general election resulting in a coalition government led by MacDonald but with only a small minority of Labour representatives.

Many studies on the crises focus predominantly on the financial aspects, however there are other facets which contribute to a crisis, that may be more significant in relation to both causation and escalation of a crisis. These include policy matters pursued by the Central Bank as put forward in the Friedman and Schwartz (1963) hypothesis upon the monetary policy of the US Federal Reserve. Although other studies give more importance to the role of the Gold Standard such as Eichengreen (1992), the basis of the analysis remains embedded to a policy matter which in the case of the Gold Standard was a global concern. Temin (1993) considers that the nature of the 'Gold standard was flawed' but further the 'rules of the game' made the policy maker's response heighten the crisis. Hamilton (1988) identifies that contradictions in the policy approaches to the defence of the gold standard between the US and France contributed to the downward pressures on the global economy. Further Eichengreen and Sachs (1995) find that countries exiting the Gold Standard had a faster rate of recovery. Some aspects of the restrictions of the exchange rate policy such that countries adhering to the Gold Standard found that they were necessarily limited to following a policy of deflation in order to maintain the parity instead of devaluation which would have the potential to stimulate the economy. For example, the Bank of France, Eichengreen (1986) had prohibitions in place that meant it was unable to conduct open market operations and hence it has been argued, forced deflation on the rest of world through very large influxes of gold.

Eichengreen and Temin (2010) find similarities to the more recent experience of the Eurozone countries such as Greece, which faced arguably much more restrictions in the approach to the downturn, the only option for Greece was to pursue austere policy measures as there was no option to devalue and gain any benefit from

lower exchange rates. Bernanke and James (1991) investigate the transmission mechanism from the deflationary policy measure to the continuation of the depression., They use dummy variable to model the incidence of crisis and compare 24 countries both on and off the gold standard as well as those that may have or have not experienced a banking panic. They find two interesting results from the progressive but slightly limited approach. The first is that banking panics had a role in limiting output and hence prolonging the downward pressure upon the economies that suffered the worst panics. The worsening of banking panic could be linked to the Gold Standard policies limiting the manoeuvrability of the monetary authorities or central banks in being able to stimulate the supply of money or prevent banking failures spreading as seen in the US with a number of banks failing. As Hamilton (1988) identifies the 1928 monetary tightening pursued by the Federal Reserve was potentially a critical factor in the 1929 market collapse. Bernanke and James (1991) find that the impact of the banking panics upon output was considerable around '16 percentage points', hence a major factor. They also identify gaps in the approach as to the investigation of the level of external debt as an additional contributory factor in the transmission mechanism of deflationary policy and subsequent impact upon output. Such research leads to the question of the reasoning behind the pursuit of maintaining the Gold Standard despite the apparent detrimental impact upon the opportunity for a recovery.

Eichengreen and Temin (1997) attempt to explore the reason for the approach of policy makers including governments and central banks in adherence to the restrictions of the Gold Standard. They describe a 'pervasive and compelling' belief amongst the leadership of those nations which was endorsed, through internal discussions. Asserting that 'Central bankers continued to kick the world economy while it was down until it lost consciousness' which is a strong indictment of the strain the policy measure caused. They put forward a concept of institutional 'mentalite' or notional mindset which formed the framework through which the approach to policy making took place. They further assert that the pre-war mentality of thrift and prudence was re-established in the Gold Standard and also was an attempt to assert a 'hegemonic ideology' over the changing nature and role of the workers with an increased voice and presence following the Great War. They mention that the previous structure of the Gold Standard was no longer valid given that workers had improved wage bargaining through union membership and other political mechanisms which included the rise of socialist parties favourable to worker rights. Hence deflationary policy was the only route seemingly open to the policy makers seeking to preserve the status quo. It was also seen as a potential counter to the new socialist parties to implement 'doses of deflation', however market players took this as a signal to enter and resulted in destabilisation. This led to voter dissatisfaction and created a climate of political policy uncertainty. Eichengreen and Temin (1997) further purport that this institutional uncertainty was a global phenom and not restricted to the policy of the Federal Reserve as observed by Friedman and Schwartz (1963). Given the role of Central Bank policy makers acting across international forums was important such as the relationship between Governor Noman of the Bank of England and Benjamin Strong of the New York Federal Reserve.

Strong is quoted as sharing the feelings of Norman in fearing that without a return to the global Gold Standard there would be a period of 'unsettled conditions too serious to really contemplate' across the world.

The role of the countries and the respective Central Banks' at the centre of the Gold Standard System during the pre-war and the early interwar period is depicted by Eichengreen (1995), identifying that to a certain extent the mechanism required a limited amount of government intervention. Such that if 'sterling weakened' there was an influx of capital which anticipated the Bank of England adjusting the 'discount rate', the response of capital flows would hence strengthen sterling and no other intervention was required. The markets anticipated a complete commitment to the parity 'beyond question'. The internal political discourse was before the war in 'no position' to question the merits of the system. These countries are also described by Kindleberger (1986) as being at the Centre of the system such that France and Germany could support farmers with tariff protection should they be threatened with global exporters. The countries at the periphery and before the war this included the United States, faced a disproportionate impact from deflationary policy and hence there was more domestic opposition around the pursuit of the policy.

Eichengreen (1995) further states that cooperation between the Central Banks was required such that in order to maintain the parity they had to be willing to let gold transfer to the US or that the Bank of France was prepared to purchase sterling bills or lend gold to the Bank of England when there was any danger of coming off the parity for example. Eichengreen and Temin (2010) identify that the US remained on the Gold Standard during the war and that the UK and France had to face deflationary pressure in order to re-join the standard due to the changes to prices after the war. They further argue that although Gold flowed to the US, at the high point this amounted to almost 40% of global reserves after the war, there was however only limited scope for 'open market operations' due to the statuary requirements stipulated by the Federal Reserve Act of 1914 which stipulate that notes issued by reserve banks had to hold gold in reserve at 40% of the value. In the UK there was additional post war pressure to reduce wages and the Treasury attempted to promote 'rationalisation' as means of reducing cost rather than wage reduction. According to Eichengreen and Temin (2010) Norman wanted to maintain the pressure on the economy and wages and refused to engage in expansionary policy. Such that in 1925 there was excess gold to allow for an expansionary monetary policy but he was reported to have placed this surplus reserve in a hidden account at the Federal Reserve Bank of New York. They further identify that trade patterns had changed given that during the war there was a standstill to European agriculture. The 'pattern of international settlements' was further complicated by the reparations imposed upon Germany. Hence the return to the pre-war era was intractable given that the balance of trade was altered and also the capital account balances of the European nations had been depleted. Despite the major strain faced in 1931 upon the preserving the parity of Gold, the Macmillan Committee of 1931 (Committee on Finance and Trade) put forward a willingness to consider the implementation of trade tariffs before leaving the Gold Standard, despite the UK having been a proponent of the free trade ideology for the past half century or more.

UK POST WAR POLICIES

Following the end of the war there was a short boom in 1920 during initial transitioning of economies out of war production but then a general downturn occurred. Particularly in the UK Lennard (2018) depicts the significant amount of uncertainty in 1920 this related to the War wealth levy and whether it would continue or be rescinded. There was further political uncertainty through riots in Londonderry relating the question of Irish independence. Then again in 1923 there was the launch of Prime minister Stanley Baldwin renegade on a party pledge for fiscal stability with a 'fiscal revolution' being proposed leading to an early general election and subsequent 'hung parliament'. The uncertainty stabilised with the return to the Gold Standard in 1925 at the pre-war level. However significant events continued to impact upon the level of uncertainty including a potential general strike relating to a 'coal crisis' this continued until 1930 with uncertainty over alterations to the trade protection measure of the Mckenna Duties and the Safeguarding of Industries Act. The figure below depicts the context of days lost during this period in comparison to the 20C for the UK.

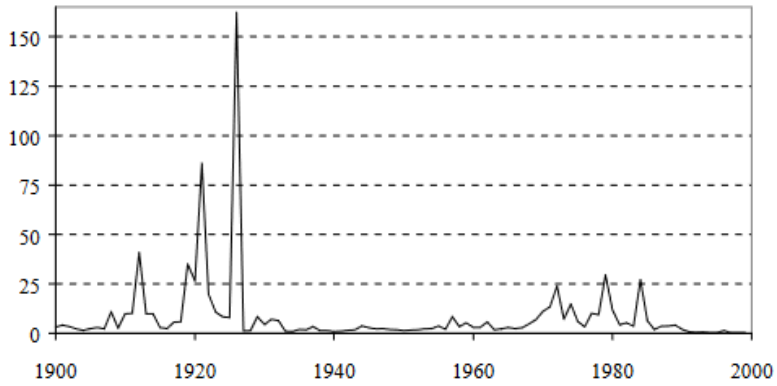


Figure 30: UK - Working Days Lost Through Stoppages (millions) – Hicks and Allen (1999)

In a wider context, following the Treaty of Versailles and the subsequent reparations negotiations Germany entered into a period of high uncertainty with initial significant inflation followed by French occupation of the Ruhr culminating in the hyperinflation of 1923. Following the end of the war and War the 1919 unpegging from gold as depicted by Kunz (1987) there was no longer any anchor currency for world trade Britain had remained unpegged from the Gold Standard until 1925 and the US dollar was not in a position to take the role of sterling.

US FEDERAL RESERVE

Friedman and Schwartz (1963) explore four critical junctures in policy making which compounded the downturn and created a long-term depression. The first which was also identified by Hawtrey (1932) was to link the tightening of monetary policy which led to rising interest rates beginning in early 1928 and extending to October 1929, this is seen as a trigger for the stock market crash. The second key policy occurrence was the policy aimed at defending the dollar against speculative currency attacks in the form of an increase in interest rates during the third quarter of 1931. Friedman and Schwartz (1963) argue that the Federal Reserve was causing the commercial banking sector immense strain. The third was the incoherence of lowering rates

in the first quarter of 1932 only to raise them in the fourth quarter which again led to collapse of credit and hence the wider economy. The fourth point raised was a conflation of the above and wider maltreatment of the domestic commercial banking sector in the US. The Federal Reserve throughout 1930 failed to promote the granting of credit and instead through the monetary policy pursued, actively discouraged recovery of bank lending. The Federal Reserve failed to promote countercyclical policy advocacy and reduced incentives to lend throughout the period by failing to bailout any domestic bank as the lender of last resort in numerous banking panics. Friedman and Schwartz (1963) highlight and then contrast the monetary policy actions of the Federal Reserve through the example of three episodes. During 1920 the discount rate was raised and was followed by a 9% contraction of the money supply, this resulted in a 30% drop in industrial output. The next episode in 1931 the restrictive policy led to a 14% drop in the money supply and 24% decline in output. Finally, policy of the 1937 contraction resulted in a 34% reduction in output. These incidents were identified as the three of the worst six, twelve-month periods for industrial production alongside 1929-31 and 1945, the later was during which the accelerated war time economy transitioned to peace time production.

In response to the monetary hypothesis and arguments against the Federal Reserve, some such as Temin (1977) have argued in regards to the question over whether the quantity of money was endogenously determined rather than exogenously through the policy actions of the Federal Reserve. Another counterpoint to the criticism of the monetary authorities is the perspective of Eichengreen (1992) in which a case is made for the restrictions imposed by the Gold Standard upon the ability of the Federal Reserve to make significant adjustments to the money supply. Although this argument is perhaps somewhat undermined in some respects by the UK policy of exiting the Gold Standard with overall beneficial impact in such that the proceeding period the UK economy fared a lot better than the US. Another counterpoint to such arguments, that in some ways supports a more general monetary hypothesis, despite Friedman and Schwartz (1963) giving it lesser attention, is presented in the work of Romer (1991). Here identification is made of the linkage between the expansion of the monetary supply being linked with the recovery in later part of the 1930s. Bernanke (1994) puts forward the case for the role of monetary policy with the global context of the Gold Standard which is supported through the research undertaken by Bernanke and James (1991) and Hamilton (1988). Here clear identification is made with the case that countries that left the Gold Standard were able to reflate their economies, those that remained pegged to Gold, suffered from further deflation.

In addition, the work of Bernanke (1983b) supports certain aspects of the Friedman and Schwartz (1963) hypothesis ,in particular regard to the adverse impact that the instability had upon the bank sector. Which in turn led to a rise in the cost of credit granting activity and resulted in reduction in the quantity of credit being granted, this led to a reduction in overall demand. The lack of aggregate demand then stifled any prospect of a sustained recovery. Snowden (2014) extends the analysis of monetary factors into the role of unbalanced credit expansion into one sector which entails technological advance but another sector of the economy lags

behind and the resulting imbalance leads to structural affects and hence authorities need to aware of the credit allocation that is occurring during a boom.

Financial frictions

The role of financial frictions, credit and bank failure splayed a significant part of US uncertainty during the most recent and past periods, the collapse of mortgage lending in the most recent crisis is well documented such as Shiller (2009). Bernanke (1983b) explores the role of credit availability in prolonging the depression, in a study of the impact 1930s of financial crisis upon output at the aggregate level. Furthermore, Bernanke (1983a) identifies that the cost of credit intermediation can explain the link between investment outlay and uncertainty shocks. The case put forward by Bernanke (1983b) is that the instability between 1930-1933 had an adverse impact upon the process of credit granting, in turn made the cost of credit was increased which reduced the allocation of credit in the wider economy and leading to lower demand overall. This perspective advances upon the work of Friedman and Schwarz (1963) which advocated the role of monetary shock and the weakness of Federal Reserve policy in extending the depression through inadequate countercyclical measure to prevent deflation. Friedman's main hypothesis was to argue that the money supply should have been expanded at the central level whereas Bernanke (1983b) consider the transmission mechanism of bank lending as a major hindrance to advancement of aggregate demand. The countries arguably most significantly impacted were the once with the largest banking collapses Germany and Austria faced significant difficulties. Mishkin (1978) furthers explores the ole of household 'balance sheets' as an important factor which led to the reduction of aggregate demand. Mishkin argues that the combination of the difficulties faced by households with indebtedness in combination with the broader adversity faced by financial markets contributed to the duration of the Great Depression.

Although as depicted earlier there is an increase in analysis within the literature which explores the post war period in relation to crises, policy uncertainty and bank credit. There is however a dearth of literature which explores the interwar period in relation to bank credit and economic policy uncertainty, Bordo and Haubrich (2009) as well as Bordo and Haubrich (2012) contains aspects of US historical interwar period analysis in relation to bank lending and crises but without any particular focus upon to policy uncertainty nor a quantitative empirical investigation into this aspect. Bordo and Haubrich (2010) consider a period from 1875 until 2007 for the US economy and attempt to develop an innovative framework to explore the level to which bank lending 'distress' is attributable to 'monetary policy' and the relative impact upon the economy. This is undertaken with documentation of a 'historical narrative' of events in combination with econometric analysis. The approach utilises 'turning points' of the Harding Pagan algorithm to explore 'co-movements' in cycle episodes relating to monetary policy, bank lending and production through analysis of the 'timing, duration and amplitude' of the co-movements. The results of the study are supported by the later finding of other work relating to post war bank credit and the economic policy uncertainty index. Bordo and Haubrich (2010) find that in this period since 1875 until 2007 the credit contractions due to 'financial distress' had an adverse

impact on the downward turn of a 'regular' business cycle but in particular that a more severe recessionary period is extenuated with such incidences occluding in combination with the other factors.

Zarnowitz (1992) explore recovery trends during recessions with banking panics and finds such downturns are 'typically' more severe than those without significant banking disruption but further the recovery should also be accelerated in comparison of those without. The Great Depression and Great Recession were both incidences in which there was a significant banking distress however in both circumstance the recovery was very slow to materialise. Bordo and Haubrich (2012) explore 27 economic crises in the US from 1882 until the most recent financial crisis and find comparable results. As Friedman (1969) states 'a large contraction in output tends to be followed on the average by a large business expansion' and 'a mild contraction, by a mild expansion', and hence the interest in identifying the extenuating circumstance surrounding the circumstances of the 1930s period and the post 2007 recovery lags. Bordo and Hubrich (2012) find potential to attribute the slow recovery as down to the residential market disruption as an additional factor. In addition they also consider the ineffectual nature of the monetary policy approach with inter rates close to lower bound and quantitative easing attempting to flatten the yield curve for a longer period. Choudhry (2018) explores the role of economic policy uncertainty and house prices for selected regions of the UK, finding a negative impact of more uncertainty over long and short time periods. Hence the uncertainty element is a potential additional explanatory variable to this work on explaining part of the extenuation of both the great recession and great depression in confluence with other factors such as bank credit.

Level 5 - Trade episodes

The trade dynamics in this period have also been given a considerable role in the accentuation of the depression. In particular the role of agricultural trade has been highlighted as a major factor in the onset and deepening of the crisis. Of relevance is the research focus upon the changing dynamic for the US trade patterns, which has been given considerable treatment within the literature. The US had benefited from the opportunity during the war in agricultural production and further the decline of UK exports, since 1913, US industrial production had risen by 75%, according to Kindleberger (1986). However the farm sector was increasingly at risk as Temin (1993) states that for the US after the war 'agriculture had gone from prosperity to poverty' and this has been attributed to the oversupply and subsequent fall in agricultural prices forcing many US farmers into difficulty and reliance upon debt during the mid to late 1920's. Federico (2005) identifies that technological progress had increased supply but demand had slowed in the 1920s and hence there was a long-term problem. Kindleberger (1986) indicates that the long run deflationary pressure on agricultural prices meant that farmers were 'highly vulnerable' to even a mild reduction in prices. In 1929, 29% of fam income was reliant upon exports and prices had fallen by 30% between 1920 and 1929. According to UN statistics (1962) agriculture contracted to more than 50% of exports from the US hence the downward pressure on prices and general lack of demand meant that the 1929 crash put the sector under significant pressure. James (2009) identifies that had pre-war trade trajectories continued, US exports overall should have been 20%

higher by 1929, hence after the crash any further reduction in trade would have been very harmful to the US economy. Irwin (1998) identifies the imposition of the Smoot-Hawley Act of 1930 combined with a 50% reduction in prices, this severely deepened the crisis for US framers and the wider economy. The trade tariff policy was a highly significant issue and is given further consideration in the later chapter 4.

James (2009) identifies the significance of bilateral trade agreements as depicted below.

Increase of bilateral trade -1929-1935 (%)	1929	1931	1932	1933	1934	1935
Bilateral merchandise trade	71.7	68.1	69.4	71.3	71.9	74.2
Balances of total merchandise trade	9.9	16.4	15.6	14.4	13.0	12.0
Triangular merchandise trade	18.4	15.5	15.0	14.3	15.1	13.8

Figure 31: League of Nations, Review of World Trade, 1935 (based on James 2009)

PRE-WAR – GLOBAL TRADE DYNAMICS FOR TRADE WITH US AND GERMAN RISING PRODUCTIVITY

Towards the end of the 19th Century as shown by Irwin (2002) and Brechling and Lipsey (1963) there was a rapid acceleration of US exports, sometimes depicted by Europeans as the 'American Commercial Invasion'. Irwin (2002) depicts that from the 1850s until around 1940 US exports were predominantly in the agricultural or raw materials sector however from around 1895 there was a rapid increase in manufacturing and export of steel and other manufactured products. Broadberry (1997) highlights the significance of resources allocation and domestic demand homogeneity as one explanation for the US ability to increase productivity through mass production methods, Germany and Britain had more differentiated markets and resource availability which led to reliance upon labour skills than machinery. Broadberry (1997) goes further to state that post 1870 Britain began to focus on the British Empire (later Commonwealth) due to the rise of German exports with a focus on Europe and the US focus on North America, hence some of the international competition was segmented. Abramovitz and David (1996) highlight US access to a wealth of mineral resources as a key reason for rise in productivity but also note that there was a 43% average increase in growth rate of exports relative to GDP in continental Europe between 1870 to 1913. Britain remained the leading exporter until the war.

FLUCTUATIONS IN TRADE CAUSED BY THE WAR (UK LOSS OF MARKETS AND GERMAN LOSS OF MARKETS)

The outbreak of war put a short initial strain on international trade as the belligerents were now geared towards war time production, as Lockwood (2015) explores countries such as Japan benefited from increased demand such as through cotton exports rising 185% between 1913 and 1919. Also, with demand for other war related goods Japan went from a current account deficit to surplus. Rockoff (2004) also finds that the US staved off a recessionary trend through demand from Europe following the outbreak of the war. In contrast UK and Germany lost export markets and investments. Horsewood, Sen and Voicu (2010) show that pre-war UK had 14% of world exports by 1929 this had declined to 11% further pre-war the UK held 45% of the world foreign investment, Post war the UK has 'consistent, structural and long term deficits in merchandise trade'. Allen (1979) notes that the UK fell into third place in steel production by 1914 behind the US and Germany.

Indicatively with calculations based on the Statistical Office UN (1962) world trade data, there is an apparent fall in UK share (including reexports):

- 1900
  - UK exports 18% of global exports
  - German exports 11% of global exports
  - US exports 14% of global exports
- 1913
  - UK exports 16% of global exports
  - German exports 12% of global exports
  - US exports 13% of global exports

However, the outbreak of war had reduced German reach to wider export markets severely. US exports in agriculture were favourable during the war with a significant boom in demand from Europe but over the course the interwar period with European recovery in production there was significant declining trend in demand as explained by Kindleberger (1987).

UNCERTAINTY FOR UK TRADE DURING THIS PERIOD

The UK faced a range of uncertainties in regard to overseas trade and investment on the post war period and the below outlines some of the areas of uncertainty which could lead to a detrimental impact of firms engaged in trading activity in relation to Europe and Eastern Europe in particular.

Key areas of uncertainty:

1. Nostrification – many states in Eastern Europe were being granted autonomous rule following the collapse of the Austro-Hungarian Empire such as Czech regions, Hungary. Yugoslav regions etc. with potential new regulations disrupt business activity
2. Enemy Trading Act – limitation of receiving governmental support in recently independent or nostrified sates – the trade was still seen to be linked with a former sate enemy hence the government was non-committal to proposal in making any direct intervention
3. Treaty of Versailles and Treaty of St Germain – opportunity to advance UK trade without German competition however some aspects of the Treaties were ambiguous hence open to interpretation…
4. US influence in Europe - Europe was in debt to the UK but UK was in debt to US
5. Rationalization – decline in productivity and threat of US competition in manufacturing/German recovery…
6. Trade rivals - French industrial firms and US financial firms - competition
7. Political instability - threatening trade routes through Europe to Middle East regions of the Ottoman Empire and Persia
8. Currency devaluation – Austrian Krona depreciation was a typical example of the decline in value of currencies in Europe proceeding the war which could jeopardise firms with assets or linkages to the respective branches in foreign banks

9. Trade displacement - for example war disruption to Textiles exports with Japanese firms taking over British export destinations
10. Gold standard – decision to re-join uncertainty over valuation of Sterling

TARIFFS AND SMOOT HAWLEY ACT

The Smoot Hawley Act of 1930 was a significant factor that has been subject to subsequent scrutiny in the literature. The below charts depict the dramatic shifts in tariffs that occurred within this period.

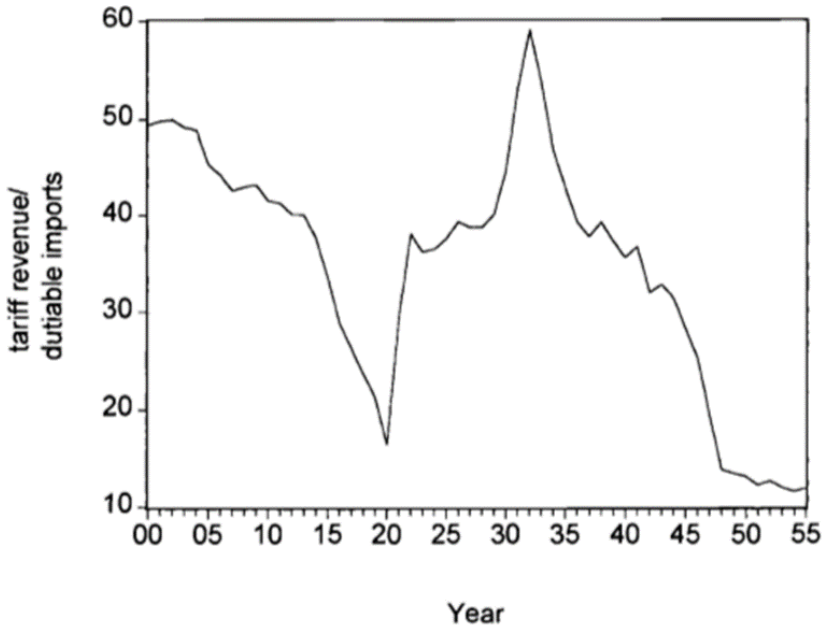


Figure 32: US Average Ad valorem tariff by Year, 1900-55 (US Department of Commerce's 1975)

The chart shows that up until the end of the first world war trade barriers had fallen sufficiently and this was accompanied with an increase in supplies of materials from the US to Europe. Over the 1920's period there was a gradual increase in tariff's but the major spike of protectionism following the passage of the Smoot Hawley Act of 1930 and in the subsequent period. The proceeding tariffs that were applied perhaps in retribution by other former significant trade partners such as in Canada and also parts of Europe escalated the global decline in trade. The US Republican administration had introduced the Emergency Tariff Act of 1921 and the Fordney-McCumber tariff of 1922. They felt this was necessary to protect home industry from European rivals recovering and expanding following the war. This was according to Irwin (1998) seen as abhorrent for the agricultural sector and a vast community of farmers petitioned President Hoover to rescind the passage of the Act. The drop in imports could be attributed to the passage of the act but Irwin (1998) questions the process of the dramatic fall in exports. This could be attributed to the retaliation which Jones (1934) identifies was directly visible from the actions of 'Canada, Spain and Switzerland'. Although Eichengreen (1989) argues that such barriers would have been erected regardless of US actions. The League Nations (1933) identifies the act as a 'signal' for 'reprisals' hence there is certainly a strong case that the act bought about a more dramatic rise in trade barriers than would have been expected had the act been altered or prevented

from passing into law, as the US agricultural sector had requested. Irwin and Krosner (1996) analyse Senate voting rolls to identify the political vested interests for which the passing of the act was seen as naturally within their benefit. Archibald and Feldman (1998) identify that the passage of the act led to a high degree of uncertainty for business and 'depressed investment' which could have therefore contributed to the prolongation of the downward spiral triggered by the 1929 Stock Market Crash and financial crisis which occurred thereafter.

	Equivalent ad valorem rates	
Product	Fordney-McCumber	Smoot-Hawley
Chemicals	29.72%	36.09%
Earthenware, and Glass	48.71	53.73
Metals	33.95	35.08
Wood	24.78	11.73
Sugar	67.85	77.21
Tobacco	63.09	64.78
Agricultural Products	22.71	35.07
Spirits and Wines	38.83	47.44
Cotton Manufactures	40.27	46.42
Flax, Hemp, and Jute	18.16	19.14
Wool and Manufactures	49.54	59.83
Silk Manufactures	56.56	59.13
Rayon Manufactures	52.33	53.62
Paper and Books	24.74	26.06
Sundries	36.97	28.45
Total	**38.48**	**41.14**

Figure 33: US Ad-valorem (U.S. Tariff Commission, The Tariff Review, July 1930)

Bond et al (2013) use microeconomic data to construct a 'truer' model of the impact of the act and find that it had an impact much greater than erstwhile reported. The average tariff rate of 46%, which is reported actually, had a cumulative impact upon the economy of 70% 'uniform tariff' rate. Hence Bond et al (2013) argue the subsequent impact was greater than commentators have subsequently reported as shown by the above chart which shows the value of around 40%. This is supported in the work of researchers such as Meltzer (1976) along with Crucini and Kahn (1996) both identify the dramatic increase in import tariffs on a global level as a significant detrimental factor in the continuation of the depression.

Comparison between episode clusters and fluctuations of uncertainty (especially various components)

The tables below compare the episode clusters highlighted through the above review of the historical narrative and fluctuations in the cycle component of the EPU indices for the UK and US respectively. They indicate the impact of historical episodes clusters upon the spikes in the time series components and hence the potential impact upon the fluctuations.

UK EPU fluctuations

UK Uncertainty fluctuations					
EPU Shocks / spikes	**Historical episodes**				
	L1 -> global episodes	**L2 -> global policies**	**L3 -> local episodes**	**L4 -> local policies**	**L5 -> trade episodes**
Jun-20	Spanish Flu	Treaty of Versailles	'Rationalisation' and export disruption	War levy	Post war trade shifts
May-21					
Aug-21					
Jul-23	International investment dynamics & Post war rebuild				
Nov-23				PM Baldwin U-turn/Election	
Feb-24					
Mar-24					
Jul-Sep 24		Dawes Plan - Aug 1924			
Apr-26			Bank lending constraints	Return to Gold standard	
Jul-Oct 26			Miners strikes		
Jun-29					
Aug-29		Young Plan - Aug 1929 & started 1928			
Sep-29	Great crash - Oct 1929		Hatry crisis - Sep 1928		
Feb-30				Budget	
Jul-Dec 30		Smoot-Hawley - Jun 1930			Smoot-Hawley - Jun 1930
May-31	Credit Anstalt - May 1931				
Sep-31				Strike/Election/Gold Standard	
Apr-32				Budget setting	
Dec-32				War Debts to US	
Apr-33				Budget - Mar 1933	
Apr-37				Budget	
Jul-Oct 37	European Political & Gold scare				
Mar-38		Munich Agreement			
Sep-38	Anschluss				

Figure 34: UK historical episode clusters

US EPU fluctuations

US Uncertainty fluctuations					
EPU Shocks / spikes	Historical episodes				
	L1 -> global episodes	L2 -> global policies	L3 -> local episodes	L4 -> local policies	L5 -> trade episodes
Mar-20	Spanish Flu	Treaty of Versailles	Recession 1918-19		Post war trade shifts
Jun-21			Recession 1920-21		
Jul-21					
Sep-22				Fordeny-McCumber - Sept 1922	
Jul-24		Dawes Plan - Aug 1924	Recession 1923-24		
Jun-26	UK Gold standard Apr 1926				
Aug-29		Young Plan - Aug 1929 & started 1930			
Oct-29	Hatry crisis - Sep 1929		Stock crash - Oct 1929		
Feb-30	Great Depression				
Jun-30				Smoot-Hawley - Jun 1930	
Nov-30	UK Exit Gold standard - Sep 1930				
Dec-30			First Banking Crisis - Nov-Dec 1930		
			Second banking crisis - Apr-Aug 1931		
	Credit Anstalt - May 1931				
Sep-31			Third banking crisis Sep-Oct 1931		
Mar-Oct 32			Fourth banking crisis Jun-Jul 1932		
				Bonus Army crisis - Jul 1932	
Nov-32	UK war debts to US - Dec 1932			FDR election - Nov 1932	
				National Recovery Agency - Jun 1933	
Dec-33				US gold standard exit - Mar 1933 - Jun 1934	
Jul-35				Wagner Act - Jul 1935	
				Social Security Act - Aug 1935	
Aug-35				Wealth Tax - Aug 1935	
				Undistributed Profits Tax - Mar 1936	
Dec-36			Flint sit-down strike - Dec 1936 - Feb 1937		
May-37	European Political & Gold scare - Jun 1937		FDR court packing plan - Feb-Jul 1937		
May-37			'Mistake of 1937' Monetary policy - May 37 - Feb 38		
Oct-37	Quarantine speech - Oct 1937		Quarantine speech - Oct 1937		
	Panay incident - Dec 1937		Panay incident - Dec 1937		
Mar-38	Munich Agreement - Mar 1938				
Sep-38	Anschluss - Sep 1938				

Figure 35: US historical episode clusters

h. Concluding remarks

This chapter makes comparisons between interwar historical episode clusters and fluctuations in uncertainty, especially various components. This is supplementary to the existing literature and theories of crises, of which in particular relation to the 1920-40 period which encompasses significant fluctuations for the US during the great depression, and less severe but still significant fluctuations for the UK which suffered less uncertainty in the 1930s but had slightly more uncertainty and relatively significant episode clusters in the 1920s.

Overall it is apparent that significant historical episode clusters can be linked with the fluctuations in the economies of the US and UK during the interwar period. The application of the economic policy uncertainty index could hence be applied in a number of further directions. The following chapters consider the application of the EPU index to the investigation of business cycle fluctuations and also with regard to potential explanations for the severity of the US depression as well as spill over effects.

Chapter 3: US and UK Interwar business cycles and uncertainty

History doesn't repeat itself, but it does rhyme.

Mark Twain, reputed

a. Introduction

Economic fluctuations and uncertainty

The following chapter explores the empirical relationship between uncertainty and the business cycle of the UK and US. Following the prior chapters in which the literature and theoretical basis for the relevance of uncertainty to economic fluctuations was considered which utilises the narrative identification of historical episode clusters with fluctuations in components of uncertainty. Here two particular aspects are considered, firstly the relevance of economic policy uncertainty is considered in relation to whether it is applicable as an explanatory variable for changes to GDP for the US and the UK respectively during the interwar period utilising the general to specific model selection approach akin to the approach of Hoover and Perez (1999). Secondly consideration is given as to whether there is the potential for spill over as analysed using Granger causality methods, between economic policy uncertainty and the business cycle of the UK and the US again during the interwar period, as per the approach of Choudhry et al (2020) both linear and non-linear causality is considered.

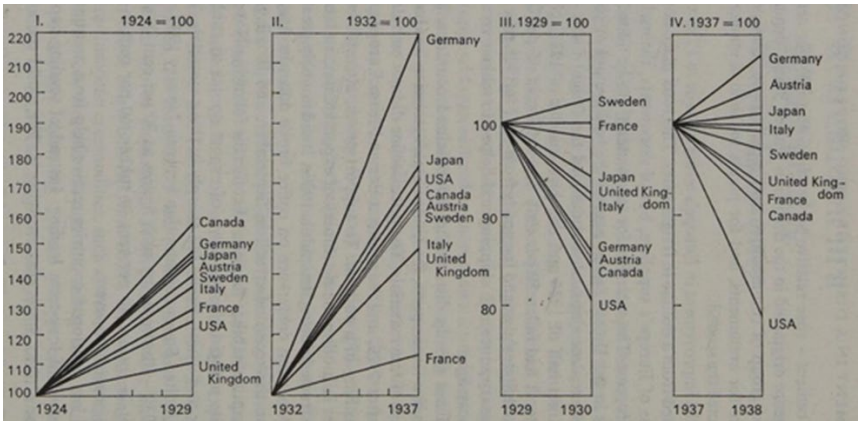


Figure 36: Changes in industrial production, 1924 to 1938 (Kindleberger 1987)

The chart above shows that there were significant fluctuations and shifts in output during this period when considering a global macro perspective. Hence the relevance of the proceeding analysis.

The literature upon crises highlighted the role of sectoral imbalances as an underlying causal factor in the 1930's depression hence initially consideration is given to the sectoral composition of the US and UK economy using descriptive data upon the matter. Then an overview is provided of the most relevant explanatory factors for GDP and potential role of economic policy uncertainty within the literature, as considered as relevant components of the GUM, general unrestricted model. Following this the modelling set up and data analysis of

results is presented. The general to specific methodology as followed by Hoover and Perez (1999) is favourable approach to identifying the most relevant variables given that the data generating process is unknown.

Business Cycles and Uncertainty

As discussed in Chapter 2 and Chapter 4 as well as being espoused empirically and in relation to the existing literature by Bloom (2009) uncertainty may have potential influenced causal impact in relation to economic fluctuations. Such as may be experienced in the business cycles of countries when experiencing specific shocks or increasing levels of uncertainty relation to economic policies or political factors such as elections as well as other exogenous events such as natural disasters and wars. Within the literature the work of Claessens et al (2012) finds a that output has a 'negative correlation' with macroeconomic uncertainty and further the evidence of the 'robust negative' impact of uncertainty upon the economic output in the research of Caldara et al (2016). Hence the following chapter considers the potential for the existence of a causal relationship to exist between uncertainty components and the business cycles of the US and UK respectively during the interwar period.

Spill over theory and uncertainty relationship

As discussed previously, in which the role of uncertainty was identified in impacting macroeconomic variables including output. Following this the work of Sum (2013) finds that there is a long-term equilibrium relationship between US economic policy uncertainty and European uncertainties. Combined with the studies upon the negative impact upon the activity of economic agents such as indicated by Caldara et al (2016), this highlights the relevance of exploring the potential for spill over from a major economy to other related economies. The work of Choudhry et al (2020) considers the spill over of US economic policy uncertainty upon European economies at the country level post 1991 finding a significant causal impact. In addition, Colombo (2013) explores the impact of uncertainty more broadly upon the overall block. Overall, the existing spill over literature has focused upon the impact upon other macroeconomic variables or financial markets, Bloom (2016) provides an overview of this literature. However, there is a significant dearth of studies concerning uncertainty spill over during the interwar period, which is addressed here. In relation to the current theories and literature upon the spill over effects an outline is presented below.

b. Literature review

Business Cycle theories

There are a range of theories of business cycles which consider the short run cycles which may be typical to occur over a period of ten years, in such cycles the speed of the drop in output is accompanied with an equally rapid rise. A so called 'V' shape recovery is usually expected to occur, this was not seen during the latter half of interwar period with the rapid drop off in output and trade post 1929, there was no rapid recovery forthcoming especially seen in the trajectory of output in the US which did not recover until the outset of war post 1939.

Real business cycle (RBC)

A development of the business cycle theories has been termed the 'real business cycle' theory as developed in the work of Kydland and Prescott (1982) in which a model was developed that built upon pre-existing growth models and business cycle theories. Such that the fluctuations to employment are given relevance with additional significance given to the requirements of capital good production. Here 'multiple time' periods are needed for a finite capital good to be produced and as such only on completion are they of relevance to the 'productive capital' stock of goods. Hence the delay in completion of capital goods can lead to fluctuations in the measured output. Alongside this aspect consumer preferences are also given prominence such as also explored by Long and Plosser (1983). In their analysis they consider consumer preference for goods and leisure to be 'allocated' for future consumption of all such goods such that 'incremental' savings are preassigned. The limiting factor depicted is the 'production possibility' and any such physical limits upon the production of goods are reflected within prices. So that production of any goods is dependent on a variety of inputs which leads several possibilities of production and usage of the inputs. So that the overlap view is that 'persistence and comovement' in output fluctuation sis identifiable with consumer preferences across all goods and leisure such that there option to consume more or less of a good which may become available in an increase in supply quantity due to technology or some other production possibility, hence this leads to changes to output.

Such models have relative explanatory power but are predicated on a number of assumptions which lack empirical validity such as complete information; rational expectations; no government policies; no serial dependence in the 'stochastic elements of the environment'; no adjustment costs; no technological change; stable preferences; no financial fiction. All of these elements are contrary to the empirical evidence of disruption surrounding significant shocks which generate uncertainty and as such they are unable to adequately explain the large fluctuation and disruption in outputs experienced during the interwar period and also in subsequent disruption of the 1970s and 2009 Great Recession for example. McCallum (1988) provides an indication of some of these shortcomings which include the deficit of any of the shocks occurring to the system being explained due to policy or import price adjustment and also the role of frictions being particularly relevant in considering the interwar period.

Minsky Hypothesis

Minsky (1982) put forward a hypothesis related to the instability of finance generating real economic crises, such that there are three levels to the process of instability and the spill over to economic output being realised through a significant drop in output and welfare. The development of the financial instability hypothesis formerly stated by Minsky (1992) gave credence to the empirical and theoretical notion that an economy can experience deflations and inflations that become self-perpetuating which is in contrast to classical theories of the economy which is regarded as being an 'equilibrium seeking' system. Instead an economy displays disequilibrium tendencies, and these relate to the nature of the economy evolving due to 'capital development' such that the financing of such future development can hence influence the output stability. Three types of entities which utilise finance for 'real' capital development are identified. They include hedge

financing; speculative financing and Ponzi financing each of these as an operating mechanism in relation to the production of real goods. Hedge finance are depicted as 'units' or firms able to fulfil contractual obligation from the self-derived cash flows and typically have a substance equity component. In contrast speculative units are those which may be able to meet an element of payment on 'income account' such that debt must be rolled over continuously as the loan principle for example is not serviceable from these incoming cash flows. Ponzi financing units are those which must continuously borrow to service existing debt obligations or otherwise sell assets to pay the interest component of the debt servicing costs.

The Minsky (1992) financial instability hypothesis has two main theorems the first is that an economy has 'financial regimes' which can make it stable or unstable. Such as having predominantly hedge financing units there is stability expected whereas a regime with speculative and Ponzi financing units there is an expectation of instability. The second theorem is that economy which experiences a long period of prosperity then an endogenous 'transition' may occur in which the financial regimes may tend towards on in which an unstable system evolves. The theory postulates that during the transition of the economy, agents experience 'prolonged prosperity' an increase in speculative and Ponzi units occurs. When this occurs during an deflationary period and p[policy makers attempt to curb the inflation with a contractionary monetary policy. The speculative units inevitably become the equivalent to Ponzi and any formerly Ponzi units are unviable, hence they 'disappear' as entities. The monetary contraction leads to an asset value 'collapse' due to the 'units' with illiquidity attempting to sell assets making position by selling position' which may explain the rapid fall in prices experienced during a downturn.

The key differentiating factor amongst many other theories of fluctuation is the endogenous nature of the formation of the business cycle. Whereas many theories indicate exogenous shocks generate the fluctuations, Minsky (1992) finds that:

a. 'internal dynamics' of the economy including those which led to the transition of the financial regime which permeates more speculation and,
b. Policy making objectives/interventions' combine to induce the occurrence of fluctuations

Balance sheet recession

The 'Zarnowitz rule' was developed from the work of Zarnowitz (1984), which postulated that a downturn which occurs following a large drop in output in general with result in a 'steep' recovery. Further the notion of a balance sheet recession has also been established, this postulates that during a downturn many firms require a period of repair to the balance sheet during which the liabilities are paid down and the overall position of the firm improves. This has been taken further by Koo (2011) as explanation for the time taken for a recovery to occur based on perceived events in Japan during the 'lost decade' and inferences regarding the Great Recession. The viewpoint of Koo (2011) is that the slower the process of balance sheet repair the more gradual the recovery. This perspective has been questioned especially in relation to sever recessions such as during

the interwar period, by Greenwald et al (2012) as well as given that many firms post the Great Recession were actually able to build cash reserves but despite the 'repaired' balance sheet and lowering of liabilities there was no recovery in investment and output forth coming.

This contrasts with the early post war literature which incorporated a wider spectrum of analysis and the work of Polanyi (1944) considers combining the notion of the transformation of the economy with aspects of policy and political motivation. There was also awareness of the impact of the financial sector upon the economy and the fragility of capitalism which can lead to the formation of cycles as espoused in the work of Kondratiev (1925). The work of Mill (1909) has been prominent in the depiction of the tendency of capitalist profits to fall and induce crisis. Other more politically motivated studies of the economy such as Marx (1976) apply a fundamental critique of capitalism and this work further highlights such aspects as profit collapses as being endemic failures, hence proposing alternative systems. Boulding (1945) is another contributor in the early post war period that noted stability was related to maintaining the balance of demand in relation to the growth of output. Arrighi (1978) highlighted another aspect of wages being a significant factor in reducing profits and hence wage rises leading to potential crises. Furthermore, Kalecki (1937) notes that investment is critical in the prevention of deflation during a transitionary period between economic cycles.

Secular stagnation hypothesis

In the midst of the slow recovery from the Great Depression some observers such as Hansen (1938) precluded that due to factors relating to the limitations in the supply of core factor endowments and labour there was no further potential for an acceleration or even long term growth in the US economy. This was perceived to be a point of 'secular stagnation' from which any applications of policy stimulus including monetary would be ineffectual due to the underlying constraints upon resources or the inputs of production. Backhouse and Boianovsky (2016) depict that this depiction although clearly unsubstantiated given the post war recovery in the US and Europe has been revived during periods of unexpected falls in output such as during the great Recession. Summers (2013) raised such a proposition as well as the Economist (2015) "describe what he feared was the fate of the American economy following the Great Depression of the early 1930s: a check to economic progress as investment opportunities were stunted by the closing of the frontier and the collapse of immigration". Such a perspective has been empirically demonstrated to be unfounded as explanation for the long duration or 'unexpected' occurrence of a downturn such as the great recession of great Depression. Hence a consideration of more empirically grounded explanations and contributory factors is required to gain a clearer perspective of the dramatic fall in output and slow burning nature of recovery experienced during the interwar period.

Spill over theory and uncertainty relationship

Spill over to macroeconomic variables

There have a number of studies which consider the impact that a major event or economic shock to a major economy can have spill over effects to the financial markets and macroeconomic variables of other economies. For the post 1945 period the US economy has emerged as a clear 'leading economy' and as such a number of studies have identified the way shocks that disrupt the US economic activity can have a spill over upon other economies this includes the work of Ehrmann and Fratzscher (2009) in which the transmission of US monetary shocks is considered on a global financial level. Favero and Giavazzi (2008) find evidence to show that long term European interest rates are explained by US shocks. As well as that innovations to US macaronic and financial variables are more relevant than innovations in Europe area variables in relation to the response of European monetary policy. During the interwar period the two leading economies were the UK and the US hence the following analysis consider the potential for spill over of uncertainty from these economies may have had on each other as well as upon the economies of other major trading partners here consideration is given to that of the economies of France and Germany. Such a study has a study provides an extension of the more recent studies upon the spill over of US uncertainty into the European economies.

Theories and empirical studies of global transmission of shocks

There is considerable empirical evidence to show that a major economy such as the US can transmit domestic shocks to other economies, the work of Diebold and Yilmaz (2013) finds significance for this occurrence. There are also ways in which the US economy can influence growth in other economies such as through trade linkages which found to be a significant channel of growth transmission by the work of Arora and Vamvakidis (2004). Given that shock or interruptions to US import demand can determine fluctuations in output in other economies which directly or indirectly export goods which are traded to the US. Choudhry et al (2020) identify the role that direct or portfolio investments can have a significant influence upon the financial flows on a global level such that FDI (foreign direct investment) changes may also have a potential impact upon on financial interlinkages which can then transmit shocks from one economy to another. There is evidence of the transmission of business cycles in the work of Billio et al (2016) as well as shocks to US uncertainty impacting economic output in other economies within the work of Jones and Olson (2015). Another mechanism for the transmission is the level of 'financial integration' and the role of agent behaviour during times of crises such as the propensity to follow the herd which can cause domestic shock to become global, with contagion and a potential 'common lender effect' identified by Apostolakis and Papadopoulos (2014). Such that there is spill over from a 'financial shock or stress' and economic uncertainty in one country to another.

c. Research gaps and contributions

Hence this chapter considers the following principle questions which are so far not considered for the duration of the 1920-40 period for the UK and US:

i. *Is policy uncertainty as measured through the EPU index a relevant explanatory variable for UK business cycle fluctuations in the interwar period*?
ii. *Is policy uncertainty as measured through the EPU index a relevant explanatory variable for UK business cycle fluctuations in the interwar period*?
iii. *Did UK economic uncertainty cause the economic activities of the major global economies of the interwar period, namely the US, France, and Germany*?
iv. *Did US economic uncertainty cause the economic activities of the major global economies of the interwar period, namely the UK, France, and Germany*?

The empirical analysis of uncertainty presented below in considering the above principle questions, involves three aspects of particular analysis for each question respectively. The first is to consider whether the causal relationship between UK (US) policy uncertainty and the business cycles (for which industrial production growth is used as a representation) of the US (UK), France and Germany. This is based on monthly data for the period between January 1920 and December 1938, and in relation to Germany for January 1920 to December 1935, due to the limitations of data availability. The potential causal relationship is based upon the 'interdependence and integration' as indicated by Choudhry et al (2020) that existed between these countries in particular relation to financial flows, investments and trade. The second aspect relates to considering the potential nonlinearity of the causal relationship. Nonlinearity has been considered in the work of Hiemstra and Jones (1994), Shiller (2005) as well as Shin et al (2014). So here nonlinearity causality testing employed to investigate this aspect in relation to uncertainty and causal relation to business cycle spill over. Third the impact of the US great depression post the 1929 Stock market crash, in relation to the UK the 1926 return to the Gold Standard as well as the 1931 departure from Gold which occurred around the time of the 1931 Credit Anstalt crisis. Hence some empirical investigation is undertaken to ascertain whether the acute escalation of uncertainty relating to 1929 crash had implication upon an increase in spill over upon the other major economic business cycles. As well as whether major spike in uncertainty for the UK which occurred during 1926 and in 1931 also had a greater spill over impact on the business cycle of the other major economies considered.

d. Methodology

GETS/Hendry/LSE method

The benefits to utilising empirical research methods as opposed to 'purely' theoretical approaches is perhaps very well demonstrated through the general to specific methodology, within the field of econometrics also known as the LSE or Hendry method. The way the LSE method was developed provides some insight into the applicability of this approach to answering an array of economic questions, Popper (1963) had put forward a notion that the real world or real economy is often in a state of 'disequilibrium' and hence as opposed to merely applying this data to theories based on a state of equilibrium the empirical aim should be to find the

dynamic aspects through both an exploration of the data and the theoretical underpinnings. As Rao (2007) and Rao et al (2008) point out the method developed by Sargan (1964) at the LSE built upon an aspect of the error correction model of Phillips (1957). This has overtime been further refined with the work of Hendry and Mirzon (1978) into a formal approach known as the general to specific method (GETS). This empirical approach to economic analysis of quantitative data requires the application of theory to establish a general unrestricted model as an estimation of the erstwhile unknown data generating process, Hendry and Krolzing (2004). In order to ascertain the accuracy of the general unrestricted model there is a procedure to check that it contains a form of the 'true' model of the data generating process then further analysis such as the calculation of the F-statistic is used to restrict the model into a parsimonious form.

Synopsis of the approach

A generic example of the modelling approach has been provided in Hendry and Nielsen (2007) in which there is a potential model with a 'large' number of potential explanatory variables, N , with the proposed 'general linear model' of:

$$Y_t = \sum_{i=1}^{N} \gamma_i Z_{i,t} + u_t$$

Eq. 3.d.1: general linear model (based on Hendry and Nielsen 2007)

hence the 'conditional data-generating equation' is 'nested' in the above as:

$$Y_t = \sum_{j=1}^{N} \beta_j Z_{(j),t} + \varepsilon_t$$

Eq. 3.d.2: conditional data-generating equation (based on Hendry and Nielsen 2007)

for which $\varepsilon_t \triangleq \mathrm{IN}\,[0, \sigma_\epsilon^2]$, distributed independently for all of the $\{Z_{i,\,t}\}$ for $n \leq N$. The variables of interest are denoted by $Z_{(j),t}$ these are the variables which are to be determined through the GETS approach. Essentially the GETS procedure seeks to identify the most relevant regressors which can be defined as: n different $Z_{(j),t}$ where $\beta_j \neq 0$ and therefore remove the 'irrelevant regressors', the $N - n$.

As a priori all N are initially considered to be of potential relevance. Hence the procedure aims to find a reduced form of the data generating equation with m variables. Such that the aim is to find the:

$$Y_t = \sum_{r=1}^{m} \delta_r Z_{(r),t} + \varphi_t$$

Eq. 3.d.3: reduced form data-generating equation (based on Hendry and Nielsen 2007)

Here $Z_{(r),t}$ represents the regressors which are a subset of the original N and the focus is to find the combination which is the most 'closely' representative model of the data generating process. A simple approach is to identify from a case in which all the regressors In the proposed general linear model are

uncorrelated (mutual orthogonality) and selection is based upon 'individual t-tests', for a more complex analysis Hendry and Krolzig (2005) provide further variations. Hendry and Nielsen (2007) identify five main stages in the process of commencing from the proposed general linear model and proceeding to the reduced form.

Step 1 – model formulation (GUM)

The first stage is to draw upon the available information including the data sample, the existing theoretical research, the existing empirical analysis, relevant, measurement and institutional details. This formulation is known as the *General Unrestricted Model* (GUM). This should encompass the all the variables which leads to the determined parsimonious formulation. Hendry and Nielsen (2007) indicate that at this stage a key aspect to endure that all potentially relevant variables from a 'logical' perspective are included and that 'omitted' variables can cause the model to be invalidated due to the 'interdependence' of economic variable of interest. Further, the theoretical construction is important, as a blanket coverage of an excessively large data set is also unconstructive to the reduction process. An additional stage could be the utilisation of suitable 'data transformations' including using differencing, logs and potential 'cointegrating relations'. This should enable the formulation of orthogonality amongst the variables. Also, an empirical evidence base should enable an appropriate formulation of the parameters such there is 'constancy' over the sample and enable the potential interpretation as 'elasticises or propensities' also evolution with changes to the regulatory environment over time.

Step 2 – Mis-specification testing

In order, to test the formulation for consistency k independent mis-specification tests are undertaken, which are 'based upon' $t_1, \dots, t_k$ statistics. As Hendry and Nielsen (2007) specify each test is conducted with a significance level $\propto$ and critical values $c_\propto$ and with rejection for $|t_i| > c_\propto$ so that for the null hypothesis of equation (6.b.2) the probability that any of the tests reject (6.b.1) is calculated:

$$P\left(|t_i| \leq c_\propto, i = 1, \dots, k\right) = (1-\propto)^k \cong 1 - \propto k,$$

Eq. 3.d.4: mis-specification tests (based on Hendry and Nielsen 2007)

which gives the level overall $\propto k$. Another critical aspect which is highlighted by Hendry and Krolzig (2005) is that an increase in the number of tests increases the likelihood of a false rejection of the specified model and there are further conditions that can be applied than a simplified 'accept/reject decision'.

In addition, further testing can be undertaken as Hoover and Perez (1999) summarise a 'battery of tests' for mis-specification within a search algorithm formulation of the procedure:

- *Normality of residuals* – Jarque and Berra (1980)

- *Autocorrelation of residuals up to second order* - X^2 test; Godfrey (1978)
- *Autocorrelated conditional heteroscedasticity* – ARCH up to 2nd order; Engle (1982)
- *Stability test for in sample* – Chow (1960)
- *Stability test for out of sample for specification* – Chow (1960)

As Hoover and Perez (1999) indicate if the general specification formulation fails one of the tests, that particular test is not used again for subsequent iteration testing of this 'replication'. On the other hand, if a formulation fails more than one test then that replication is abandoned, and another search begins from a general specification of another formulation.

Step 3 – Elimination of irrelevant variables

The next stage is to undertake t-testing for each of the variables, these are squared to negate for the sign (positive/negative) and then ranked. Such that $t_1^2 \geq t_2^2 \geq \ldots \geq t_N^2$ with t_1^2 denoting the largest *t*-value, hence the objective is to determine the t_m^2 for the m^{th} such variable with the smallest *t*-value which remains significant such that, $t_m^2 \geq c_\propto^2 > t_{m+1}^2$. Hendry and Nielsen (2007) note that in theory there is a possibility for 2^N potential models give the N prospective regressors which could result in an incalculable amount of 'sub-models' but in practice the orthogonalized general unrestricted model permits one such decision to be made for the selection process to continue.

The automated search procedure as illustrated by Hoover and Perez (1999) is then to:

- remove the variable with the lowest *t*-statistic, and then,
- the regression is estimated with the remaining variables which then becomes the 'current specification'
- the battery of tests in Step 2 are then repeated with the addition of
    - *F*-test with a hypothesis assuming the 'current specification' is a valid restriction of specification of step 1
- Then a recursive process continues if the specification passes all test:
    - Variable with next lowest *t*-statistic is removed
    - Revised specification undergoes Step 2 testing
    - If a revised specification fails one of the tests then the last removed variable is restored
    - The re-stored specification is 're-estimated' with the variable with the next lowest *t*-statistic is removed
- The reductive process is completed at the point when the 'current specification' passes all the diagnostic testing, and:
    - all the remaining variables are significant, or
    - It is not possible to remove any further variables without failing one of the Step 2 tests

- Once the testing has been completed the terminal specification has been reached, Hoover and Perez (1999) re-test the 'current specification' over a full sample of data (given they start the process over a selection of the sample). They then proceed with the battery of tests and removal of insignificant variables in 'blocks', if the 'new' model passes then this becomes the terminal model, however if it does not pass the testing they then restored the removed 'block' and recommence from Step 2 testing

Step 4 – Encompassing

An additional step is to commence a search process for multiple search paths and the terminal selection as utilised by Hoover and Perez (1999) and incorporated into an evolved version of the approach as indicated by Hendry and Nielsen (2007) into an *Automated Gets* procedure. The additional step is to then recommence with an alternate model specification. In order to find a model which may encompass all other formulations with the 'lowest standard error of regression'. If a single model dominates all the other terminal selections in a set which encompasses all others, then this becomes the chosen model. If there is no single dominant model, then all the dominated models are removed, and a union is formed with the remaining models becomes the point to begin a the 'multipath search procedure'.

Step 5 – Obtaining 'nearly' unbiased estimators

When using an automated procedure Hendry and Nielsen (2007) note the potential for selection bias when 'substantive context' may be missed out. Given that it was included in the initial starting point in which a 'conditional interpretation is put forward' and a normal distribution is assumed or considered for the estimators. Hendry and Krolzig (2005) put forward formulas for the bias correction which is based on a derivation from the work of Heckman (1976) on sample selection corrections. The two components of selection bias are due to 'strongly correlated regressors' and weak or marginal *t* – test statistics.

Caveats

Hoover and Perez (1999) find that size and also power can be distorted for the lags of the variables particularly the dependent variable. Which arises due to an un-orthogonal specification and hence as Hendry and Krolzig (2007) stress the significance and importance of having an orthogonalized dynamic 'specification' to begin the procedure. Furthermore, perhaps the most critical aspects are to evaluate inference within the context of existing theory and underlying features of the data sample and period.

Causality analysis methods

Granger causality

A further interaction that can be approached for time series is the ability of one time series to forecast another, whereas a regression indicates the potential for correlation between two or more series. The work of Granger (1969) identifies that analysis can be undertaken to indicate the relative 'causality' of one time series to predict the values of another series with the past values of the former series. Granger (1969) puts this forward as a

forecasting approaching as opposed to identifying 'true causality', Granger (1980), this Granger causality is able to determine a direction of causation through a 'temporal relation'. In essence the procedure utilises t-testing and F-testing to identify whether the lagged values of a particular series, Y in combination with the lagged values of another series X provided an improved prediction of the future values of Y than merely utilising the past values of Y alone. This is relevant to the analysis of economic fluctuations such as to identify the impact that uncertainty can have over the business cycle and whether there is a potential for Granger causality.

As Eichler (2011) identifies a more general definition of Grange causality entails two characteristics:

I. Over time cause 'precedes' effect
II. The 'causal' time series has 'unique information' upon the time series being 'caused'

Further Eichler (2011) notes that Granger causality in contrast to various other approaches is a 'probabilistic concept' in as much as it does not make an inference upon the 'specification' of the data generating process or 'scientific model'. In particular the second characteristic given above can be utilised to derive the definition of Granger causality, as Eichler (2011) describes the process is to separate information about the past information of a particular series X from the set of all information available, hence the two sets of interest are:

i) $\tau^*(t)$ – set of all information (within known universe) up to the point in time t

ii) $\tau^*_{-X}(t)$ – same information up to the point in time t excluding the values of the series X

The above assumes that $t \in \mathbb{Z}$, all variables are measured at equally spaced 'points in time'. Then if there exists causation from series X the series Y it should be expected according to Eichler (2011) that it is the 'conditional probability distribution of series Y_{t+1}' as the two sets of information, $\tau^*(t)$ and $\tau^*_{-X}(t)$ differ.

Hence Eichler (2011) defines the relation for the basis of set up for test of a null hypothesis as follows.

The series X does not Granger cause Y if

$$Y_{t+1} \perp\!\!\!\perp \tau^*(t) \mid \tau^*_{-X}(t),$$

Eq. 3.d.5: Granger causality (based on Eichler 2011)

for all $t \in \mathbb{Z}$; hence if not then the series X does Granger cause the series Y.

Further Eichler (2011) presents the multivariate representation of Granger causality as an intervention, for a time series, $V = (X, Y, Z)$ case with an *intervention* $\sigma_t(t) = s$ that satisfies the below.

X^{t-1}, Y^t, $Z^t \perp\!\!\!\perp \sigma_t$ and $\{ X_v , Y_v , Z_v \mid t' > t \} \perp\!\!\!\perp \sigma_t \mid X^t$, Y^t, Z^t

Eq. 3.d.6: Multivariate Granger causality (based on Eichler 2011)

Hence the series X does not Granger cause Y with respect to V if $Y_{t+1} \perp\!\!\!\perp X^t \mid Y^t, Z^t$, for all $t \in \mathbb{Z}$; hence if not then there is no causal effect of X_t intervening in Y_t.

In particular relation to obtaining the best predictor Granger (1980) specifies that there is difficulty in obtaining optimum predictors given there may exist non-linearity unless there is an assumption that all sets are normally distributed. So that the Granger causality works most satisfactorily if there is an assumption of linearity with *linear predictors*. Such that for the case of seeking the best linear predictor of X_t, with only utilising the previous X_t and Y_t gives the following

$$P_t(X \mid \bar{X}, \bar{Y}) = \sum_{j=1}^{\infty} a_j X_{t-j} + \sum_{j=1}^{\infty} b_j Y_{t-1},$$

Eq. 3.d.7: Best linear predictor Granger causality (based on Granger 1980)

where the a_j 's and b_j 's are selected to minimise $\sigma^2 (X \mid \bar{X}, \bar{Y})$

Granger causality – using a linear VAR model approach

In testing for linear Granger (non) causality Giles (2011) indicates that care need to be taken in the presence of non-stationary data. As L*ü*tkepohl (2007) states that when using a VAR model with some non-stationary data a Wald test statistic on the 'linear restrictions' on the parameters the statistic 'does not follow its usual asymptotic chi-square distribution under the null'. Hence in this study utilisation is made of an approach specified by Giles (2011) for using the procedure of Toda and Yamamoto (1995). Here the estimation is based on a VAR model:

$$Y_t = a_0 + a_1 Y_{t-1} + \ldots + a_p Y_{t-p} + b_1 X_{t-1} + \ldots + b_p X_{t-p} + u_t$$

$$X_t = c_0 + c_1 X_{t-1} + \ldots + c_p X_{t-p} + d_1 Y_{t-1} + \ldots + d_p Y_{t-p} + v_t$$

Eq. 3.d.8: VAR model Granger causality (based on Giles 2011)

So then to test the null hypothesis that X does not Granger cause Y is H_0: $b_1 = b_2 = \ldots = b_p = 0$, against H_A: 'Not H_0'.

Then also, to test the null hypothesis that Y does not Granger cause X is H_0: $d_1 = d_2 = \ldots = d_p = 0$, against H_A: 'Not H_0'.

For both cases a 'rejection' of the null then give implication for the existence of Granger causality.

Then Giles (2011) depicts a careful approach to the application of the Toda and Yamamoto (1995) procedure with 13 steps (based on levels of the data, i.e. non difference but a logarithm can be taken to 'linearise a trend'):

1. Determination of the order of integration with an ADF test, where the *null is non-stationarity* and KPSS test, where the *null is stationarity*
2. Define the maximum order of integration for the data as m, so that if the variables are I(0) and I(1) then $m = 1$ and if the variables are I(1) and I(2) then $m = 2$ and so forth
3. The VAR model is set up with the data in levels regardless of whether the data is stationary or non-stationary
4. Determine a suitable maximum lag length p for the variables, with suitable information criteria, such as the AIC, SIC
5. Ensure the VAR is well specified, such as making sure the residuals have no serial correlation, here an increase in the lag length can be made to avoid any autocorrelation
6. If Step 1 identified that two or more of the variables have the same order of integration then a test for cointegration such as the Johansen method should be used
7. The information from Step 6 is used as a 'cross-check' at the end of the procedure
8. Using the 'preferred' VAR model for each equation an additional m lags for each variable
9. Perform Granger causality testing using a Wald test to test the hypothesis that the 'coefficients of the first p lagged values of (for example with two equation model):
    a. *X are zero in the Y equation*
    b. Y are zero in the X equation
10. Here the additional m lag coefficients for each variable are not to used they are included to *balance the asymptotics'*
11. Under the null hypothesis the Wald test statics should have p degrees of freedom with an asymptotic chi-squared distribution
12. Hence rejecting the null hypothesis (of Granger non-causality) implies Granger causality
13. The last part is to cross check with the Step 6 findings for cointegration:
    a. With cointegrated variables there should be Granger causality between these variables either in one direction or both
    b. However, if there is no causation but the variables are cointegrated then there is a 'conflict' hence the sample size could be insufficient for example

The above relates to a linear VAR model, In the case of a non-linear model there are some alternative approaches for the identification of Granger causality.

Non-linear causality testing

As Giles (2012) indicates for a non-linear approach there has been some development of 'non-parametric' methods to test for Granger causality. Such as Hiemstra and Jones (1994), however caution is advised as the simulation testing of this approach raises certain queries. Diks and Panchenko (2006) identify that the basis of the Hiemstra and Jones (1994), HJ procedure is testing to ensure that a specific condition holds for a *conditional probability*, a potential weakness may arise given that the condition required is not an implicit part of a Granger non-causality test. Which means that using the HJ method can lead to a rejection of the null hypothesis for non-linear Granger non-causality, in cases in which it should not be rejected. This was supported by a simulation study showing that an increase in sample size increased the likelihood for the HJ test to reject the null. Such that using a given 'nominal significance of 5%' with a sample size that approached 5,000 leads to an actual significance level of 100%. Diks and Panchenko (2006) further provide an alternative 'non-parametric' approach for nonlinear causality testing.

However there a number of approaches to overcoming such issues, for example undertaking cross checking of nonlinear Granger causality testing such as that taken by Choudhry et al (2020). In that study both the HJ test and Diks and Panchenko (2006) tests are undertaken to cross check the results, as well as robustness analysis which is discussed further the following subsections in relation to smooth transition models. Here an overview of the two most prominent approaches to non-linear Granger causality analysis is given.

Hypothesis in a nonlinear setting

Diks and Panchenko (2006) present a summary of the notation for the nonlinear set up, again the objective is to test for Granger non-causality for a strictly stationary bivariate time series process with $\{(X_t, Y_t)\}$ with $t \in \mathbb{Z}$. Such that for $H_0 : \{X_t\}$ is not Granger causing $\{Y_t\}$. They specify that Y_{t+1} 'is conditionally independent' of X_t, X_{t-1}, ..., given Y_t, Y_{t-1}, ..., In a non-parametric setting they identify that it is necessary to apply a model restriction given 'conditioning on the infinite past' is not possible. So that, finite lags are used to test 'conditional independence'. The lags used are l_X and l_Y, so that

$$Y_{t+1} \,|(X_t^{l_x};\, Y_t^{l_y}) \sim Y_{t+1} \,|Y_t^{l_y},$$

Eq. 3.d.9: Nonlinear Granger causality (based on Diks and Panchenko 2006)

where $X_t^{l_x} = (X_{t-l_x+1}, \dots, X_t)$ and $Y_t^{l_y} = (Y_{t-l_Y+1}, \dots, Y_t)$. Diks and Panchenko (2006) specify that given strictly stationary bivariate time series process with $\{(X_t, Y_t)\}$, the above is a 'statement about the distribution' of the vector $W_t = (X_t^{l_x}, Y_t^{l_y}, Z_t)$ which has ($l_X + l_Y + 1$) – dimensions and where $Z_t = Y_{t+1}$. They further simplify to use $W = (X, Y, Z)$ as a random vector with the 'invariant distribution' of $W_t =$

$(X_t^{l_x}, Y_t^{l_y}, Y_{t+1})$ and further that $l_X = l_Y = 1$ hence $W = (X, Y, Z)$ denotes a 'three variate random vector distributed' as $W_t = (X_t, Y_t, Y_{t+1})$ and also having the assumption of W being a *continuous random variable*.

Hiemstra and Jones (HJ) approach

Hence Diks and Panchenko (2006) identify that the **HJ** test is based upon a test for 'conditional independence' in which asymptotic theory is used as the basis for the critical values. The null hypothesis is that the conditional distribution of Z given $(X, Y) = (x, y)$ is equivalent to Z given $Y = y$ only. Such that considering the 'joint probability density function' $f_{X, Y, Z}(x, y, z)$ and its relevant marginals must adhere to:

$$\frac{f_{X,Y,Z}\ (x,y,z)}{f_{X,Y}\ (x,y)} = \frac{f_{Y,Z}\ (y,z)}{f_Y\ (y)} \qquad (a)$$

Or

$$\frac{f_{X,Y,Z}\ (x,y,z)}{f_Y\ (y)} = \frac{f_{X,Y}\ (x,y)}{f_Y\ (y)} \frac{f_{Y,Z}\ (y,z)}{f_Y\ (y)} \qquad (b)$$

Eq. 3.d.10: Nonlinear conditional independence– HJ test (based on Diks and Panchenko 2006)

Applicable to each vector (x, y, z) supporting (X, Y, Z). Hence the last equation (**Eq. 3.d.10**b) above can be seen to be the same as $f_{X,Z|Y}\ (x, z|\ y) = f_{X,|Y}\ (x|\ y) f_{Z|Y}\ (z|\ y)$ from which it can be shown that having $Y = y$ for every 'fixed value' of y implies conditional independence for X and Z.

The **HJ** test as summarised by Diks and Panchenko (2006), is effectively depicted as an approach to measure the difference between the left hand side and right hand side of the above first equation (Eq. 3.d.10a) using ratios based on 'correlation integrals'. Such that taking a vector V given it is multivariate and random with $\mathbb{R}^{d_v}$. So that for this vector the probability of 'finding two independent realisations of the vector' for a distance $d \leq \varepsilon$ is given by $C_V(\varepsilon)$ which is the applicable integral of correlation with V_1, V_2 independent ~ V for $C_V(\varepsilon)$

$= P[\ \|V_1 - V_2\| \leq \varepsilon]$

$= \iint I(\ \|s_1 - s_2\| \leq \varepsilon)\ f_V(s_1) f_V(s_2) ds_2 ds_1$ where the indicator function is $I(\|s_1 - s_2\| \leq \varepsilon)$

Eq. 3.d.11: Nonlinear integral of correlation– HJ test (based on Diks and Panchenko 2006)

The value of which is zero or otherwise equals 1 if $\|s_1 - s_2\| \leq \varepsilon$ and the supremum norm. is denoted by $\|x\| = sup_{i=1,\ldots,d_V} |x_i|$. Hence Hiemstra and Jones (1994) purport that for $\varepsilon > 0$ the implication for (a) above is

$$\frac{C_{X,Y,Z}\ (\varepsilon)}{C_{X,Y,}\ (\varepsilon)} = \frac{C_{Y,Z}\ (\varepsilon)}{C_Y\ (\varepsilon)} \qquad (a)$$

Or

$$\frac{C_{X,Y,Z}\ (\varepsilon)}{C_Y\ (\varepsilon)} = \frac{C_{X,Y}\ (\varepsilon)}{C_Y\ (\varepsilon)} \frac{C_{Y,Z}\ (\varepsilon)}{C_Y\ (\varepsilon)} \qquad (b)$$

Eq. 3.d.12 (a & b): Nonlinear integral of correlation– HJ test (based on Diks and Panchenko 2006)

The **HJ** test then proceeds to estimate the integral correlations in (**Eq. 3.d.10**a) from the samples and then examines if there is a significant difference between the ratios on the left hand side and the right hand side. The integral correlation estimators are as follows $C_{W,n}\ (\varepsilon) = \frac{2}{n(n-1)} \sum_{i<k} \sum I_{ij}^W$,

Eq. 3.d.13: Nonlinear integral correlation estimators – HJ test (based on Diks and Panchenko 2006)

where $I_{ij}^W = I(\|W_i - W_j\| \leq \varepsilon$. The asymptotic theory behind this estimation is provided in Hiemstra and Jones (1994).

Diks and Panchenko (2006) find that a Monte Carlo simulation reveals an over rejection of the null hypotheses as sample sizes are increased. Further, analytically they also identify 'bias from correlations in conditional concentrations'. In particular the inconsistency is identified as being due in part to the presumption of equation (**Eq. 3.d.10**a) implying (**Eq. 3.d.12**a) whereas in general this is not the case. This is only applicable to special cases in which there is no dependence on *y* for 'conditional distributions' of *X* and *Z* with *Y = y.* They show that the null hypothesis is:

$$\mathrm{P}[\ \|X_1 - X_2\| < \varepsilon, \|Z_1 - Z_2\| < \varepsilon \mid Y_1 = Y_2 = y]$$

$$= \mathrm{P}[\|X_1 - X_2\| < \varepsilon \mid Y_1 = Y_2 = y]\ \mathrm{P}[\ , \|Z_1 - Z_2\| < \varepsilon \mid Y_1 = Y_2 = y]$$

Eq. 3.d.14: Nonlinear integral correlation estimators – HJ test (based on Diks and Panchenko 2006)

and that from equation (**Eq. 3.d.12**b):

$$\mathrm{P}[\ \|X_1 - X_2\| < \varepsilon, \|Z_1 - Z_2\| < \varepsilon \mid \|Y_1 - Y_2\| < \varepsilon\ ]$$

$$= \mathrm{P}[\|X_1 - X_2\| < \varepsilon \mid \|Y_1 - Y_2\| < \varepsilon]\ \mathrm{P}[\ , \|Z_1 - Z_2\| < \varepsilon \mid \|Y_1 - Y_2\| < \varepsilon]$$

Eq. 3.d.15: Nonlinear integral correlation estimators – HJ test (based on Diks and Panchenko 2006)

Hence generally the conditions do not have equivalence as there is a required statement upon the 'factorisation of probabilities' but there are different events upon which the conditioning occurs for each and Diks and Panchenko (2006) elucidate further in regard to these conditional distributions.

Diks and Panchenko (DP) modification of HJ approach

A modification to the **HJ** approach has thus been formulated by Diks and Panchenko (2006), the concept of the approach is to localise the measurement of dependence for each y_i between X and Z, with $Y = y_i$. This approach allows for adjustments to the 'bandwidth' aligned to the change in sample size and hence any changes to the conditional distribution of X and Z, given Y at a local level, these are then incorporated into the test statistic.

They derive from the null hypothesis in equation (b) an alternative implication:

$$q_g \equiv \mathbf{E}\left[\left(\frac{f_{X,Y,Z}\ (X,Y,Z)}{f_Y\ (Y)} - \frac{f_{X,Y}\ (X,Y)}{f_Y\ (Y)}\frac{f_{Y,Z}\ (Y,Z)}{f_Y\ (Y)}\right) g(X,Y,Z)\right] = 0$$

Eq. 3.d.16: Nonlinear (DP) modification of HJ approach (based on Diks and Panchenko 2006)

In which the function $g(x,y,z)$ has a positive weight. They further infer that given the null hypothesis the function $g(x,y,z)$ is multiplied by nothing (the other terms 'vanish') hence the expectation becomes zero. Furthermore they assert that q_g under a 'one sided test' is not assured to be positive but will reject he null when the 'estimated value' is too great and also that such a one sided test has more power than a two sided test in practice. They utilise Monte Carlo simulations with a stationary bootstrap and settle upon the following weight function, as $g_2(x,y,z)=f_Y^2(y)$. This is beneficial given that even for 'weakly dependent data' an asymptotic distribution can be derived given that the relevant estimator can be represented with a U-statistic. Hence deriving:

$$q = \mathbf{E}\left[f_{X,Y,Z}\ (X,Y,Z)\ f_Y\ (Y) - f_{X,Y}\ (X,Y) f_{Y,Z}\ (Y,Z)\right]$$

Eq. 3.d.17: Nonlinear (DP) modification of HJ approach (based on Diks and Panchenko 2006)

Further they show that using indicator functions a 'natural estimator' of q is the following

$$T_n(\varepsilon) \equiv \frac{(2\varepsilon)^{-d_X-2d_Y-d_Z}}{n(n-1)(n-2)} \sum_i\left[\sum_{k,k\neq j}\sum_{i,j\neq i}\left(I_{ik}^{XYZ} I_{ij}^{Y} - I_{ik}^{XY} I_{ij}^{YZ}\right)\right]$$

Eq. 3.d.18: Nonlinear (DP) modification of HJ approach (based on Diks and Panchenko 2006)

With $I_{ij}^{W} = I(\|W_i - W_j\| > \varepsilon)$. The test statistic is thus for conditional distribution of X and Z given $Y=y_i$ with the interpretation of representing a mean value over 'local BDS test statistics' . They further denote for a d_w variate random vector W at W_i 'local density estimators' by the function

$$\hat{f}_W(W_i) \equiv \frac{(2\varepsilon)^{-d_W}}{(n-1)} \sum_{j,j\neq i} I_{ij}^{W}$$

Eq. 3.d.19: Nonlinear (DP) modification of HJ approach (based on Diks and Panchenko 2006)

From which the derived test statistic is simplified to

$$T_n(\varepsilon) \equiv \frac{(n-1)}{n(n-2)} \sum_i \left(\hat{f}_{X,Y,Z}(X_i,Y_i,Z_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i,Y_i)\hat{f}_{Y,Z}(Y_i,z_i)\right)$$

Eq. 3.d.20: Nonlinear (DP) modification of HJ approach (based on Diks and Panchenko 2006)

In particular when using a suitable 'sequence' of bandwidth values, ε_n , the estimators are shown to consistent and further that the test statistic is made up of $\hat{f}_{X,Y,Z}(X_i,Y_i,Z_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i,Y_i)\hat{f}_{Y,Z}(Y_i,z_i)$ which is a weighted mean across the 'local contributions' and under the null the value tends to zero.

Diks and Panchenko (2006), further derive an equation for the bandwidth and show that the test is consistent when $d_X = d_Y = d_Z = 1$ and the sample size is used to determine the bandwidth which is

$$\epsilon_n = C_n^{-\beta}$$

$$\text{for which } C \text{ is a positive constant and } \beta \in \left(\frac{1}{4},\frac{1}{3}\right)$$

Eq. 3.d.21: Nonlinear (DP) bandwidth (based on Diks and Panchenko 2006)

Such that they show that for the above if there is no 'dependence between the vectors W_i ' then statistic is 'asymptotically normally distribute' and hence more formally T_n satisfies:

$$\sqrt{n} = \frac{(T_n(\epsilon_n)-q)}{S_n} \xrightarrow{d} \text{N(0,1)}$$

Eq. 3.d.22: Nonlinear (DP) normality condition (based on Diks and Panchenko 2006)

Reference should be made to Diks and Panchenko (2006), and the relevant appendices for the derivations of the asymptotic variance and suitable approach to optimal bandwidth selection.

VAR – Impulse response

In further support of causality analysis in addition to the smooth transition models which can be used as robustness checks, Choudhry et al (2020) also utilise Impulse response functions. These are based on the VAR

model framework of Sims (1980), Stock and Watson (2001) state that such models can be used to provide an indication (with caveats) for a potential approach in analysis of the 'endogeneity' between variables. Such that a linear model may contain n variables with n equations each variable n_i can be explained by the previous values (lagged values) in combination with previous and existing values of the other n-1 variables. Lennard (2018) provides a basic set up with two variables and two equations. These could represent a basic view of output Y_t and government expenditure G_t, the error term ε_t^Y represents macroeconomic innovations including shocks to supply and demand. With the error term ε_t^G representing changes to government outlook induced by factors such as 'political' perspective or 'ideology'. Lennard (2018) withholds the constant terms for purpose of ease of demonstration. Such that the following

$Y_t = \beta G_t + \varepsilon_t^Y$ and $G_t = \gamma Y_t + \varepsilon_t^G$

Eq. 3.d.23: VAR output and government expenditure model (based on Lennard 2018)

With the innovations in supply or demand impacting output and hence influencing government expenditure. The following equation then represents the correlation relationship in the output equation.

$\hat{\beta} = \beta + \frac{Cov\,(G_t, \varepsilon_t^Y)}{Var(G_t)}$ with Lennard (2018) providing the following exposition:

Eq. 3.d.24: VAR output and government expenditure - correlation relationship (based on Lennard 2018)

- Here β is the parameter of interest
- with $\hat{\beta}$ representing the estimation
- If $Var(G_t)$ is not 'explosive' then an OLS estimation will hence lead to 'biased estimates'
- The signs of β and γ have implications for the 'direction' of bias
- With $\gamma < 0$ occurring for a 'countercyclical' rise government expenditure vis. Fiscal policy:
    - Hence a negative shock, ε_t^Y to output generates and increase to G_t,
- So that with $\beta > 0$ occurring for the case of a positive 'fiscal multiplier' resulting in a 'downward' bias in $\hat{\beta}$
    - Given a negative covariance between, ε_t^Y and G_t,

VAR set up

Hence a VAR formulation with one lag of each variable is represented by

$Y_t = \beta_1 G_t + \beta_2 Y_{t-1} + \beta_3 G_{t-1} + \varepsilon_t^Y$ and $G_t = \gamma_1 Y_t + \gamma_2 Y_{t-1} + \gamma_3 G_{t-1} + \varepsilon_t^G$

Eq. 3.d.23: VAR output and government expenditure model set up (based on Lennard 2018)

Here Lennard (2018) demonstrates an approach formulating an estimation which can overcome the obvious bias that will occur for OLS estimations. The reduced form VAR formulation proceeds as follows:

$$Y_t - \beta_1 G_t = \beta_2 Y_{t-1} + \beta_3 G_{t-1} + \varepsilon_t^Y \text{ and } G_t - \gamma_1 Y_t = \gamma_2 Y_{t-1} + \gamma_3 G_{t-1} + \varepsilon_t^G$$

Eq. 3.d.24: VAR output and government expenditure – reduced form (based on Lennard 2018)

In matrix notation,

$$\begin{bmatrix} 1 & -\beta_1 \\ -\gamma_1 & 1 \end{bmatrix} \begin{bmatrix} Y_t \\ G_t \end{bmatrix} = \begin{bmatrix} \beta_2 & \beta_3 \\ \gamma_2 & \gamma_3 \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^G \end{bmatrix}$$

Eq. 3.d.25: VAR output and government expenditure –in matrix notation - a (based on Lennard 2018)

Then,

$$\begin{bmatrix} Y_t \\ G_t \end{bmatrix} = \begin{bmatrix} 1 & -\beta_1 \\ -\gamma_1 & 1 \end{bmatrix}^{-1} \begin{bmatrix} \beta_2 & \beta_3 \\ \gamma_2 & \gamma_3 \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & -\beta_1 \\ -\gamma_1 & 1 \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^G \end{bmatrix}$$

Eq. 3.d.26: VAR output and government expenditure –in matrix notation - b (based on Lennard 2018)

The reduced form VAR is represented by the following arrangement:

$$\begin{bmatrix} Y_t \\ G_t \end{bmatrix} = \begin{bmatrix} \varphi_2 & \varphi_3 \\ \varphi_2 & \varphi_3 \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ G_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^G \end{bmatrix}$$

Eq. 3.d.27: VAR output and government expenditure – reduced form in matrix notation (based on Lennard 2018)

Essentially the reduced form removes the contemporary values of the independent variables. Here Lennard (2018) identifies that the estimation of an impulse response function enables the estimation of the 'dynamic response' for a given variable which results from an innovation to the other variable. Such that for a given time period or horizon h, the impulse response to output for a shock or adjustment in government expenditure is represented as follows.

$$\frac{\delta Y_{t+h}}{\delta \epsilon_t^G}$$

Here an innovation to government expenditure represented by the change to ϵ_t^G is actually a 'weighted average of innovations or shocks to both output and government expenditure, given as noted by Lennard (2018) that the original or structural error terms ε^j are combined to form the 'reduced-form' error terms, ϵ^j. Such that: $\epsilon_t^Y = \frac{1}{1-\beta_1\gamma_1}(\varepsilon_t^Y + \beta_1\varepsilon_t^G)$ and $\epsilon_t^G = \frac{1}{1-\beta_1\gamma_1}(\varepsilon_t^G + \gamma_1\varepsilon_t^Y)$

As Stock and Watson (2001) identify a recursive VAR defines the pasts error terms in each equation as being 'uncorrelated' to the prior error term. This requires a computation of the Cholesky decomposition of such a reduced form VAR as shown by Lutkepohl (1993) as well as Ramey (2016). Essentially this requires the correct implementation of a critical step in ordering the VAR equations and then utilisation of the contemporary value

of the independent variable in the equations in addition to the lagged value of all variables in order to derive uncorrelated 'regressor' across all the equations. Stock and Watson (2001) note the key importance that the 'order of the variables' has upon outputs, but also the potential difficulty in finding the correct ordering such that there are prospectively $n!$ different orderings for n variables.

SVAR and Cholesky decomposition for Impulse response

As Lennard (2018) as well as Ronayne (2011) explore in order to utilise the Cholesky decomposition for the VAR the structural shocks are 'set to equal zero' in the example above $\gamma_1 = 0$ for example so that in the present time output innovations do not influence government expenditure instantaneously. Lennard (2018) identifies three potential issues which can cause interference with such an implementation with respect to the example of output and government expenditure:

i) Practically policy makers may act with a lag but 'automatic stabilisers' are then contrary to the assumption of only having lagged effects.
ii) Requires higher frequency data, such as monthly data could more suitably reflect policy implementation lags however annualised data is unlikely to be relevant given the lag of one year is unrealistic
iii) Policy making is made utilising forecasting and available 'proxies' whereas this method is based on posthumously verified data for such time series as GDP, such an assumption requires that the policy maker expenditure shock is 'orthogonal' to the actual or most accurate output record, resulting in a misspecification of the 'policy maker reaction function'

A supplemental approach is to utilise 'economic theory' as outlined by Stock and Watson (2001) in order to define the 'contemporaneous links' which are relevant between the variables of interest. Furthermore Lennard (2018) shows that the narrative approach can also be of benefit for the identification problem.

Unit roots

A time series or stochastic process for example a random walk may contain a unit root, indicating the process is non-stationary, if the characteristic equation contains a 1 as a root then it is non-stationary. For example, Nkoro and Uko (2016) indicate that for a given random walk model:

$$Y_t = \rho Y_{t-1} + U_t \text{ with } -1 \leq \rho \leq 1$$

Eq. 3.d.28: Time series random walk model (based on Nkoro and Uko 2016)

In the case of $|\rho| \leq 1$ that this in which the absolute value of ρ is below 1 then this is an indication of a stationary series and as such with U_t having the characteristic of being White noise with zero mean and variance following a normal distribution it can be postulated that

$E(Y_t) = 0$ and $Var(Y_t) = 1/(1- \rho_2)$

Eq. 3.d.29: Time series random walk model with stationarity and normality (based on Nkoro and Uko 2016)

Alternatively, for the case of ρ=1 this indicates nonstationary process and further Nkoro and Uko (2016) indicate that a stochastic process has a unit root issue in the circumstances in which the first difference is stationary.

$(Y_t - Y_{t-1})$ for the stochastic process of Y_t

A series which contains a unit root problem with the fist difference being stationary likely to have no long run return to original and there is time dependence for the variance of the series as well. In the case of a I(1) series which is a random walk without drift it may still have a constant mean and variance with a trend. The purpose of testing for unit root is to determine the number of times series must be differenced in order to be stationary. According to Engle and Granger (1987) a series such as *Y* that must be differenced a number of times, *d* in order to be stationary is integrated of order I(*d*). The Dickey-Fuller (1979) approach is a standard method used for testing for unit roots.

Application of unit root testing

The standard approach as depicted by Nkoro and Uko (2016) to Unit root testing is to utilise the Dickey-Fuller (1979) approach:

a. for a variable Y_t following a random walk process $Y_t = \rho Y_{t-1} + u_a$
b. the regression model is $Y_t = \rho Y_{t-1} + u_t$
c. if Y_{t-1} is taken from both sides then
    i. $Y_t - Y_t\text{-}1 = \alpha_1 Y_{t-1} - Y_{t-1} + u_t$
    ii. $\Delta Y_t = (\alpha\text{-}1) Y_{t-1} + u_t$
    iii. $\Delta Y_t = (\alpha\text{-}1) Y_{t-1} + \alpha_2 T + u_t$
d. with $\alpha\text{-}1 = p_1$; Δ is change in Y_t (first difference); t is the trend factor; u_t is a white nose residual
e. incorporating drift yields $\Delta Y_t = \alpha_0 + p_1 Y_{t-1} + u_t$

The test hypothesis is that p=0 and hence for

- $Y_t - Y_{t-1} = \alpha 1 Y_{t-1} - Y_{t-1} + u_t$
    - if p=0 then α=1 indicating a unit root and a non-stationary series
    - if p ≥ 0 then there is indication of stationary timer series with mean equal to zero
- $\Delta Y_t = (\alpha\text{-}1) Y_{t-1} + \alpha_2 T + u_t$
    - if p ≥ 0 then there is indication of stationary time series with a 'determined' trend
    - if p ≥ 1 then the variable of interest is 'explosive'
- The above assumes the residual or error terms are uncorrelated

- If U_t is correlated then
    - Augmented Dickey-Fuller, ADF (1981) test is required
    - Incorporates the lagged difference terms of the variable of interest

The ADF approach as depicted by Nkoro and Uko (2016) in applying the Augmented Dickey-Fuller (1981) method is to determine the number of lags required (k) of ΔY_t to endure there is no serial correlation in ii. and iii. above and another assumption is that the process followed by the series is AP(p). The General ADF model can be depicted as:

$$\Delta Y_t = \alpha_0 + p_1 Y_{t-1} + \alpha_2 T + {}^{k}\Sigma_{i=1}\, \alpha_i \Delta y_{t-1} + u_t$$

Eq. 3.d.30: General ADF model (based on Nkoro and Uko 2016)

Nkoro and Uko (2016) indicate the application of the test follows as per the DF test:

$$H_0: p_1 = 0(p_1 \sim I(1)), \text{ against } H_1: p_1 < 0(p_1 \sim I(0))$$

In the application of the Pesaran et al (2001) bounds testing approach the ADF (1981) test can be applied to test if any of the variables are integrated of order I(2) with the null hypothesis that p_1 is biased 'negatively' for a restricted sample size . The alternative implies an 'explosive' process for a positive value of significance.

e. Econometric model

Data and model estimation

The period of interest is the interwar years of 1920 until 1938. An automated model selection procedure is utilised following Hendry and Mizon (1978). Using the GETS approach which is predicated upon incorporating several variables which may have explanatory relevance for GDP, given the actual data generating process is unknown. Hence the basis for formulating the General Unrestricted Model (GUM) with relevant variables is to use those which encompass the perspectives of previous studies and existing theories. The procedure as outlined within chapter b of the methodology depicted in Chapter 5 then reduces the model by removing redundant variables based on a battery of tests until the parsimonious form is identified.

The expectation is that there will be a negative impact on growth from exchange rate appreciation, increases to wholesale producer prices a proxy for commodity prices of inputs to production, increase in interest rates as per Woodford (2003) and from increase to policy uncertainty. Whereas there is potential for a positive impact upon growth from increase to foreign demand, increases to the level of employment should also increase demand for goods and services, increase in bank lending as per Schumpeter (1939), rises in the monetary aggregates as per Friedman and Schwarz (1963).

GUM set up

The modelling approach is utilise an autoregressive distributed lag, as per the methodology specified in Chapter 5, set up with the dependent variable Y_t with GDP as the proxy for growth for the UK and Industrial

Production as the proxy for growth for the US, a lag length of four is selected. The explanatory variables are denoted by X_j for each log differences are taken denoted by Δ. Such that the model equation is as follows:

$$\Delta Y_t = \alpha_i + \sum_{i=1}^{4} \beta \Delta Y_{t-1} + \sum_{j} \sum_{i=0}^{4} \gamma_j \Delta X_{j_{t-1}}$$

Eq. 3.d.31: GETS model (based on Hendry and Nielsen 2007)

The variable selection is further influenced by the work of Lennard (2018) in the analysis of the UK economy and also Mathy (2016) in the analysis of the US economy respectively. Both studies are undertaken during the interwar period, although both studies are more domestically orientated rather than giving so much consideration to global macro, business cycle spill over or trade impacts.

Summary of variables of interest for UK and US

The explanatory variables of interest selected for the GUM includes those based upon existing literature and theory as well the inclusion of variables relating to uncertainty. Given the prior analysis of the US expansion of exports during the early part of the period, exchange rates and export demand are relevant variables, industrial steel production of the US (respectively UK for US fluctuation analysis), Germany and France is used as a proxy for this variable, as per availability of comparable data, these are selected given these three countries were the largest trading partners and largest economies globally.

As per Woodford (2003) interest rates are relevant as part of the traditional or neoclassical theory of the rates being a key instrument of monetary policy to influence investment and consumption. Variables relating to the quantity of money are also included both for narrow money and broad money, as King and Levine (1993) state it is a relevant proxy for financial development which could therefore also enhance foreign trade and export production. Monetary aggregates include for UK Narrow money, M0 relates to notes and coins in circulation as well as commercial banking sector reserve deposits at the central bank, whereas broad money is a measure of the wider money supply (M3) includes in addition private sector deposits, with respect to US Money stocks are included. In addition bank deposit data could also be an additional variable of interest as this could potentially have relevance in relation to the consideration of precautionary savings due to uncertainty as considered within Romer (1990), Leland (1978) and Bernanke (1983a). The level of bank loans is also included given as Friedman and Schwarz (1963) as well as Schumpeter (1939) find significance of bank credit as well as in relation to the financial frictions effect perspectives upon uncertainty of Gilchrist et al. (2014) and Bloom (2009) indicate the potential consequences of increased credit spreads for firms seeking to borrow.

The level of employment is also included given that Bloom (2009) finds that reluctance to hire due to uncertainty is a supply side consequence, it is permissible to include here, given than unlike investment (another supply side variable) it is not a component of GDP. An indices of wholesale prices for all commodities is also included given that it was significant aspect of goods traded for both the US and UK, the UK was

predominantly a commodity raw material importer whereas the US was an importer of some raw materials particularly chemicals, and exporter of raw material commodities with some fluctuations in the dynamics over the course of the interwar period.

The source for the data used includes the Bank of England and the FRED database held by the Federal Reserve Bank of St Louis, USA and the NBER Macro history database. The table and charts below depict the key variables considered as part of the GUM.

The frequency is monthly. Dummy variables are used for major structural occurrences such as the 1926 General strike period and Gold standard adjustments and the 1929 great market crash for the UK and US respectively.

Linear causality

To test the Granger causality as depicted by Granger (1969), between changes in the business cycles and changes in components of economic uncertainty a Vector autoregression (VAR) is utilised, which follows the work of Choudhry et al (2020) as depicted within chapter 5. The purpose of the test is to consider the time 'precedence' of the variables and hence provide an indication of any linear causal 'relationship' between industrial production growth which is used as a proxy for business cycles in the work of Colombo (2013) as well as Choudhry et al (2020) and the economic policy uncertainty (EPU) indices. For the interwar period at present this is the only uncertainty indices available. Here economic policy uncertainty for the US considered for a potential causal relationship with US EPU and economic policy uncertainty for the UK is considered for a potential causal relationship with UK EPU.

The specification for the VAR is as follows:

$$y_t = \alpha + \sum_{i=1}^{n} \beta_i y_{t-i} + \sum_{i=1}^{n} \gamma_i x_{t-i} + \varepsilon_{1t} \quad \text{(a)}$$

$$x_t = \theta + \sum_{i=1}^{n} \lambda_i y_{t-i} + \sum_{i=1}^{n} \varphi_i x_{t-i} + \varepsilon_{2t} \quad \text{(b)}$$

Eq. 3.d.32 (a & b): Linear causality – EPU spill over (based on Choudhry et al 2020)

In the above equations y denotes the changes in business cycle for the US and UK while x denotes the economic policy uncertainty for the US and UK respectively. The two equations hence test bivariate causality between business cycles and the respective EPU indices for the US and UK. A significant γ_i value indicates causality from economic policy uncertainty in the UK (US) with the business cycle of the UK (US). A significant λ_i value indicates causality from business cycle of the UK (US) with economic policy uncertainty level in the UK (US). A feedback effect is implicit when there is the existence of a unidirectional causation as opposed to when there is only a bidirectional causation evident. The results of the tests are presented below.

Modelling set up and exposition of Business cycle spill over

The model basis and set up follows the procedure considered in chapter 5 and outlined in Chapter 7 chapter e above. With regard to the variations given the testing procedure is now set up to consider the spill over of economic policy uncertainty to business cycles, this is outlined below and followed by the analysis of the outputs. Again the testing is now set up to consider the spill over from policy uncertainty from the UK and the US to the business cycles of each other respectively as well as to the other major global economies of the interwar period, Germany and France.

Linear causality

As discussed in Chapter 7 to test the Granger causality as depicted by Granger (1969), spill over to business cycles from changes in components of economic uncertainty within the US and UK a Vector autoregression (VAR) is utilised, which follows the work of Choudhry et al (2020) as depicted within chapter 5. The purpose of the test is to consider the time 'precedence' of the variables and hence provide an indication of any linear causal 'relationship' between industrial production growth which is used as a proxy for business cycles in the work of Colombo (2013) as well as Choudhry et al (2020) and the economic policy uncertainty (EPU) indices. Again, for the interwar period at present this is the only uncertainty indices available. Here economic policy uncertainty for the US and UK is considered for a potential causal relationship with US EPU and economic policy uncertainty for the UK is considered for a potential causal relationship with UK EPU.

The specification for the VAR is as follows:

$$y_t^{UK} = \alpha + \sum_{i=1}^{n} \beta_i y_{t-i}^{UK} + \sum_{i=1}^{n} y_i^{UK} x_{t-i} + \varepsilon_{1t} \quad \text{(a)}$$

$$x_t = \theta + \sum_{i=1}^{n} \lambda_i y_{t-i}^{UK} + \sum_{i=1}^{n} \varphi_i x_{t-i} + \varepsilon_{2t} \quad \text{(b)}$$

$$y_t^{US} = \alpha + \sum_{i=1}^{n} \beta_i y_{t-i}^{US} + \sum_{i=1}^{n} y_i^{US} x_{t-i} + \varepsilon_{1t} \quad \text{(c)}$$

$$x_t = \theta + \sum_{i=1}^{n} \lambda_i y_{t-i}^{US} + \sum_{i=1}^{n} \varphi_i x_{t-i} + \varepsilon_{2t} \quad \text{(d)}$$

Eq. 3.d.33 (a, b, c & d): Linear causality – BC spill over (based on Choudhry et al 2020)

In the above equations y^{UK} denotes the changes in business cycle for the UK while y^{US} denotes the changes in business cycle for the US. While x denotes the economic policy uncertainty for the US or UK, Germany and France. The two pairs of equations hence test bivariate causality between business cycles of global trading economies and the respective EPU indices for the US and UK. A significant γ_i value indicates causality from economic policy uncertainty in the UK or US respectively with the business cycle of the other economies. A significant λ_i value indicates causality from the business cycle of the UK (US), Germany or France with economic policy uncertainty level in the US (UK). A feedback effect is implicit when there is the existence of a unidirectional causation as opposed to when there is only a bidirectional causation evident. The results of the

tests for the spill over of UK uncertainty are presented within chapter d and results of the tests for the spill over of US uncertainty within chapter e, below.

Non-linear causality

The existence of potential non linearity within macroeconomic time series is considered within chapter 5 and has been reported within a significant proportion of the empirical literature for example Shiller (2005) depicts the relevance of nonlinear relationships as well as Shine et al (2013). In particular research upon financial time series has been significantly informed through the study of Hiemstra and Jones (1994). Following this there have numerous studies which consider the nonlinearity perspective for analysis of a range of variables relevant to economic and financial research. This includes the work of Shin et al (2014) and Diks and Panchenko (2006) amongst others which specifically seek to identify suitable approaches to relationships within nonlinear framework. Choudhry et al (2020) summarise and mention some of the key contributions succinctly. The overview includes a depiction of some of the various factors which may induce nonlinearity and subsequently generate time series which may move away from the expected convergence to the long run equilibrium. Some of the factors which may cause this divergence and generate nonlinearity are briefly reviewed below.

Transactions costs

Frictions such as transactions costs and informational asymmetries can perpetuate disequilibrium within market clearing mechanisms such that adjustments or return to the expected long term equilibrium are subverted. Anderson (1997) considers the role of such frictional costs within assets markets, an aspect which is less well considered in the literature. The Anderson (1997) study finds that models which incorporate nonlinearity have improved estimation performance in comparison to models which are based upon linear interactions.

Agent based perspectives

There are also a number of agent based factors which have been considered within the literature, these may generate asymmetries and nonlinearity such that there is long run divergence from any expected equilibrium, given the absence of such factors. Brock and LeBaron (1996) consider the 'diversity of agent beliefs' such that market participants may each act rationally but the basis of the rationality is varied hence the market mechanism may not function as they may through an entirely linear process. In addition individual agents have varying objectives which relate to heterogenous appetite for risk and 'investment horizons' some aim to obtain returns over shorter or long time frames with varying levels risk being acceptable, hence the work of Peters (1994) has considered the relevance of such differences in relation to market outcomes. Another aspect which has been considered in varying form such as Galbraith (1954) and Luc (1995) is the propensity for 'herd behaviour' which generates participants to act in an irrational manner when the decision is considered in isolation but for the agent it appears to be following the behaviour of the majority of others which is some way can make the decision appear rational when it is again working against the expected market outcome.

Nonlinear approach

The relevance of the inclusion of the nonlinear approach is hence relevant considering the above and the discussion within chapter 5. The two most prominent approaches to nonlinear causality testing are considered in chapter 5. The work of Hiemstra and Jones (1994), **HJ** method created a model which considers the relationship between a pair of stationary time series and considers the 'probability' of having a 'dynamic or lagged' co-movement which is denoted by Choudhry et al (2020) as the 'correlation of integrals'. This enables the testing of nonlinear causality relationships between variables, this work is advance by Diks and Panchenko (2006) and Diks and Panchenko (2005), **DP** method, in which a new statistic is developed based on the **HJ** method for nonlinear Granger causality tests, this avoids some potential for the rejection probability may tend to one for larger sample sizes. The **DP** method takes 'average of local conditional dependence measures' to avoid such potential for over rejection of the null as per Diks and Panchenko (2005) . Hence the **DP** approach is utilised to test the nonlinear causality between the business cycle and economic policy uncertainty indices. The results of these test are reported in the subsections below.

Variables

The industrial output growth rates for the countries of interest are shown below. Given the data availability the production of steel has been used as proxy for industrial output for the UK, Germany and France. The variable sources are depicted below.

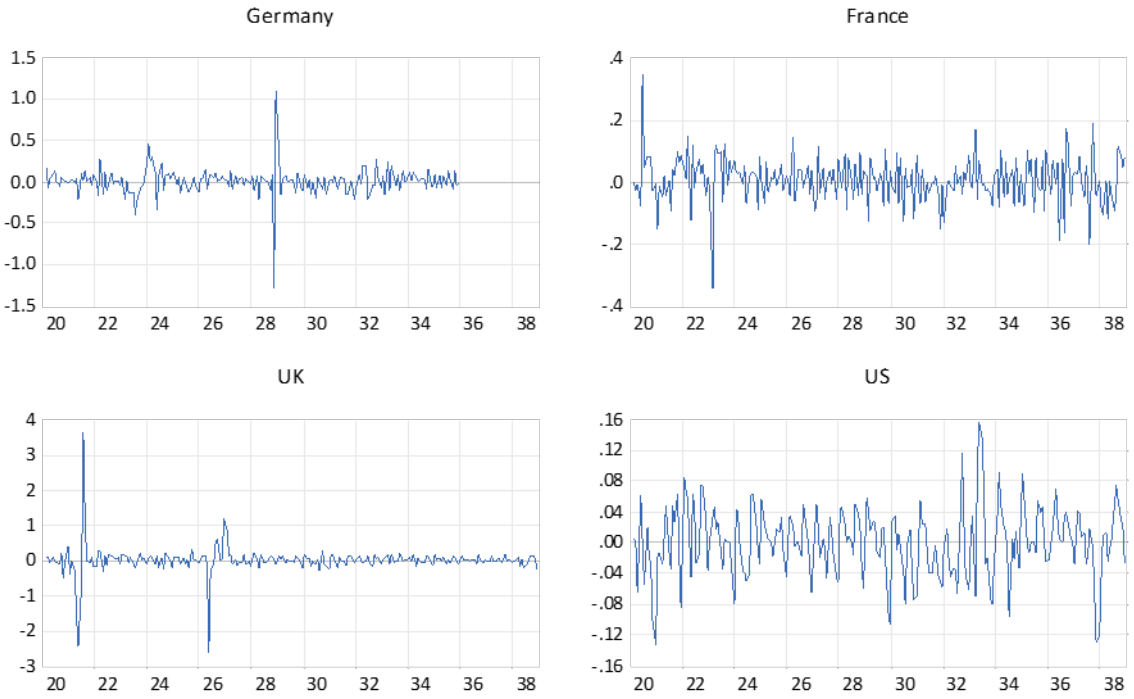


Figure 37: Changes in industrial production, 1920 to 1938 (NBER)

UK and France experienced more volatility in the earlier part of the 1920s, with the UK 1926 gold standard and strike period apparent.. The early post war recession is visible for the UK and US. The post-crash period is also

visible with respect to the US. Germany experienced sharp declines with higher political uncertainty during the late 1920s period in particular which converged with the great crash and post 1931 Credit Anstalt crisis.

First difference of US and UK EPU indices is shown below respectively.

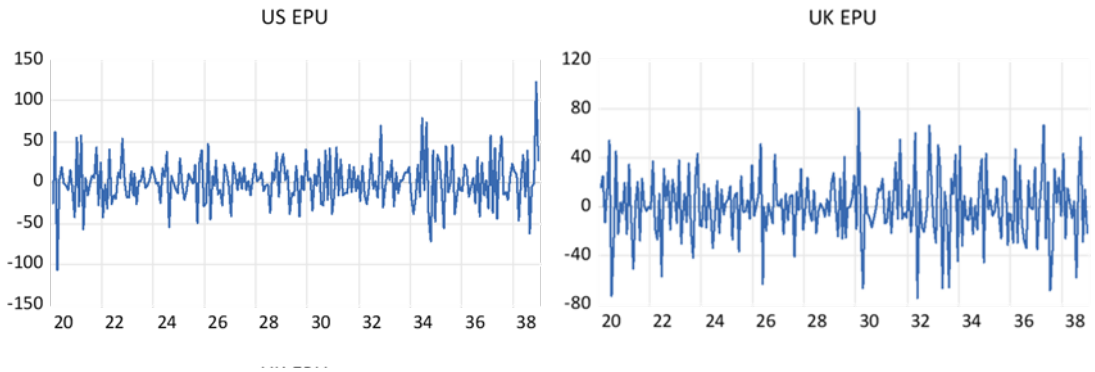


Figure 38: EPU, 1920 to 1938 (NBER)

f. Results

Output Analysis – UK interwar growth fluctuations

Variable table

Variable	Description	Notes	Source
GDPfac	**GDP at factor cost 1920-1938**	£mn, 1938 prices	*A millennium of macroeconomic data for the UK, BoE*
Advances	**London clearing banks' advances**	End period stocks, £mn	*Capie and Collins (1983)*
DR	**Monthly short-term rates**	%pa Bank Rate 1694-2015	*A millennium of macroeconomic data for the UK, BoE*
EPU	**UK Economic policy uncertainty index**	Average 1920-38 = 100	*Lennard - EPU Historical policyuncertainty.com*
ER	**US to UK Exchange rate**	$'s per £	*Craighead (2010), Federal Reserve Board and ONS*
ERFr	**France to UK Exchange rate**	Franc's per £	*NBER, calculations*
ERGe	**Germany to UK Exchange rate**	Marks's per £100	*NBER, calculations*
M0	**Monetary base**	Stock outstanding at month end (nsa) 1870-1969	*Unadjusted stocks from Capie and Webber (1985)*
M3	**Broad money**	Stock outstanding at month end (nsa) 1870-1970	*Unadjusted stocks from Capie and Webber (1985)*
Wages	**Index of Weekly Wage Rates 1919-1925; Average Weekly Wages 1925-1939**	Jan 1939=100	*Capie and Collins (1983)*
UKP	**Commodity price index**	Sauerbeck Statist index, all commodities 1885-1951 1867-77=100, nsa	*Journal of the Royal Statistical Society and the Statist, various editions*
Shareprice	**Share Price Index**	Weighted by Market Capitalisation Apr 1962=100	*A millennium of macroeconomic data for the UK, BoE*
EY	**Monthly unemployment rate**	Monthly activity 1846+ (%)	*A millennium of macroeconomic data for the UK, BoE*
Bondyield	**Yield on Consols**	Mixture of end month and averages. uncorrected for Goschen's conversion issues, 1870-1982	*Capie and Webber (1985)*
USSi	**Steel Output for US**	Thousands of Long Tons per avg day, Monthly, nsa	*NBER*
FrSl	**Raw Steel Output for France**	Thousands of Metric Tons, Monthly, nsa	*NBER*
GeSl	**Raw Steel Output for Germany**	Thousands of Metric Tons, Monthly, nsa	*NBER*
US_EPU	**US Economic policy uncertainty index**	Average 1920-38 = 100	*EPU Historical policyuncertainty.com*

Figure 39: UK interwar growth fluctuations – variable tables

Variable chart

The first difference of the variables is presented below.

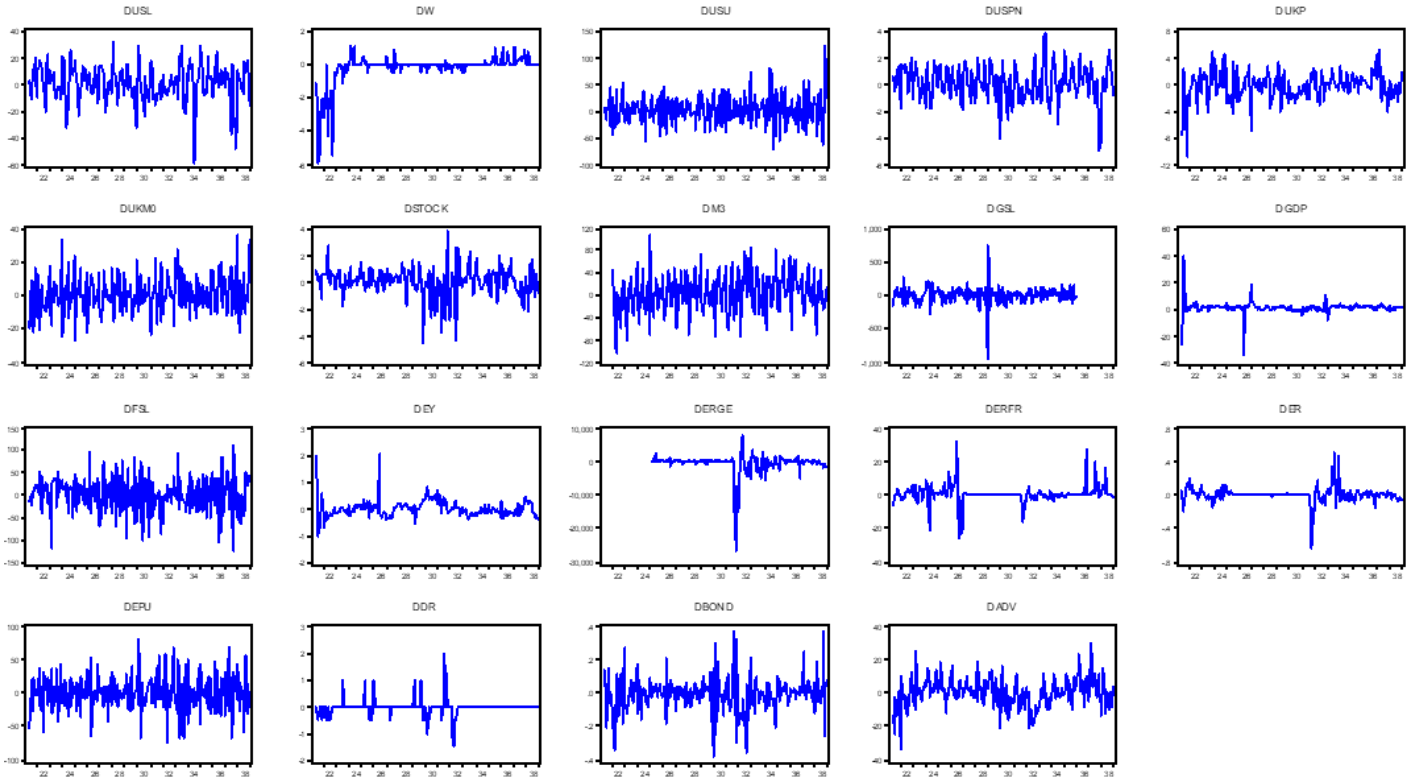


Figure 40: UK macro variables, 1920 to 1938

Variable testing – Unit root

Unit roots are taken to test for stationarity and the results indicate that all of the variables are stationary at first difference. Consideration of the ADF and KPSS unit roots tests is given the results of the ADF are presented below.

UNIT ROOT TEST RESULTS TABLE (ADF)
Null Hypothesis: the variable has a unit root

At Level

		GDPFAC	ADVANCES	DR		UKM0	ERFR	M3	ERGE	EY	BONDYIELD	US_EPU	USSL	FRSL	UKPRICE	GESL
With Constant	t-Statistic	-1.1955	-0.9816	-2.6146	-	0.8939	-1.1620	-1.1828	-0.4738	1.5018	-1.9247	-5.9281	-3.5976	-2.3777	-2.1352	-2.0566
	Prob.	*0.6766*	*0.7598*	*0.0916*		*0.9953*	*0.6908*	*0.6818*	*0.8920*	*0.5309*	*0.3205*	*0.0000*	*0.0066*	*0.1493*	*0.2312*	*0.2627*
		n0	n0	*		n0	n0	n0	n0	n0	n0	***	***	n0	n0	n0
With Constant & Trend	t-Statistic	-2.5148	-1.1117	-3.4804	-	-1.6304	-1.3162	-2.1906	-2.3508	1.5384	-1.5385	-7.0334	-3.6607	-2.1059	-1.7698	-2.0513
	Prob.	*0.3207*	*0.9237*	*0.0441*		*0.7778*	*0.8811*	*0.4917*	*0.4040*	*0.8133*	*0.8133*	*0.0000*	*0.0272*	*0.5391*	*0.7160*	*0.5688*
		n0	n0	**		n0	n0	n0	n0	n0	n0	***	**	n0	n0	n0
Without Constant & Trend	t-Statistic	2.0932	0.3628	-1.4715	-	1.2655	0.9265	1.1913	-1.6177	0.8613	-1.7418	0.1069	-1.0122	0.2465	-2.0572	-0.2103
	Prob.	*0.9915*	*0.7885*	*0.1318*		*0.9477*	*0.9054*	*0.9400*	*0.0996*	*0.3418*	*0.0774*	*0.7155*	*0.2793*	*0.7568*	*0.0383*	*0.6092*
		n0	n0	n0		n0	n0	n0	*	n0	*	n0	n0	n0	**	n0

At First Difference

		d(GDPFAC)	d(ADVAN...	d(DR)	c	d(UKM0)	d(ERFR)	d(M3)	d(ERGE)	d(EY)	d(BONDY...	d(US_EPU)	d(USSL)	d(FRSL)	d(UKPRICE)	d(GESL)
With Constant	t-Statistic	-14.6047	-9.7662	-7.7190	-'	-6.1635	-11.8338	-3.2693	-7.0730	5.3640	-18.4851	-10.9767	-9.8796	-22.4126	-10.8547	-18.2984
	Prob.	*0.0000*	*0.0000*	*0.0000*		*0.0000*	*0.0000*	*0.0177*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
		***	***	***		***	***	**	***	***	***	***	***	***	***	***
With Constant & Trend	t-Statistic	-14.6262	-9.7700	-7.7028	-'	-6.9277	-11.8100	-3.0750	-7.0623	5.3315	-18.5542	-11.0245	-9.8674	-22.5658	-10.9649	-18.2460
	Prob.	*0.0000*	*0.0000*	*0.0000*		*0.0000*	*0.0000*	*0.1153*	*0.0000*	*0.0001*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
		***	***	***		***	***	n0	***	***	***	***	***	***	***	***
Without Constant & Trend	t-Statistic	-14.1571	-9.7749	-7.7106	-'	-6.0452	-11.7362	-3.0283	-7.4647	5.3530	-18.3813	-10.9868	-9.9010	-22.4138	-10.6912	-18.3367
	Prob.	*0.0000*	*0.0000*	*0.0000*		*0.0000*	*0.0000*	*0.0026*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
		***	***	***		***	***	***	***	***	***	***	***	***	***	***

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no)
b: Lag Length based on SIC
c: Probability based on MacKinnon (1996) one-sided p-values.

Figure 41: UK macro variables, Unit root testing

GETS model – parsimonious form

The parsimonious form of the model is shown below. The outputs indicate that GDP is impacted upon by lagged GDP, uncertainty both UK and US, wages, stock prices, employment, bank rate, as well as to a certain extent foreign (German) output and exchange rates. The variables that dropped out were the bond yields, commodity prices. monetary aggregates, foreign demand (US and France) understandable given the UK shifted towards imperial preferences for trade in this period.

The estimation sample is: 1926(3) - 1935(12)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DGDP_13	0.196509	0.02627	7.48	0.0000	0.3708
Constant	0.820754	0.1204	6.82	0.0000	0.3285
DW_1	-2.39393	0.5077	-4.72	0.0000	0.1896
DUSU_7	-0.0155825	0.003639	-4.28	0.0000	0.1618
DUM1926	-3.75236	0.9093	-4.13	0.0001	0.1520
DUM1926_1	-16.9673	1.498	-11.3	0.0000	0.5745
DUM1926_2	19.3438	1.199	16.1	0.0000	0.7326
DUM1926_8	6.18124	1.028	6.01	0.0000	0.2758
DUM1926_9	-11.6422	1.770	-6.58	0.0000	0.3130
DUM1926_10	4.07160	1.101	3.70	0.0004	0.1259
DSTOCK_6	-0.333460	0.08233	-4.05	0.0001	0.1473
DSTOCK_7	0.399659	0.07706	5.19	0.0000	0.2207
DEY	-5.82527	0.4200	-13.9	0.0000	0.6694
DEPU_12	0.0109367	0.003615	3.03	0.0032	0.0879
DDR_10	1.04812	0.2664	3.93	0.0002	0.1401
DDR_11	1.47457	0.3060	4.82	0.0000	0.1964
DGSL_1	0.00244756	0.0006727	3.64	0.0004	0.1223
DERFR_5	0.148407	0.02588	5.73	0.0000	0.2572
DERFR_6	-0.148919	0.02465	-6.04	0.0000	0.2776
DERFR_13	0.111319	0.02551	4.36	0.0000	0.1670
DERGE_8	0.000222487	3.330e-05	6.68	0.0000	0.3197
DERGE_11	0.000151926	3.317e-05	4.58	0.0000	0.1809
DERGE_12	-0.000122439	3.509e-05	-3.49	0.0007	0.1136

sigma	1.01178	RSS	97.2521531
R^2	0.950275	F(22,95) =	82.52 [0.000]**
Adj.R^2	0.938759	log-likelihood	-156.025
no. of observations	118	no. of parameters	23

Figure 3.f.4 UK GETS analysis

Overall the above results are in line with the historical episode narrative analysis in Chapter 2.

Diagnostic testing

The diagnostics test indicate the model is a reasonable fit without indication for autocorrelation, heteroskedasticity and normal distribution of residuals as shown below.

AR 1-7 test:	F(7,88)	=	1.5874 [0.1496]
ARCH 1-7 test:	F(7,104)	=	0.61626 [0.7414]
Normality test:	Chi^2(2)	=	0.27834 [0.8701]
Hetero test:	F(38,79)	=	0.92697 [0.5935]

Figure 43: UK GETS analysis - diagnostics

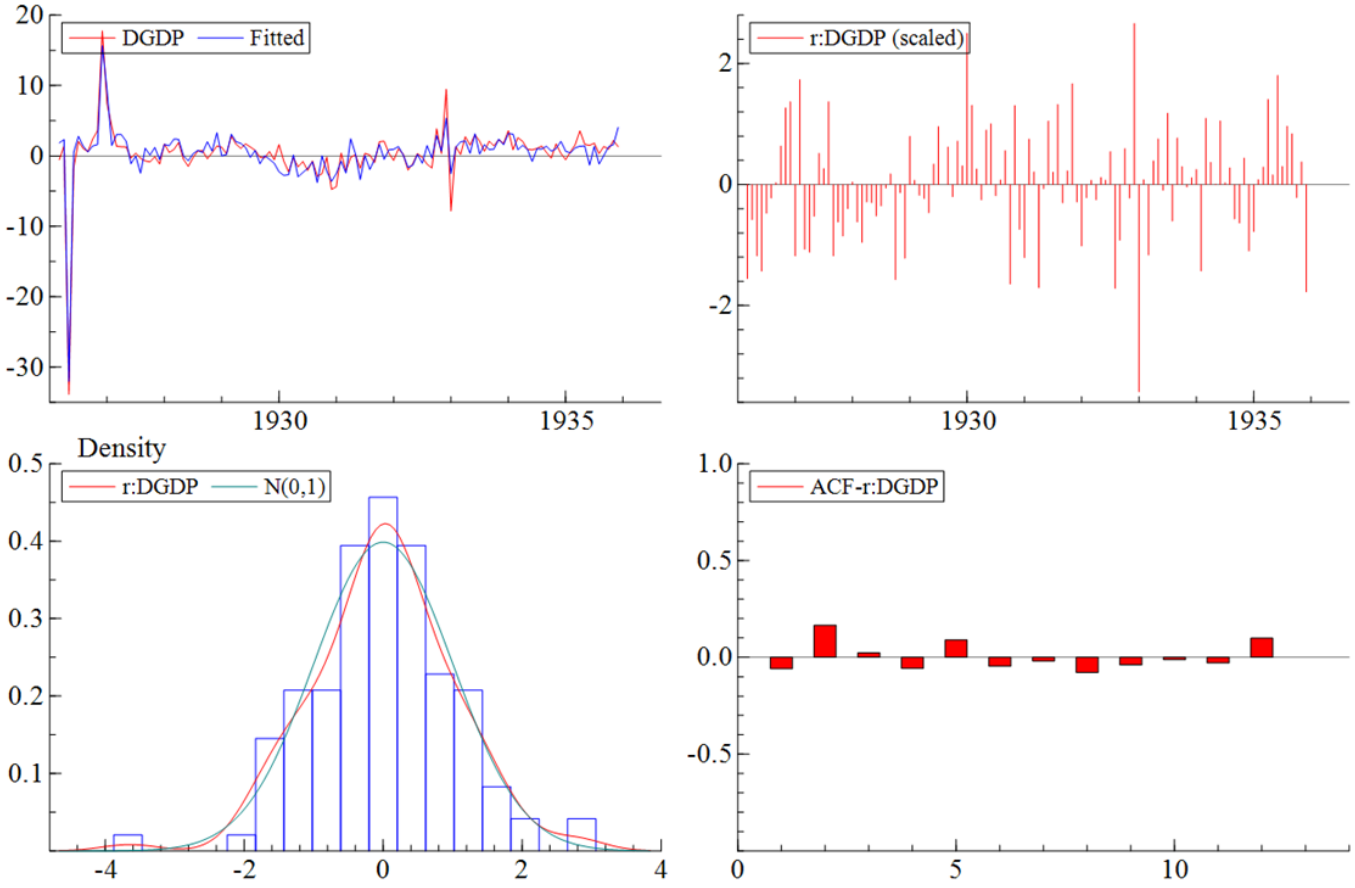


Figure 44: UK GDP – unobserved components analysis

Output Analysis –US interwar growth fluctuations

Variable table

Variable	Description	Notes	Source
IPM	Industrial Production	Total Index Vintage: 2022-07-15, Index 2017=100,nsa	NBER
TOLN	Credit - All Other Loans	Reporting Member Banks, Federal Reserve System US, $ Billions nsa	NBER
DR	Discount rates %pa	Discount Rates, Federal Reserve Bank of New York US % nsa	NBER
EPU	US Economic policy uncertainty index	Average 1920-38 = 100	EPU Historical policyuncertainty.com
ER	US to UK Exchange rate	$'s per £	Craighead (2010), Federal Reserve Board and ONS
ER_Fr	France to US Exchange rate	Franc's per $	NBER, calculations
ER_Ge	Germany to US Exchange rate	Marks's per $100	NBER, calculations
LR	Bank Rates on Customer Loans	Leading Cities for United States, % nsa	NBER
Emp	Index of Factory Employment	Total Durable Goods Index 1923-1925=100	NBER
Un	Unemployment	Insured Workers Unemployed for United Kingdom Vintage: 2005-08-01, Percent of Total, Monthly, Not Seasonally Adjusted	NBER
Inc	Index of Composite Wages	Index 1926=100, nsa	NBER
Share	Stock Price Index	Dow-Jones Industrial , $ per Share, nsa	NBER
FRB Cash	Narrow money	Cash Reserves of Federal Reserve Banks Vintage: 2005-08-01, $ Billions of Dollars, nsa	NBER
MS	Broad money	Money Stock, Commercial Banks Plus Currency Held by Public for United States Vintage: 2005-08-01, Billions of Dollars, Monthly, Seasonally Adjusted	NBER
WP	Index of Wholesale Prices	Index 1957-1959=100, nsa	NBER
CPI	Consumer Price Index	All Items for US Index 1957-1959=100, nsa	NBER
TBILL	Yields on Short-Term United States Securities	, Three-Six Month Treasury Notes and Certificates, Three Month Treasury Bills for United States % pa, nsa	NBER
Bond	Yield on Long-Term US Bonds	Vintage: 2005-08-01, %, nsa	NBER
UKSi	Steel Output for UK	Thousands of Long Tons per avg day, Monthly, nsa	NBER
FrSl	Raw Steel Output for France	Thousands of Metric Tons, Monthly, nsa	NBER
GeSl	Raw Steel Output for Germany	Thousands of Metric Tons, Monthly, nsa	NBER
UK_EPU	UK EPU index	Average 1920-38 = 100	Lennard - EPU Historical policyuncertainty.com

Figure 45: US interwar growth fluctuations – variable tables

Variable chart

The first difference of the variables is presented below.

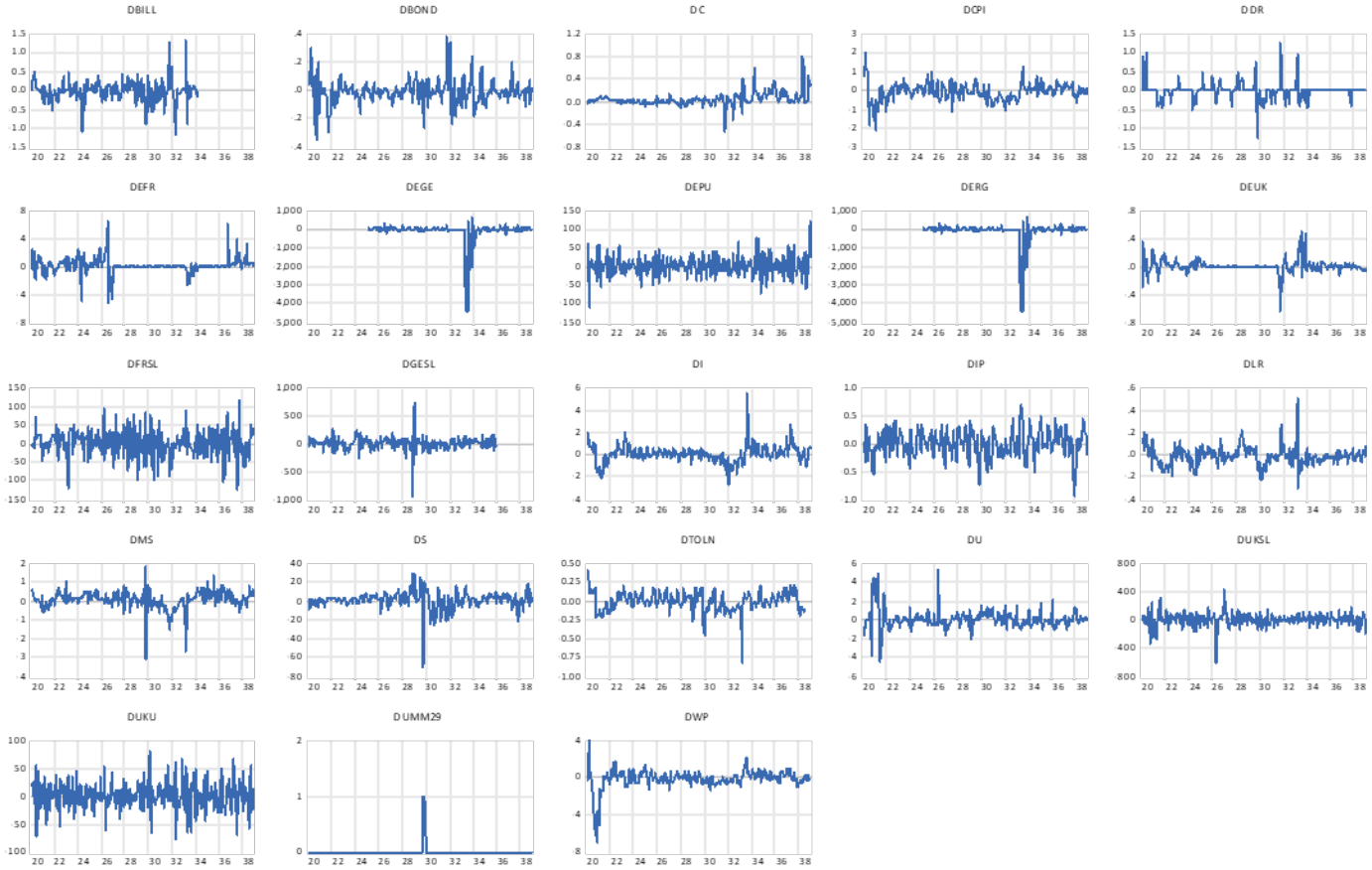


Figure 46: US interwar growth fluctuations – variable charts

Variable testing – Unit root

Unit roots are taken to test for stationarity and the results indicate that all of the variables are stationary at first difference. Consideration of the ADF and KPSS unit roots tests is given the results of the ADF are presented below.

UNIT ROOT TEST RESULTS TABLE (ADF)

Null Hypothesis: the variable has a unit root

At Level

		IP	CPI	DR	FRSL	UKU	ERFR	ERGE	UN	INC	SHARE	MS	WP	UKSL	GESL
With Constant	t-Statistic	-2.1784	-1.7247	-1.6771	-2.2930	-5.4953	-0.7992	-0.7835	-2.9406	-1.0512	-1.4806	-1.1760	-4.2509	-3.2915	-2.1593
	Prob.	*0.2149*	*0.4174*	*0.441*	*0.1751*	*0.0000*	*0.8171*	*0.8208*	*0.0424*	*0.7349*	*0.5418*	*0.6851*	*0.0007*	*0.0164*	*0.2221*
		n0	n0	n0	n0	***	n0	n0	**	n0	n0	n0	***	**	n0
With Constant & Trend	t-Statistic	-2.1924	-1.8169	-2.8687	-1.8128	-5.5630	-1.1753	-2.4706	-2.8042	-1.4845	-1.4529	-1.3411	-4.7581	-3.7657	-2.1686
	Prob.	*0.4909*	*0.6935*	*0.174*	*0.6955*	*0.0000*	*0.9124*	*0.3423*	*0.1974*	*0.8323*	*0.8426*	*0.8749*	*0.0007*	*0.0201*	*0.5039*
		n0	n0	n0	n0	***	n0	n0	n0	n0	n0	n0	***	**	n0
Without Constant & Trend	t-Statistic	0.4164	-1.7469	-1.793	0.2782	-1.2179	0.8379	-1.1695	-0.5192	0.5272	-0.3767	0.6398	-1.7661	-1.1312	-0.1765
	Prob.	*0.8023*	*0.0766*	*0.0694*	*0.7658*	*0.2045*	*0.8912*	*0.2205*	*0.4909*	*0.8290*	*0.5478*	*0.8537*	*0.0735*	*0.2344*	*0.6214*
		n0	*	*	n0	n0	n0	n0	n0	n0	n0	n0	*	n0	n0

At First Difference

		d(IP)	d(CPI)	d(DR)	d(FRSL)	d(UKU)	d(ERFR)	d(ERGE)	d(UN)	d(INC)	d(SHARE)	d(MS)	d(WP)	d(UKSL)	d(GESL)
With Constant	t-Statistic	-4.8099	-8.3539	-11.681	-22.8234	-15.3326	-12.7372	-4.4274	-10.7634	-8.1785	-10.6092	-5.1248	-6.0432	-7.1538	-19.0007
	Prob.	*0.0001*	*0.0000*	*0.000*	*0.0000*	*0.0000*	*0.0000*	*0.0004*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
		***	***	***	***	***	***	***	***	***	***	***	***	***	***
With Constant & Trend	t-Statistic	-4.8100	-8.3968	-11.650	-22.9688	-15.3033	-12.7490	-4.4263	-10.7906	-8.2403	-10.5904	-5.1196	-6.1796	-9.6178	-18.9503
	Prob.	*0.0006*	*0.0000*	*0.000*	*0.0000*	*0.0000*	*0.0000*	*0.0026*	*0.0000*	*0.0000*	*0.0000*	*0.0002*	*0.0000*	*0.0000*	*0.0000*
		***	***	***	***	***	***	***	***	***	***	***	***	***	***
Without Constant & Trend	t-Statistic	-4.7767	-8.1854	-11.615	-22.8095	-15.3669	-12.6828	-4.3088	-10.7755	-8.1690	-10.6283	-5.0661	-5.9489	-9.6612	-19.0329
	Prob.	*0.0000*	*0.0000*	*0.000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
		***	***	***	***	***	***	***	***	***	***	***	***	***	***

Notes:

a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% an

b: Lag Length based on SIC

c: Probabilitybased on MacKinnon (1996) one-sided p-values.

Figure 47: US interwar growth fluctuations – variable unit roots

GETS model – parsimonious form

The parsimonious form of the model is shown below. The outputs indicate that the industrial production is impacted upon by lagged values, uncertainty both UK and US, wages, monetary aggregates, unemployment, bank lending rates, as well as to a certain extent foreign (German) output and whole sale prices. The variables that dropped out were the financial market yields, exchange rates., foreign demand (UK and France) understandable given that UK and France shifted preferences for trade in this period.

```
       The estimation sample is: 1926(3) - 1934(3)

                 Coefficient  Std.Error  t-value  t-prob Part.R^2
DIP_1               0.595126    0.05890     10.1  0.0000   0.5576
DIP_2              -0.182310    0.05063    -3.60  0.0005   0.1380
DIP_7               0.181692    0.04352     4.17  0.0001   0.1771
DIP_12              0.384178    0.05410     7.10  0.0000   0.3837
DIP_13             -0.456664    0.06241    -7.32  0.0000   0.3980
DEPU_3           0.00277996  0.0004809     5.78  0.0000   0.2921
DGESL_1         0.000205983  7.089e-05     2.91  0.0047   0.0944
DLR_3               0.422536     0.1077     3.92  0.0002   0.1596
DMS                 0.103751    0.01797     5.77  0.0000   0.2915
DTOLN_1            -0.271138    0.08177    -3.32  0.0014   0.1195
DU_3                0.0620142   0.01315     4.71  0.0000   0.2153
DUKU_10          -0.00134574  0.0004168    -3.23  0.0018   0.1140
DWP                 0.0741210   0.02101     3.53  0.0007   0.1331
DWP_3              -0.0576888   0.02099    -2.75  0.0074   0.0853
Dumm29             -0.223119    0.06288    -3.55  0.0006   0.1345
DC_5                0.330634     0.1110     2.98  0.0038   0.0988

sigma               0.101118  RSS               0.828207494
R^2                 0.878189  log-likelihood        93.3783
no. of observations       97  no. of parameters           16
mean(DIP)        -0.00916598  se(DIP)               0.266291

AR 1-6 test:     F(6,75)   =   2.1293 [0.0597]
ARCH 1-6 test:   F(6,85)   =   1.3283 [0.2536]
Normality test:  Chi^2(2)  =   1.9619 [0.3750]
Hetero test:     F(31,65)  =  0.73054 [0.8302]
```

Figure 48: US GETS analysis

Overall the above results are in line with the historical episode narrative analysis in Chapter 2.

The diagnostics tests indicate the model is a reasonable fit without indication for autocorrelation, heteroskedasticity and normal distribution of residuals as shown above.

Granger linear causality results

The table below shows the results of the bivariate linear causality tests, as described above, between the UK EPU index and the UK business cycle as well as between US EPU index and the US business cycle. In order to consider the relationship to the great crash if any, the outputs are presented with respect to the precrash and post-crash sample periods.(Across both periods Standard procedures are used to identify lag length with variation of maximum lag length between 4-12.)

	Pre crisis	After crisis
UK EPU to UK Business Cycle	3.17**	3.04*
US EPU to US Business Cycle	1.81*	2.11*

*Significance at the 10% conventional level. **Significance at the 5% conventional level.

Figure 49: EPU to BC Causality

The outputs above indicate there is potentially significant evidence of causality between the EPU index of the UK and US with the respective business cycles. Further analysis for the spill over of UK (US) uncertainty onto each of the other major economies of the period, US (UK), France and Germany.

Results - UK Business cycle (BC) spill over

Linear causality

The table below shows the results of the bivariate linear causality tests, as described in chapter 8b. above, between the UK EPU index and the respective BC for the US, France and Germany. In order to consider the relationship to the great crash if any, the outputs are presented with respect to the precrash and post-crash sample periods. Across both periods and for both linear and non-linear analysis standard (AIC) procedures are used to identify lag length with variation of maximum lag length between 4-14.

UK EPU to BC	Pre crisis	After crisis
US	2.12*	1.96** (full period 1.78**)
France	0.78	2.02**
Germany	0.97	1.40

*Significance at the 10% conventional level. **Significance at the 5% conventional level.

Figure 50: UK EPU spill over

Non-linear causality

The table below shows the results of the bivariate non-linear causality tests, as described in chapter 8b. above, using the DP method, between the UK EPU index and the respective BC for the US, France and Germany. In order to consider the relationship to the great crash if any, the outputs are presented with respect to the precrash and full sample periods.

UK EPU to BC	Pre crisis	Full period
US	0.48	1.75**
France	0.38	1.99**
Germany	0.85	0.83

*Significance at the 10% conventional level. **Significance at the 5% conventional level.

Figure 51: US EPU spill over

Results

The above tables show linear causality and nonlinear causality results for the pre major crisis period (1920-1929) and post crisis period, all the data for BCs start in 1920 with German data extending to 1935 and the rest to 1938, respectively.

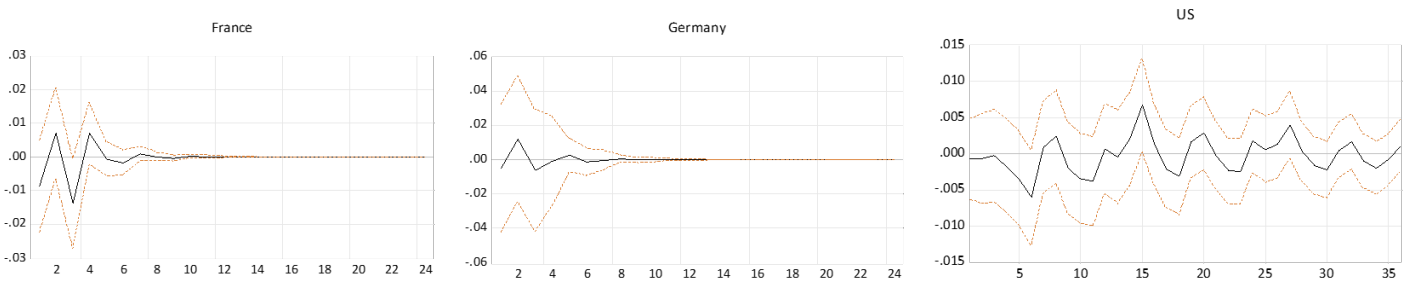
In the linear results the full sample (1920-38) which includes the great crash period, there is significant evidence of linear spill over effect of UK EPU onto the US BC. Using the post crisis sample (1930–38), there is some evidence of causality for both US and France. For the precrisis period US BC, there is significant causality from the UK EPU. The results for Germany do not show statistically significant indication of causality. The weak elements within the French and German are potentially a result of the volatile relations between these countries due to the post-war Treaty of Versailles and competition for influence in Europe between UK and France, as well as the post war slump in France and UK with Germany also hampered with hyperinflation as per James (2002).

In the non-linear causality test results. Within the total sample period, there is indication of significant evidence of non-linear causality from the UK EPU to the BC for the US and France. The results for Germany do not show statistically significant indication of causality. There is no significant indication of causality in the pre crises period.

As could be presumed, there appears some significant results of greater causality from UK EPU to the other BCs when the crisis period is included in the analysis. This is indicated within elements of the linear and non-linear analysis The change to the causality when including the crisis period could be related with the change to economic uncertainty during the period and also given the remaining influence of the UK for global macro transitions. The outputs above indicate there is potentially significant evidence of causality between the UK EPU index with the respective economy business cycles. Further analysis for the impulse response functions is presented below.

Impulse response functions

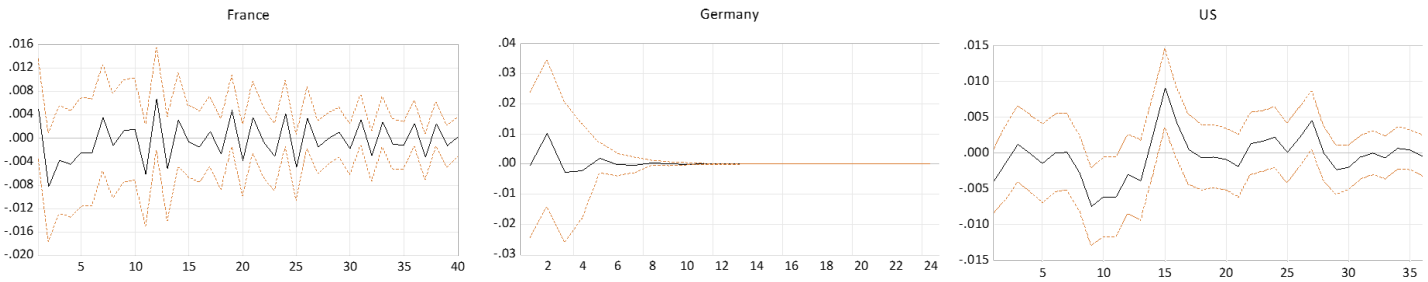
The charts below show the pre-crisis period impulse response functions.



Response of BC to UK EPU Cholesky One S.D. (d.f. adjusted) Innovation ± 2 analytic asymptotic S.E.s

Figure 52: UK EPU impulse spill over – pre 1929

The charts below show the full period impulse response functions.



Response of BC to UK EPU Cholesky One S.D. (d.f. adjusted) Innovation ± 2 analytic asymptotic S.E.s

Figure 53: UK EPU impulse spill over – full period

The above charts show the impulse response functions to a one-standard deviation shock to the uncertainty index for the pre major crisis period and total period with German data extending to 1935 and the rest to 1938, respectively. Within the VAR set up the impulse variable is the UK EPU and the response variable is the BC of the other countries, the concept is to trace out responsiveness of these response variable to shocks in the impulse variable. The outputs indicate that the responses of BCs are relatively significant across the samples. The France and US BC responses are longer lasting than compared to Germany. With the total period the lowest value for the French BC is reached after 2-3 months for Germany and around month 9 for the US. For Germany the return to pre shock level is by around month 6 where as for the UK it is after 35 months and for France it is after month 40 in the total period samples.

Comparing against the precrash period the France total period response indicates significantly more fluctuation over a longer duration before returning to the earlier level. The German total period response also shows more fluctuation before returning compared to the precrash outputs. The US precrash shows more of a similar drop in the shorter sample however slightly more of a spread in duration of the fluctuation in the total period. Overall, the outputs of the Impulse response analysis support the findings of the causality tests to indicate that there is more apparently significant spill over to US and France as well as displaying the more longer lasting impact and hence potential relevance of the UK EPU upon the on the production of the three other major economies in this period.

Results - US Business cycle spill over

Linear causality

The table below shows the results of the bivariate linear causality tests, as described in chapter 8b. above, between the US EPU index and the respective BC for the UK, France and Germany. In order to consider the relationship to the great crash if any, the outputs are presented with respect to the precrash and post-crash sample periods. Across both periods and for both linear and non-linear analysis standard procedures are used to identify lag length with variation of maximum lag length between 4-8.

US EPU to BC	Pre crisis	After crisis
UK	3.17**	3.04*
France	1.81*	2.11*
Germany	0.71	3.01*

*Significance at the 10% conventional level. **Significance at the 5% conventional level.

Figure 54: US EPU to BC spill over Causality – split period

Further analysis for the non-linear causality is presented below.

Non-linear causality

The table below shows the results of the bivariate non-linear causality tests, as described in chapter 8b. above, using the DP method, between the US EPU index and the respective BC for the UK, France and Germany. In order to consider the relationship to the great crash if any, the outputs are presented with respect to the precrash and full sample periods.

US EPU to BC	Pre crisis	Full period
UK	1.40*	1.68**
France	1.10	1.97**
Germany	0.63	0.52

*Significance at the 10% conventional level. **Significance at the 5% conventional level.

Figure 55: US EPU to BC spill over Causality – full period

Results

The above tables show linear causality and nonlinear causality results for the pre major crisis period (1920-1929) and post crisis period, all the data for BCs start in 1920 with German data extending to 1935 and the rest to 1938, respectively.

In the linear results the using the post crisis sample (1930–38), there is some evidence of causality for all countries, Germany, UK and France. For the precrisis period for UK BC, there is significant causality from the US EPU.

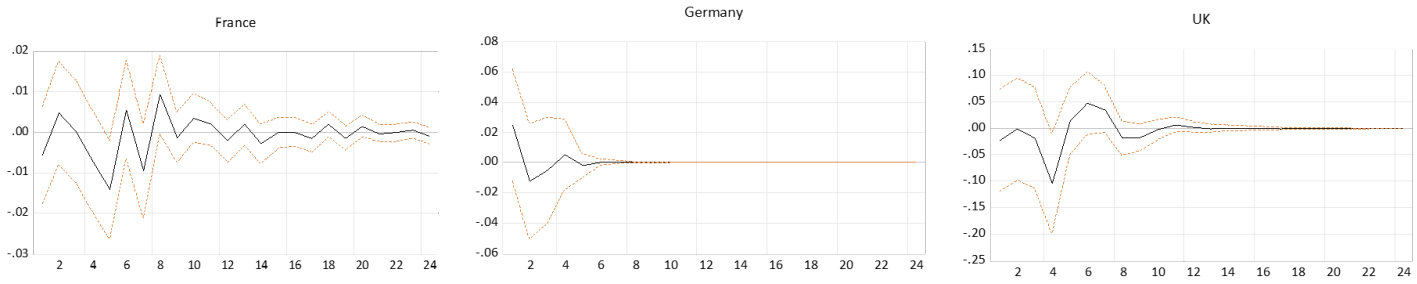
In the non-linear causality test results. Within the total sample period, there is indication of significant evidence of non-linear causality from the US EPU to the BC for the US and France. The results for Germany do not show statistically significant indication of causality. The weak elements within the German results are potentially due to the changing dynamics between the countries with end of the original Dawes Plan and Young Plan of financial support, with Germany also hampered with hyperinflation as per James (2002).There is some significant indication of causality in the pre crises period for the UK BC.

As could be presumed, there appears some results of greater causality from US EPU to the other BCs when the crisis period is included in the analysis. This is indicated within elements of the linear and non-linear analysis The change to the causality when including the crisis period could be related with the change to economic uncertainty during the period especially with the great crash and subsequent other events in Europe like the 1931 Credit Anstalt collapse. As well as given the increasing influence of the US for global investment

and capital flows that accelerated in the post war period. The outputs above indicate there is potentially significant evidence of causality between the US EPU index with the respective economy business cycles. Further analysis for the impulse response functions is presented below.

Impulse response functions

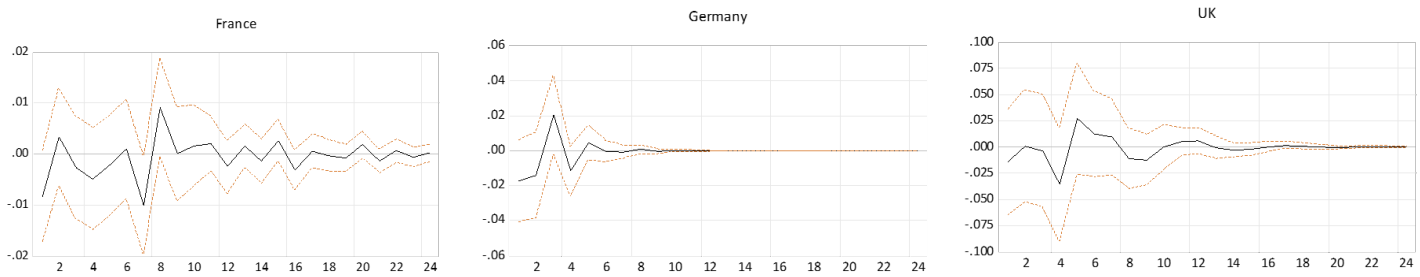
The charts below show the pre-crisis period impulse response functions.



Response of BC to US EPU Cholesky One S.D. (d.f. adjusted) Innovation ± 2 analytic asymptotic S.E.s

Figure 56: US EPU to BC Impulse response – pre-crisis

The charts below show the full period impulse response functions.



Response of BC to US EPU Cholesky One S.D. (d.f. adjusted) Innovation ± 2 analytic asymptotic S.E.s

Figure 57: US EPU to BC Impulse response – full period

The above charts show the impulse response functions to a one-standard deviation shock to the uncertainty index for the pre major crisis period and total period with German data extending to 1935 and the rest to 1938, respectively. Within the VAR set up the impulse variable is the US EPU and the response variable is the BC, the concept is to trace out responsiveness of these response variable to shocks in the impulse variable. The outputs indicate that the responses of BCs are relatively significant across the sample The France and UK BC responses are longer lasting than compared to Germany. With the total period the lowest value for the French BC is reached after 6 months sand at month 4 for Germany and the UK. For Germany the return to pre shock level is by around month 8 where as for the UK it is around 12 months and for France it is around month 22.

Comparing against the precrash period the France total period response indicates more fluctuation over a longer duration before returning to the earlier level. The German total period response also shows more fluctuation before returning compared to the precrash outputs. The UK precrash shows more of a drop to -1% in the shorter sample however slightly more fluctuation in the total period. Overall, the outputs of the Impulse response analysis support the findings of the causality tests to indicate that there is more apparently

significant spill over to UK and France as well as displaying the more longer lasting impact and hence potential relevance of the US EPU upon the on the production of the three other major economies in this period.

g. Concluding remarks

This chapter has explored the empirical relationship between uncertainty and the business cycle of the UK and US. In terms of the following principle questions which are considered for the duration of the 1920-40 period for the UK and US, the economic and econometric analysis finds that:

i. policy uncertainty as measured through the EPU index is a relevant explanatory variable for UK business cycle fluctuations in the interwar period
ii. policy uncertainty as measured through the EPU index is a relevant explanatory variable for US business cycle fluctuations in the interwar period
iii. UK economic uncertainty did Granger Cause (linear and non-linear variants) economic activities of the major global economies of the interwar period, namely the US and France, although less significant results for Germany
iv. US economic uncertainty did Granger Cause (linear and non-linear variants) economic activities of the major global economies of the interwar period, namely the US and France, although less significant results for non-linear causality with respect to Germany

Chapter 4: Uncertainty and global market distortions in the US and UK

No man is an Iland, intire of it selfe; every man is a peece of the Continent, a part of the maine;

John Donne

a. Introduction

The aims of this chapter include exploring the relationship between business cycles, uncertainty and market distortions. The analysis of such fluctuations is supported through consideration of comparison between the UK and US interwar period fluctuations These similarities are explored through a review of the relevant literature, theories and empirical analysis. Furthermore econometric models are used to enhance potential contributions to the existing literature.

The following subsections seek to combine the aforementioned conception of Knightian uncertainty with the most recent and encompassing theory explaining the underlying cause of crises, seen in the work of Greenwald et al (2012) which provides an explanation based on structural imbalances which caused the Great Depression.

The initial step is to show how the aforementioned uncertainty, developed here based upon the work of Knight (1921) on risk and uncertainty, can be used to explain the accelerated build-up of market distortions which led to the formation of sectoral imbalances that form the genesis of the Greenwald et al (2012) explanation for the deep and prolonged crisis of the 1930's.

The next step is to show that following the impact of a major financial or other shock and the onset of a crises, particularly one with antecedents from deeper structural causes, that fluctuation in components of uncertainty can exacerbate the impact and prolong the duration of time before a recovery of economic activity. The economic recovery is stymied by the continuing role of uncertainty fluctuations in reinforcing the prevailing negative market distortions and hence the exacerbation of sectoral imbalances identified by Greenwald (2012) et al.

The proceeding sections of this chapter consider the development of the conception of crises theories from which potential gaps and contributions are noted. Then further comparative analysis is undertaken of the UK vs US experiences of the period. Proceeding to potential stylised facts with a comparison of factors identified as contributing towards the prolonged depression which was experienced by the US during the 1930's including the role of uncertainty.

b. Literature review

A number of studies have considered the similarities between past economic crises and given credence to making comparisons with the great depression of the 1930s. In this section the most prominent of these studies are reviewed and in particular the developments in theories of crises are then given further treatment

with respect to the relevance and potential insights that can be contextualised with the insights of uncertainty fluctuations.

Similarities between historical crises theories and relevance

A prominent study of past crisis was undertaken by Reinhart and Rogoff (2009a) in considering the post 2008 recession and exploring the fundamental question as to whether ' this time is different' or whether there are indeed parallels and lessons to be learned from past crisis events. In this manner, studies of previous crisis events have found a number of macro factors identifiable as being of relevance and recuring 'themes' as shown by the selection below,

The work of Bernanke (2008) has often drawn upon the insights of the great depression and attempted to build a deeper understanding of relevant macro factors that contributed to the depth of the depression, including 'sticky wages' and monetary policy. Further, the more recent work of Greenwald (2012) has also developed an approach to understanding the 2008 crisis with respect to sectoral imbalances and considers the great depression as an earlier example of structural imbalances particularly in the US, where the imbalances led a potential recession into becoming a much greater depression. The work of Accominotti and Eichengreen (2016) as well as Eichengreen et al. (2008) has considered capital flow reversals as being a prominent primary cause of a number of crisis event including the great depression.

With respect to the current post pandemic period there are potential parallels to be drawn with the earlier pre depression period in the 1920s. The work of Barro and Ursua (2020) highlights the impact of the 1918 pandemic ('Spanish Flu'). Hence indicates the relevance of this current study in exploring that period with respect to gaining insights of how current circumstances may evolve.

Sectoral imbalance theories

In the following sub-section consideration is given to an alternative perspective upon the underlying cause of the great recession and the great depression. This begins with the Gatti et al (2012) critique of the financial or balance sheet view of a recession and other perspectives upon crises. Then consideration is given to the theory of sectoral imbalances which indicates that significant structural impediments need to be overcome, in order to bring the economy out of a crisis. Further this perspective is analysed in the context of the resonance with Schumpeter's theory of creative destruction which itself is underlined by a unique role for credit in the capitalist economy. This review is followed by mention of potential areas of interest which can enhance the exploratory power of the sectoral imbalance theory, in relation to the empirical reality, which includes both quantitative factor analysis.

In relation to the Great Recession, much of the aforementioned literature gives primacy to the notion of the crisis being due to the excesses of the financial sector and increased debt overhang causing the downturn to be prolonged beyond expectations. However, Gatti et al (2012) consider that the misdiagnosis from an institutional perspective was centred around the financial causes hence the policy approach taken was to focus

upon restoration of the financial infrastructure. Hence the envisaged outcome would be a return to health for the real sector given that this was a result of the detrimental overleveraged risk taking within the banking sector and related firms. Hence the authorities across most of the G7 nations and in particular the UK and the US were able to give credibility to an 'unpopular bailout' of the banking system. There were various schemes primarily designed to be of a short-term nature such as TARP (US asset transfer to remove and other mechanisms to isolate the bad assets of the banking sector and largely maintain the predominate firms in the sector. With one or two sacrifices such as Lehman Brothers and Bear Sterns in the US whilst in the UK comparatively only very small firms were allowed to fail such as Northern Rock and Bradford and Bingley. Hence largely the sector was preserved albeit as per Greenwald and Stiglitz (2003) there was some risk of moral hazard in future which is the opposite of the approach taken by the IMF and US Treasury in the case of an earlier financial crisis in East Asia. Gatti et al (2012) identify a number of reasons why the prognosis of the crisis being mainly of a financial construction is indicated through the duration of the recovery period. Zarnowitz (1992) had already identified that a 'typical' recession during which there was a banking panic would be more severe than without a banking panic but also should be followed by a more rapid recovery, which was not the case in 1930s or in 2008. The significant aspects which indicate the adverse findings against the financial sector based hypothesis are the ineffectiveness of interest rate policy, the investment dynamics, the deaveraging of household balance sheets being relatively immaterial, the global impact dynamics of the crisis amongst differing economies and the number of crisis occurring during the so called 'great moderation' era.

The ineffectiveness of the central bank policy is apparent in as much that the unconventional measure of quantitative easing has persisted over a longer duration than expected in the US , UK and particularly in the Eurozone with the ECB still actively engaging in forms of quantitative easing with plans for an extension to the LTRO (low interest lending from the ECB to the banking sector) as indicated by the ECB (2019) in 2020 and beyond. Further the ECB has maintained low to negative rates over a number of years, the Bank of England has maintained historically low rates and the Federal Reserve has also maintained near zero-rates for a prolonged duration. The result in terms of stimulation to the real economy has been severely lacking with continuing strain on SME lending and persistent declines in local and regional bank activity. Gatti et al (2012) indicate that it is difficult to disentangle between the real and financial sector because they are 'intertwined', hence identification of causality is made much more difficult to ascertain. However, they find that there should be a more significant investment issue if finance was a major factor. Instead they find that in the US investments as a share of GDP is around 10% (in 2012) whereas the post war average is around 10.7% further industrial/commercial lending was around $1.3 trillion in 2011 and at the same level in 2007. Although there is a trend towards increased cash to asset ratios for firms, the wok of Bates, Kahle and Stultz (2009) indicates that this is a longer-term trend and not necessarily a result of the crises. Such that between 1980 and 2006 cash to assets ratios doubled in the US, the reason seems to relate to the changing dynamics of the operating model for firms. Such that inventories have declined and hence cash flow risks have risen, with lower capital

expenditure but higher research and development costs. Hence the higher buffer is a natural result of the increased uncertainty level and post 2008 credit crunch conditions which make holding cash a precautionary measure. They further argue that the decline in real estate investment is a reflection of natural market correction process due to the irrational excess of the pre 2007 period. In further support of the position is the persistently low real interest rates during the 2011 inflation was approximately at 2% with real treasury bill rates below zero and very low prime lending rates of approximately 1%. This is compared to the Great Depression when prices were falling by almost 10% on an annual basis making real rates very high. This puts into dispute the efficacy of interest rate policy approaches. Conventional models of the economy do not factor in the process of credit rationing as explained in Stiglitz and Weiss (1981), however by 2011 at least 3 years after the crisis for larger firms investment does not appear constrained by credit limitation given the continued investment and availability of cash on the balance sheet.

The case for the deleveraging of household balance sheets also appears flawed due to the very slow nature of the process and given that in the US up to 2011, Moody's estimated 14 million home owners were facing the pressure of negative equity in their home loans. Furthermore, Gatti et al (2012) identify that full employment in the US appears to depend on high level of consumer spending. Dynan, Skinner and Zeldes (2004) identify that cross-income distribution quintiles, with the lowest band in the US having a zero savings rate whereas the top quintile has a savings rate of 25%. In a more in depth perspective, they show that the higher income households with 40% of total income save at a rate of 15% which accounts for 6% of the total savings rate, with the US having a total savings rate of around zero, the lower income households with 60% of total income must 'dis-save' at a rate of 6% a year that is they must spend at a rate of 110% of income on an annual basis.

In addition, Greenwald et al (2012) identify that countries with the onset of the global extension of the initial financial crisis, that even countries without overtly financial sector based economies like Finland, Japan, Denmark and Italy faced slower recoveries than the US and UK. Two countries which both have larger share of the economy related to the financial sector than other economies more adversely impacted in the longer term. Such that in countries such as Spain, Greece and Portugal the trigger appears in the real economy before traversing to the financial sector.

Another aspect is the pre-crisis discourse surrounding the 'great moderation' which purports that there was increased stability in the pre-2007 period due to improvements in economic policy and management. However, as the research of Reinhart and Rogoff (2009a) show there has been an increased incidence of crises and the level of severity has also been far higher in each proceeding crisis event in the post 1945 era. They find that the proportion of countries in the middle of the 1980's that faced external debt crises rose to around 40% and by the later 1990's the proportion experiencing banking crises was around 30% which is a dramatic rise given the contrasts against the 1945 to 1980 period. Hence this is another indicator that there is misalignment in some of the basis for the policy advice and that there are other factors being unaccounted for, which are of a non-financial balance sheet orientation in nature. This is in contrast with Eichengreen (1992)

view of the great depression whose opinion is that the depression was essentially a balance sheet recession extenuated through the gold standard induced deflationary policy and wage rigidities. Greenwald et al (2012) find that in the current crisis it is certainly the case that the extended rate of high unemployment for a number of years for the US economy arguably one of the most highly advanced with the most flexible labour market was difficult to explain given the contrast with a country such as Germany which has a less flexible labour market and suffered a milder recession certainly in terms of impact upon the rate of unemployment.

Greenwald hypothesis of sectoral imbalances

The current financial crisis is of a considerably more severe level in comparison to previous crises as Reinhart and Rogoff (2009b) depict. Due the unforeseen nature and extraordinary depth of the Great Recession including the impact comparisons have been made to the Great Depression. Temin (2010) finds the 'depth and duration' of the 2008 crisis as unseen during the post 1945 experience which has subsequently led to 'renewal of interest' in consideration of the most similar global 'long downturn' which was the Great Depression era. Hence Greenwald et al (2012) draw upon an analysis of the Great Depression in order to explain the circumstance being experienced with the events of the Great Recession. The hypothesis of the current crisis revolves around the 'real' changes which are impacting upon the economy and this is the magnitude of the rise in productivity within the manufacturing sector on a global scale far exceeds the growth of demand. Subsequently they feel this will cause labour to become 'trapped within a dying sector' and the perspective in relation to the depression is farm workers becoming trapped within the agricultural sector faced with a comparatively similar and rapid increase in productivity. Although there are numerous contributory factors to the escalation of a crises as explained by Greenwald and Stiglitz (2003) these include financial market imperfections and constraints due to asymmetric information leading to credit rationing and other aspects which are explored by Stiglitz (1999) in more depth. The Depression was seen to ignite with the 1929 bubble but then the global banking crises took place 2 years later in 1931 and they give the more recent comparison in 2009, with the example of countries such as Canada which suffered from no major banking crises yet felt a significant economic downturn. Indeed many European countries did not suffer a housing bubble or price collapse nay where near as severe as the US including for example the UK, France and Germany yet the impact of the global crisis was still felt on GDP and to varying degrees upon the rate of unemployment.

Retrospectively it is apparent that there was a select contemporaneous literature from the interwar period which gave prominence to the role of agricultural (sectoral) decline, such as a report of the League of Nations (1931) and also Timoshenko (1932) it is apparent that many of the bank failures within the US were experienced in small rural communities. Chandler (1970) finds that between 1930-31 of the 5,096 bank failures, 3,448 occurred in small rural towns or villages with populations below 2,500. An indication that those most impacted by the productivity rise and falling prices of agricultural goods were to be found in agrarian communities. United States Bureau of the Census (1970) shows the dramatic fall in agricultural revenue such as for example net income after expense went from $9.6 billion in 1919 to $6.3 billion in 1929 and fell to $1.9

billion in 1932 a collapse of nearly 70% in three years. The agricultural population was approximately 30% of the total population in 1920 hence the dramatic three year loss in farm revenue represented 13% of GDP. The model is predicated on a fall in prices due to the rise in productivity which was exacerbated by the general downturn. The decline in income could be due to a fall in the quantities of goods being sold. However, Chandler (1970) identifies that during this time total output was slightly higher in 1931 and 1932 than 1929 hence the decline in prices was the main cause. Which was due to farmers realising that reducing output would not increase the price level. Further the price drop of 56% was imbalanced by a price for inputs dropping by only 32% in this 3 year period.

The expectation would be that in such a scenario of rapidly falling incomes , this would have been incentive for rural workers to move to cities and this is seen to a moderate extent in the 1920's with the population declining from 29.9% to 24.9% up to 1929. However, between 1931 and 1934 there was net inward migration of 700k in agrarian regions as shown by Carter et al., eds (2006), however by 1940 there was a decline to 23.4%. The effective 'trapping' of workers was due to the farmers having assets locked up in rural property, or farm equipment and also perhaps having already taken mortgages or other forms of loans upon their assets, which would have been declining in value and possibly facing the prospect of negative equity upon any property loans. The cost to migrate into urban areas would have been a significant impediment. Harris and Todaro (1970) explore the developmental theories behind migration from rural to industrial or urban sectors with the many obstacles faced. Including credit restraints and potential prospect of subsequent urban employment in a certain respect this is an example of markets in this case for labour not clearing as would be expected in the neoclassical theory of markets. The declining incomes in the rural sector had an impact upon urban incomes given that demand for manufactured goods would have significantly decreased with a consequent negative downward spiral that this would have reduced urban incomes and lessened the demand for urban goods. Although it could be theoretically assumed that the lowering of prices would have provided an increase in urban surplus income. The empirical reality was the contrary as shown by the net migration to rural areas during the depths of the depression.

There are several aspects to the reason for the downward spiral of declining demand to arise between the two sectors intuitively the rural workers would have faced a more immediate adjustment to reductions in income whereas urban workers would have the opportunity to adjust to increased welfare via higher revenues. Furthermore, the differential between the marginal propensity to consume meant the consequences were inevitable. Hansen (1941) finds that the propensity to consume during 1935 for those with incomes less than $500 was around 150% whereas those with incomes above $20,000 was 50% hence as Marriner Eccles (1951) Chair of the Federal Reserve identified the reduction in 'purchasing power' for the mass consumer meant a lowering of 'effective demand' for higher earning savers. Madsen and McAleer (2001) also identifies that the marginal propensity to consume for those with declining incomes was far greater than the propensity to consume for those that would have received welfare gains from declining agricultural prices.

Another significant factor was the declining ability for rural workers to smooth consumption through borrowing Madsen and McAleer (2001) highlights that the drop in incomes combined with decline of assets, increased loan defaults and a rising cost of borrowing which led to a dysfunctional rural banking sector. Chandler (1970) further identifies that between 1930 and 1932 that 68% of bank failures occurred in the rural regions, Friedman and Schwartz (1953) also find that the initial major banking crisis in 1930 began within farming regions and the contagion spread all the more rapidly given that they had already experienced a higher rate of bank failure during the 1920s. Hence the collapse of agricultural income led to a subsequent decline in industrial demand and given as Bell (1940) and also Swanson and Williamson (1972) depict the rigidity of wages meant there was a drastic rise in overall unemployment levels. An additional factor was that the level of uncertainty for those retaining jobs would still be under threat. This is an aspect which has not been covered in the existing literature to a significant extent.

Gatti et al (2012) further identify that ultimately the war was the driving force behind the recovery given that manufacturing for the war effort and the GI Bill necessitated workers move to the cities in order to produce the necessary industrial goods. They consider the case of Argentina which did not participate in the war suffering a much slower recovery given the economic transformation to manufacturing did not receive the same concerted force to move workers into the industrial sector. Gatti et al (2012) depict the war as a provider of 'human and financial capital' to make the transition possible which the New Deal failed to make. Romer (1990) finds that the fiscal expenditure was too limited to have made a significant impact upon GDP. Further Greenwald et al (2012) identify through the perspective of the Great Depression the Great Recession faces a similar long term crisis which revolves around the transition between the manufacturing and service sector as opposed to the earlier structural transformation between the agrarian and industrial economy. Autor and Dorn (2011) find that in the period between 1980 and 2005 'real wage growth' in the lower skill professions was 6% higher per decade for service sector jobs. Bureau of Labour Statistics show that between 1979 to 2011 there was a 76% increase in US employment within the service sector whereas a decline of 39% total decline with 19.6 million employed in 1979, and 7.6 million employed in 2011 the rapid drop of 5.5 million or 71% of the total loss in the period has occurred since 2000.

Schumpeter's theory of economic development and creative destruction

The forces of structural change due to the natural progression of productivity increase in one sector depicted by Greenwald et al (2012) resonate with earlier theories developed by Schumpeter (1939). In the theory of economic development there is a place for a process of creative destruction, in which a new method of production overtakes the old method. During the transitory period there is upheaval given the rate of uptake is uneven between firms and many fail to make the transition. A key facet of the process of change is the role of credit, mentioned previously in some of the literature such as Madsen and McAleer (2001) who finds the significance in the lack of credit for rural workers during the great depression to enable them to make the transition. In addition to credit for any process of consumption smoothing given the decline of incomes.

Chandler (1970) also identifies the critical rate of bank failure within rural regions. Harris and Todaro (1970) explore aspects of theories of rural migration associated with development and here credit constraints are a key factor. Schumpeter (1939) places the role of credit as integral in order for the process of development to occur the entrepreneur needs a method of diverting resources from the pre-existing methods or production and other resources which may include land, materials or labour. The credit creates new purchasing power for the entrepreneur which enables the access to resources before the entrepreneur has fully developed the good or commodity which would otherwise enable the entrepreneur to trade and obtain the purchasing power necessary to continue operation within a normal economic cycle. The credits created through the bank lending channel are usually of a short term nature. The ability of banks to create credit has been explored by others contemporaneous researchers to Schumpeter (1943) such as Hahn (1920), also more recently Gowland (1982) and Perez (2009) this work depicts the process through which the action of bank lending creates new deposits and hence an increase in purchasing power. This new credit is non-inflationary if it is used by the entrepreneur to create new goods and services. The utilisation of bank credit for consumptive purposes or for asset based transactions in excess can be highly inflationary and typically seen during the formation of an asset bubble which occurred in the 1920's with the stock market crash and also with the 1990's Japanese property bubble, and most recently with the 2007 housing bubble which were all proceeded by a number of economic crises. Schumpeter (1939) offers a unique crystallisation of the theory behind the entrepreneurial process of the requirements for new purchasing power. As earlier discussed, the work of Chandler (1970) finds the collapse of credit in the rural sector through incidence of bank failure which then precipitated throughout the economy and this was also an aspect of the Friedman and Schwartz (1963) hypothesis for the prolongation of the depression.

Greenwald et al (2012) find that the downward deflationary of the spiral of the depression was halted through the governmental intervention necessitated by the war effort. The war production proceeded to enact the transition for rural works to move into the industrial sector the result was the uplift of the economy out of a depressed state with a rapid increase in output in all sectors. Schumpeter (1939) identifies that the economic developmental process must require credit or another form of new purchasing power in order to divert resources. This was lacking during the late 1920s up to the mid 1930's as bank lending was contracting and hence the rural labour did not have the means to move out into urban regions and seek employment in the manufacturing sectors. The state intervention provided the means despite the lack of credit. Schumpeter (1939) explains 'that where there is no direct power of disposal by leaders over the means of production, development is in principle impossible without credit'. This direction over the means of production can take as in the case of war a very direct intervention by the state or through adapted bank lending as was seen in the development of Japan and much of East Asia in the post 1945 period. This has been explored in the work of Wade (1990) in the depiction of the 'window guidance' given to the banking sector by the central banking

authorities or the Finance ministries within the economies of South Korea, Taiwan and most recently seen in the development of China explored by Xu and Chen (2012).

Perez (2003) provides an exploration of the way that technological change is intertwined with the financial infrastructure required to enable the transition to new methods of production and organisational changes on a social and institutional level which are necessary to facilitate such transformations. This follows the work of Schumpeter (1939) and builds on the aspects of creative destruction in the which the older methods must necessarily be displaced in order to facilitate the oncoming technologically more advanced systems. This has some resonance within certain aspects of the interwar period in particular for the UK. The UK was throughout the 19th century the most advanced in terms of the technology available for manufacturing and in terms economies of scale. During the early parts of the 20th century advancements in both the methods and scale of production in Germany and in the US meant that many of the UK production facilities were under competitive. As Garside and Greeves (1996) consider it as a form of 'industrial malaise'. The US in particular had advantages of developing forms of mass production and industrial organisation that was on a larger scale and more efficient with higher levels of productivity. Such as the development of mass production lines at the Ford Motor Company. The Bank of England also took part in the process of attempting to rationalise industrial concerns alongside elements of Governmental interest which is also considered by Garside and Greaves (1996) the domestic elements of the interventions in a number of industrial concerns. Tolliday (1987) explores thoroughly the interwar period and the development of 'British Steel' this work identifies the difficulty of the transitory problem for the interventions that were made, alluding to the numerous 'intractable problems' which included cultural and institutional issues. Whereas the US was as per Gatti et al (2012) faced sectoral issues in the more sectoral transition from agriculture to the manufacturing sector the UK had already made this transition during the 19th century.

Discussion of crisis theories

Given the work of Greenwald et al (2012) with regard to the underlying causes of the Great Depression, in which they identify problems that developed in the 1920's and extended into the 1930's heightened through the stock market crash and banking failures. They also allude to some key areas of significance which have been given less consideration in the literature. In the proceeding sections of the thesis an attempt is made to enhance the theory of sectoral imbalances through an empirical investigation utilising quantitative analysis of some key facets that have been hitherto received less consideration in the literature investigating crises and in particular the studies upon the interwar recessionary period of turbulence.

The prior review of great recession and great depression literature has indicated that there was a thread relating to the role of monetary policy and the role of the banking sector in the prolongation of the great depression and crises in general. To a certain extent the literature upon the underlying cause of the depression and recession which considered sectoral imbalances as the primary factor attributes the focus upon purely the financial sector in the current crisis as a misspecification. However, as we consider earlier this analysis is based

around a non-systemic depiction of financial crises, there are further aspects considered within the literature which evaluates more systemic and structural causes, Chandler (1970). This literature on a theoretical level also identifies that the extenuation of the depression was in part attributable to uncertainty within the banking sector which heightened the pre-existing sectoral imbalances. There is therefore some merit in pursuing further investigation into the role of uncertainty and its impact upon bank credit which can subsequently contribute towards extenuation of a downturn. As explored above Schumpeter (1939) identifies bank credit as critical to making economic transformations which have been explained as sectoral shifts in the recent literature Gatti et al (2012).

In attempting to thoroughly consider the role of bank credit and uncertainty there are also concurrent aspects which have been separately covered in the literature with respect to the supply of bank credit and the subsequent impact upon the economy. Since the insightful work of Schumpeter (1939) and other contemporaneous studies into the role of credit and economic growth. Brunner and Meltzer (1963) offered an insightful critique into macroeconomic modelling which has persistently discounted the inclusion of the quantity and price of credit. Bernanke (1983) again also looked into the role of credit in prolonging the depression. Following this work there has been a number of authors which have led to the development of the 'bank credit channel' theories such as Bernanke and Blinder (1988) and Kashyap and Stein (1994). Bernanke and Blinder (1988) identify the possibility that a change in monetary policy can impinge banks given deposits as a form of liquidity funding cannot be substituted the banks would raise interest rates on loans and thus dampen the consumption and investment of economic agents. This was developed further into a 'broad credit channel' theory by Bernanke et al (1999).

The proceeding elements of the study thus consider the relevance of uncertainty, as Schumpeter (1939) states that the 'course of events in periods of depression presents a picture of uncertainty and irregularity' and the focus in on the interwar period, which has received less attention in relation to uncertainty. The role of policy uncertainty is intertwined with other key factors faced by policy makers during periods of crisis. Greenwald et al (2012) identify the potential role for uncertainty in relation to the decision making of those with jobs during periods of high unemployment may cause a further depression of demand or reduce the marginal propensity to consumer. Hence in the great depression uncertainty may have further exacerbated the deflationary pressures.

Summary of prominent theories

In the above subsections, consideration has been given to the literature which focuses upon exploring the underlying causes of the great depression. The work of Greenwald et al (2012) and Schumpeter (1939) gives insight into the relevance of economic transformations which are beyond the normal fluctuations of the business cycle. These theories can explain some of the underlying causes of the great depression and also the great recession through extending but also building upon the existing literature of crises which was explored in Chapter 2. This work also builds upon the analysis of Chandler (1970) and uplifts aspects of the work of

Friedman and Schwartz (1964) in relation to credit restraints which can prolong a crisis. Further Gatti et al (2012) identify trapped labour in US agrarian regions as a further restraint upon the transition towards the manufacturing sector. These notions of farm workers being 'trapped' by both occupational skillset restraints, homes, assets and debt in one sector perhaps leads towards another perspective upon Bernanke's (1994) question over 'why nominal wages did not adjust more quickly' as wage rigidities have been studied as a significant factor in dampening the recovery. Greenwald et al (2012) identify uncertainty of those employed as another restraint due to the uncertainty over future employment stability reducing the marginal propensity to consume.

Uncertainty perceptions and prolonged crises

The crisis literature such as Greenwald et al (2012) also identify uncertainty preventing the recovery due to the perceptions of economic agents after the crisis shock has occurred and the recession has begun. Three elements relating to the perceptions surrounding uncertainty during a crisis period, when the forces sustaining the market distortions have been diminished, may contribute to a slow recovery, they are depicted below:

i) *Uncertainty over future income* – a recovery may fail to materialise due to weak demand despite lower prices for goods and services. This could in part be due to workers retaining their job after a shock has occurred face a heightened risk of future job loss combined with potentially reduced prospects of 're-employment' hence any benefits from lower prices for goods are negated.

ii) *Uncertainty over future credit availability* – a recovery may fail to materialise in part due to weak investment despite opportunities for firms to acquire capital resources and workers at lower rates. Firms may continue to increase cash reserves, due to uncertainty over the prospect of credit markets easing, hence declining to investments.

iii) *Uncertainty over future technological change* – the 'anticipation' of technological change could impose further mobility constraints upon workers through inducing losses and difficulty in moving from one sector of the economy to another. Combined with potential uncertainty for market participants over the rate and nature of future technologically induced productivity adjustments, there could be reduction in aggregate levels of demand.

c. Research gaps and contributions

Research gaps

The review of the crisis literature has highlighted two prominent topics identifiable with the underlying causes of the depth of the great depression, the sectoral imbalances and the capital flow reversals, although the overlap between these two perspectives is not a particularly developed aspect of research. In addition the literature in general with respect to crisis comparison has a limited treatment of the 1920s build up to the 1929 crash.

Hence the following key gaps within the current literature have been identified:

- Sectoral imbalances theories are more domestic in focus and give less treatment to the relevance of international capital flows, as well as trade dynamics
- Capital flow theories lack consideration of sectoral imbalances and structural changes to the respective economies
- The relative difference in depth of depression or recession between the regions often given limited treatment
- Sparse consideration of the similarities between the 1920s post 'Spanish flu' and current pandemic period with respect to macro factors
- Relevance of uncertainty and economic policy uncertainty could be enhanced with respect to studies of the interwar period and the most prominent theories of sectoral imbalances and capital flows

Contributions

The contributions of the current study include the following aspects which are relevant gaps in the current literature.

- Empirical analysis of the differences between the early to mid 1920s period and how this may have relevance to the post 1929 crash period with respect to the two most significant global economies the UK and the US
- Interrelationship between sectoral imbalance and capital flow theories of crisis especially for interwar period and extension of and empirical analysis of sectoral imbalance theories and uncertainty
- Market distortions and policy uncertainty - role of government interventions/major international economic policy shifts
- Financial market volatility spill overs which may interact with policy uncertainty and impact capital flows, trade and the business cycle

d. Comparative analysis

US and UK interwar fluctuations

Fluctuation – recession depth and duration

Empirical exploration of the measures of the fluctuation in business cycles experienced by the UK and the US highlights prominent differences in the experiences. The charts below show that the US amplitude was much greater in terms of rising peaks or output followed by steep falls, where as the UK experienced more gradual increases in output with shorter periods of falling output between 1920 and 1940.

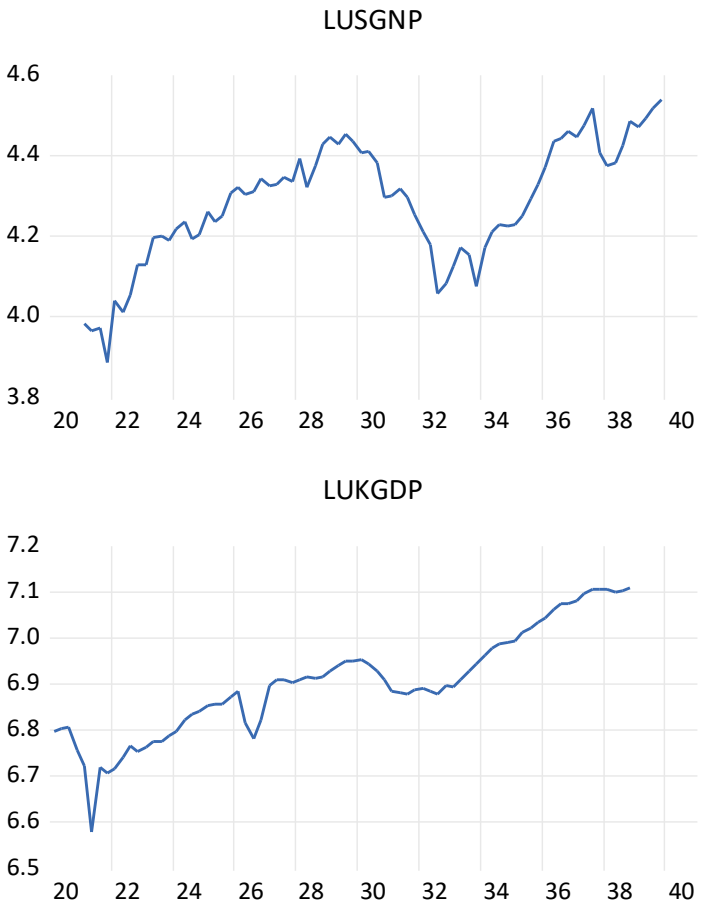


Figure 58: UK GDP & US GNP – 1920 to 1940

Over the interwar period in aggregate the US was in a recessionary state for much longer that the UK as can be seen by the tables below, the US experienced more recessions and the depth of the most significant downturns was of a longer durations. Based on a comparison of NBER business cycle (BC) dating for the US and the work of Broadberry et al. (2022) for the UIK respectively.

Periods	
US Peak	US Trough
1918	1919
1920	1921
1923	1924
1926	1927
1929	1933
1937	1938

Annual - turn points	
UK Peak	UK Trough
1918	1921
1925	1926
1929	1931
1943	1947

Quarterly - turn points			
UK Peak	UK Trough	US Peak	US Trough
1926 Q1	1926 Q3	1926 Q3	1927 Q4
1930 Q1	1932 Q3	1929 Q3	1933 Q1
1943 Q2	1947 Q2	1937 Q2	1938 Q2

Figure 59: UK & US BC dating (based on NBER & Broadberry etc al 2022)

Export fluctuations

Furthermore, as drawn out of the earlier chapter consideration of business cycle fluctuations and relevant components, it is also noted that the relative disparity between fluctuations in exports were also of relevance. The charts below also show that between 1900 and 1940, US exports were greatly accelerated by the start of the war in Europe in 1914 and then saw significant movements between 1920 and 1940. The UK obviously faced export constraints due the onset of war and only saw a partial gradual recovery with notably smaller falls than the US post 1930.

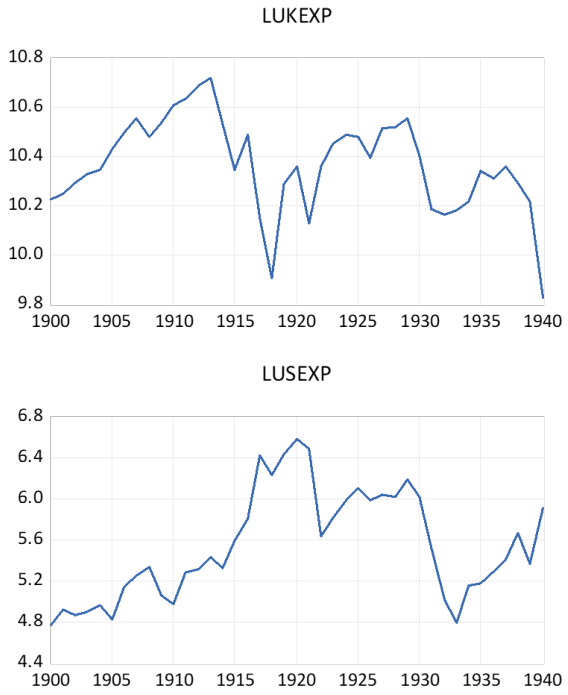


Figure 60: UK & US Exports – 1900 to 1940

Sectoral comparisons

Within the literature Greenwald et al (2012) identify the sectoral imbalances within the US being significant in relation to the shift between agricultural employment and industrial employment being prominent in leading to imbalances which led to a deeper and longer depression. Below for comparison the sectoral components for the US and UK are shown based on US Census Statistics (1970) and ONS (2019) reporting of historical trends. The charts present sectoral employment as per cent of labour in employment in terms of aggregation: Agriculture includes sea faring trades; Production includes manufacturing, construction and mining; Services includes transportation, retail and professional services.

The charts shows that the UK saw a gradual increase in the Service sector employment in the period and most significantly that the agricultural sector was a much smaller component of employment and indicatively of output and/or value added. Whereas for the US agricultural employment and indicatively with respect to output and/or valued added much more prominent. The primary thesis of the literature with respect to sectoral imbalances was that the decline in agricultural employment was marginal in comparison to the

significant increase in in productivity and output during the period. This aspect is further explored in the proceeding subsections.

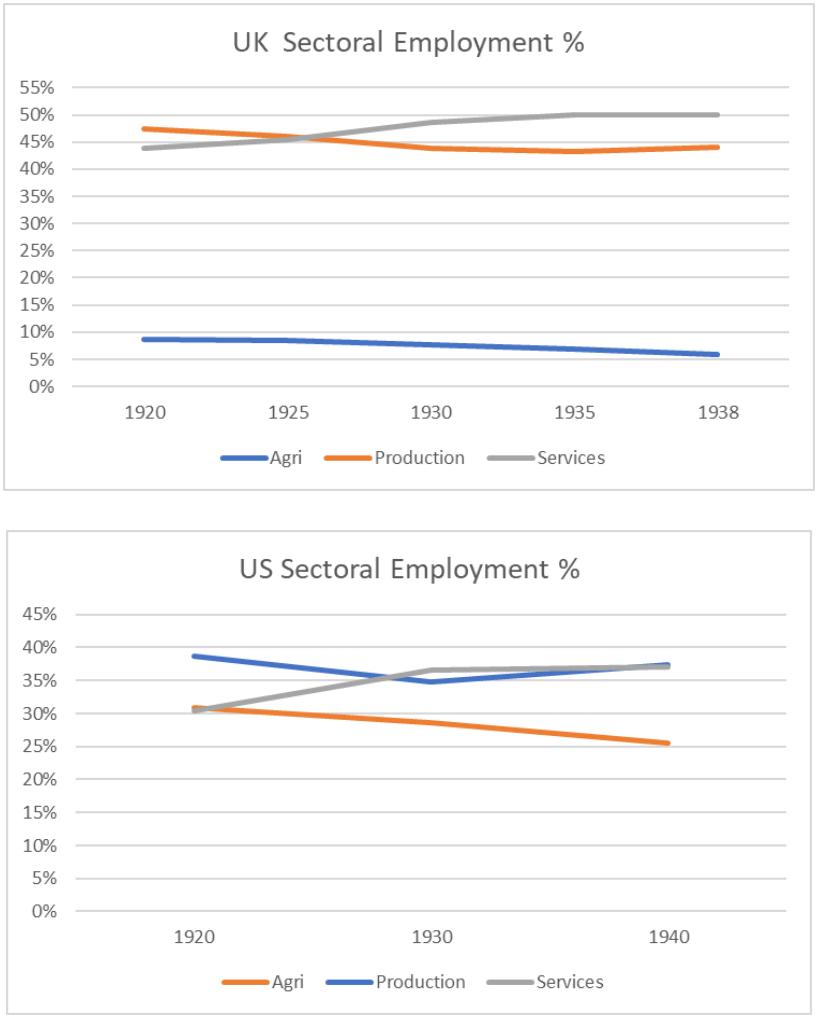


Figure 61: UK & US Employment by sector – 1920 to 1940

Capital flows

During the interwar period Kindleberger (1986) and James (2009) show that the US and UK were major centres for both global financial flows and foreign investment, as well has being major trading economies.

Country	1919–1923	1924–1928	1929–1931	1932–1938
United States	531	1,142	595	28
Britain	416	587	399	143

Figure 62: Average annual long-term capital exports, US and UK, 1919–1938, Mn $. (James 2009)

Hence it is evident that US in particular was a more significant player in international capital movements in the period overall but most significantly during the Dawes Plan period of 1924-8. The collapse of this position was quite severe with almost a complete end to such flows occurring after 1932. In comparison the UKs position was more stable and the decline before 1938 was more gradual.

e. Comparative stylised facts

Based on the prior analysis it is evident that there significant economic fluctuations during the period, the relevance of major events which took place and hence generated market distortions is also a prominent aspect which emerges. The following subsection considers the impact of market distortions with respect to the economic fluctuations through consideration of sectoral productivity, changes to trade dynamics and also with respect to the economic policy uncertainty perspectives.

Stylised facts for market distortions originating from uncertainty

Uncertainty when giving consideration of theoretical market distortions can be perceived to impact the economy in a number of ways, there are short form, mid-form and long form interactions that can occur which distort the actions of market participants as considered within the Greenwald (2012) analysis of the Great Depression.

Short form uncertainty distortions

This can occur as the result of trigger points such as considered by Galbraith (1954) the 1929 stock market crash led to a complete collapse in stock market prices. Similarly, the 2008 collapse of Northern Rock in the UK and Lehman Brothers in the US as considered by Reinhart and Rogoff (2010) led to money markets evaporating as liquidity dried up. This form of market distortion can be traced to short run impact of uncertainty given market participants are initially shocked by the collapse of an asset market such as US securities and equities in 1929 or Mortgage Backed Securities in 2008, they feel unable to price risk hence the liquidity in the market dried up paralysing any market activity.

Mid-term uncertainty distortions

The short term uncertainty usually triggers a market distortion following a significant shock or sudden collapse of a key market participant Galbraith (1954) alludes to the UK Hatry Crisis of 1928/9 as a forerunner to the 1929 stock market crash. However, once a significant shock has occurred and a larger economic crisis emerges uncertainty can also impact the actions of market participants to subvert any possibility for a rapid recovery. Romer (1990) identifies the reduction in consumer expenditures, particularly for durable goods during the 1930s as a factor in the weak recovery and prolonged depression. Greenwald (2012) also identifies a number of ways mid-term uncertainty prevented recovery, such as at the consumer level with those able to retain employment having uncertainty about future income which overrides anu inclination to increase expenditure with lower prices for goods, given the 'weak prospects' of finding another opportunity if they must leave their current role and hence constraining expenditures. In addition, at the firm level, investment making is constrained and hence firms prefer to build up cash assets with uncertainty over the easing of 'credit conditions' and financial frictions subverting any potential investment outlay.

Long form uncertainty distortions

As Knight (1921) identified uncertainty can also create opportunity for the entrepreneur and the ability to derive abnormal profits before other market participants are able to enter the new market or as Schumpeter (1930) outlines a process of creative destruction occurs. During which old forms of production are replaced with new forms and this process can occur beyond the level of the single entrepreneur instead it can occur at the level of economic geographies or market sectors. This perspective has been drawn following consideration of the crisis literature in particular the Greenwald (2102) sectoral imbalance hypothesis as well as the Knightian conception of uncertainty and the literature upon Growth options effects considered by Bloom (2009). A novel conception has been drawn following consideration of these two interrelated existing literatures and theories upon uncertainty and structural causes of crises. This novel construct can be drawn considering the dynamic shifts occurring after 1914 as follows:

- Due to the onset of the Great War, European Agricultural Outputs collapsed
    - Hence an initial period of short term uncertainty for policy makers may have briefly ensued
- US Agricultural sector was incentivised with support from US Agricultural Farm Board Program to increase productivity
    - European Agricultural sectoral collapse provided significant demand for US Agricultural exports
- Post 1920 there remained excess Demand during an initial period of recovery and rebuilding in Europe which was supported by the continuation of US support programmes, during the war this was in the form of loans to the UK which the UK used to provide credit to European Allies and later post war in alternate capital flows to Europe such as through the Dawes Plan.
- Insights of the Greenwald et al (2012) analysis on the formation of sectoral imbalances when considering a closed economy analysis of the US interwar economy especially post 1929.
- Here an adaptation of the Delli Gatti et al (2012) two sector model is used to show the potential formation of market distortions due to uncertainty in one sector, the European Agricultural Sector and the subsequent opportunity for 'certain' returns for the US Agricultural sector due to the excess demand from Europe.

Uncertainty spectrum

The following is an initial simple reduced form representation of a theoretical uncertainty spectrum which can be used as a basic framework for considering the aggregate impact of Knightian uncertainty shifts and the macroeconomic consequences. The following identification of a possible uncertainty spectrum utilises the work of Knight (1921) to put forward a tentative framework through which to apply the concept of Knightian uncertainty in relation to shifts and market distortions which have real effects on the macroeconomy.

A possible interpretation of a payoff function for a Knightian Uncertainty-Risk Spectrum, as per Knight (1921) is such that under uncertainty the returns are perceived to be zero on average. However the entrepreneur can earn above normal profit before conditions change or before other firms replicate the opportunities. Under

conditions in which risk is quantifiable such as 'typical' trading conditions for a 'real' market economy although with asymmetric information, the central part of *the spectrum*, some firms remain likely to be able to receive above normal returns. Whereas other firms may be loss making and hence receive negative returns. Here a growing economy would typically have more profit-making firms than loss making firms, hence the peaks of profit are greater and/or the density of firms with excess profit is greater than the number of firms with below zero profit. Moving to the other side of the spectrum under conditions of certainty in which all market participants have the same information and/or satisfying other traditional perfect competition conditions, excess profits reduce to zero.

Knight (1921) further identifies that under conditions of uncertainty that the entrepreneur able to identify opportunity can earn abnormal returns in excess of other market participants and hence profit from the transition to an uncertain state. As other market participants gain information and replicate the activity of the entrepreneur the abnormal profits are no longer possible. This process can occur during the process of a 'typical' business cycle or as Schumpeter (1939) identifies during periods of productivity growth due to innovation in which new technologies replace previous methods of production and there is a period of 'creative destruction' in which old processes or technologies are replaced with new innovations.

Under the normal conditions of a market economy as depicted by Knight (1921) and Schumpeter (1939) with the overlay of the Uncertainty-Risk Spectrum aggregate the optimisation of quantifiable risk generates the best possible perceived payoff for market participants such than under a high level of uncertainty the pay off in aggregate is low and also under a higher level of certainty in which the market moves towards perfect competition and perfect information the payoff for participants is also low. This is depicted by the red and green regions respectively with the chart below.

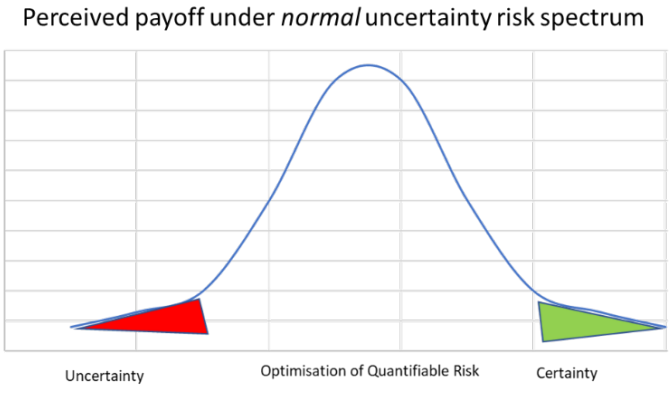


Figure 63: Stylised uncertainty payoff

Market distortions

Consideration of the interwar period, in reference to clusters of historical episodes and the literature upon sectoral imbalances as an underlying cause of crises leads towards an indication of distortions within the market which are generated by fluctuations in uncertainty. Such that as depicted under conditions of *general market* uncertainty some market participants are able to earn above normal returns and hence a fat tailed

distribution of perceived payoff under uncertainty evolves due to these market distortions. The chart below depicts this function with a fat tail emerging even with uncertainty.

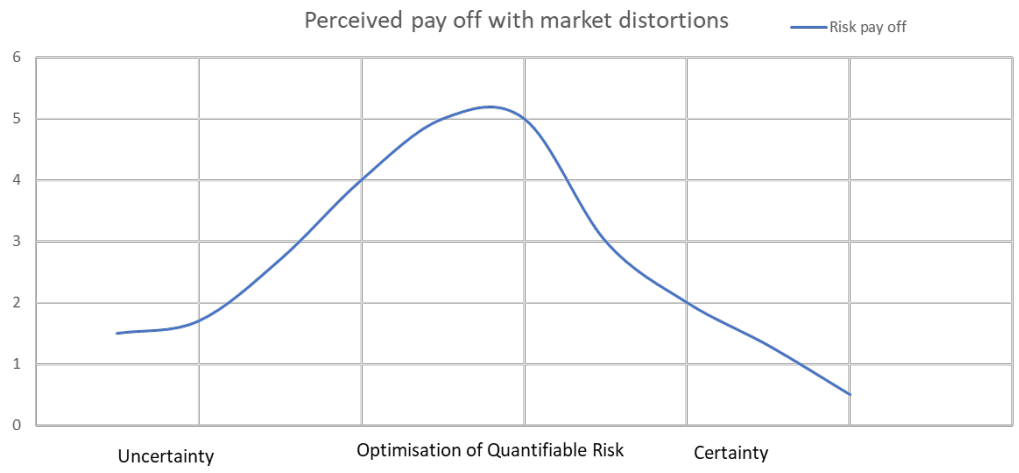


Figure 64: Stylised uncertainty payoff under distortions

The particular set of circumstances occurring post 1914, generated such market distortions that implied there was uncertainty for sectors of the economy within Europe due to the onset of the Great War. Whereas for active economic agents in countries which were either non-participants or non-direct participants in the war, the situational cluster of events generated certainty in relation to the ability to earn constant or even increasing returns to scale and hence abnormal profits, greater than in the prior state of affairs. Hence although at a global macro level the onset of the Great War bought conditions into a state of heightened uncertainty in particular for the European Agricultural sectors given the displacement of labour, resources and land. Whereas for the US Agriculture sector there was a drastic rise in demand for agricultural exports, Kindleberger (1986) and a dearth of alternative supply. Hence for this period the US Agricultural sector was able to earn abnormal returns under uncertainty as the Knightian entrepreneur may be able to achieve. There were also other sectors of the global economy which were able to benefit such as within Japan the Textile Manufacturing Sector, as depicted by Shimzu (1984) was able to also achieve increasing returns, through supplying markets that had be traditionally served by exports from the UK Textile Manufacturing Sector which was also diverted due to the circumstances.

Hence the historical episodes occurring at this time created a dichotomy between the European Agricultural Sector and global macro economy as a whole facing considerable uncertainty whereas the US Agricultural sector benefited from a peculiar form of certainty of return reinforced in essence by a monopoly over supply of goods to Europe. Hence the formation of a market distortion. The below is a summary of this development:

Productivity acceleration in US in 1914 and beyond (especially with increased mechanisation of agriculture) with:

- Excess demand from Europe due to war
- Agriculture productivity acceleration supported with US Farm and Productivity Board
- US War loans to UK vis. Europe enables rising prices despite increase to productivity

The following *subsection b* is a simplified adaptation of the Greenwald (2012) closed economy model of US sectoral imbalances in the Great Depression. This model is based on the post 1914 period of excess agricultural good demand from Europe creating market distortions resulting from the initial shift in the uncertainty spectrum and leading to the sectoral imbalances within the US economy.

Interwar Macroeconomic Narrative Synopsis

Here consideration is given to the relevant facets of the macroeconomic interwar narrative which are relevant to the perspective of the formation of market distortions which were generated through policy interventions in the face of an initial uncertainty shock of the 1914 Great War. The market distortions occurred due to the factors considered above, relating to acceleration of productivity, price dynamics, labour immobility, and post war international treaties. The focus is upon on the 1914-1925 period in relation to US and European sectoral trade.

Excess positive demand shock

As Kindleberger (1986) and James (2002) show there was an increase in demand for US exports to Europe after the outbreak of an all-consuming Great War in 1914. European Agricultural production capability was incapacitated due to the displacement of labour from the agrarian sector to the military, the battle grounds of the war also took place across the land formerly used for farming. In addition, war time production was focused upon the war efforts such that most industrial enterprises were converted to the needs of a war time economy, so that for example British firms such as Vickers and Armstrong were all geared towards the production of armaments, military equipment and vehicles. Hence there was a significant demand from Europe especially as the hostilities continued beyond 1915 for industrial and agricultural goods from the US. The rise in agrarian exports was particularly acute due to the large swathes of labour and land displaced from such activity due to the necessities of the war effort. Although there was an initial drop in exports at the close of the war, the continuation of various post war relief programmes and sustaining the American troops abroad maintained a level of demand still far in excess of the 1914 levels. Despite the recovery of European agriculture in general, a certain level of excess demand from Europe was sustained until the mid-1920s, this is considered in the below summary of global trade policy distortions.

The level of demand was such that increase in productivity were supported by the Federal government and these initiatives further enabled the increase of land under cultivation with an estimated increase of 40 million additional acres of cultivated farm land after 1917.

The below tables show the changes to agricultural land for selected countries, comparing pre 1914 against the 1924-9 in millions of acres.

Overseas Exporters	1909-14	1924-9
Argentina	16.05	19.94
Australia	7.60	11.97
Canada	9.95	22.57
US	53.91	62.99
Total	**87.51**	**117.37**

#

Europe	1909-14	1924-9
European exporters	95.51	89.42
ex-European exporters	37.27	41.70
European importers	50.48	47.39
Ex- European importers	4.07	4.62
Total	**274.64**	**300.50**

Figure 65: The World Wheat Economy, 1885-1939 (based on Malenbaum 1953)

Productivity acceleration

Kindleberger (1986) identifies the US federal support for farmers across the US to increase productivity, the US Department of Agriculture (USDA) provided the administration of the Smith-Lever Act of 1914 which was a federal law (Pub.L 63-95, Public Law and 38 Stat 372, Statutes at Large). This developed infrastructure through 'land grant universities' for collective *extension services*. Which promoted and supported the advancement of information upon the improvements and the latest methods in relation to a number of areas but particularly in relation to agriculture. This activity of information exchange to improve productivity was enhanced further with funding for the acquisition of machinery and other equipment which enabled the mechanisation of farming practices. The funding was enabled with the Federal Farm Loan Act 1916, this created a cooperative structure of 'land banks'. As detailed within the US Government Farm Credit Administration (2021) historical archives this led to the development of the Farm Credit System (FCS) which was based around 12 district federal land banks across the US each of which supported hundreds of national farm loan associations. These enabled long term funding for farmers in cooperative system similar to the older European *Landschaft* system. In order to address the short term funding needs US Congress passed the Agricultural Credits Act of 1923 so that in each of the 12 districts a further 12 federal intermediate credit banks

(FCIBs) were established as discount banks to support lending through commercial banks, agricultural cooperatives and other credit institutions which dealt directly with individual farmers. Although the commercial bank extension of short-term credits was reported to be muted the overall credit to farmers vastly rose during this period.

Mobility constraints

In a *normal* market circumstance, there could be expectations for the migration of labour from one sector to another in times of productivity shifts. However, there were constraints some of which were obvious to the disruption due to the war and the fact that until 1917 the US was seeking to avoid entry into the war directly. Taking an international trade view, rising productivity in US Agriculture sector combined with demand was unlikely to lead to workers exiting the sector or the US, many migrants having most likely arrived in the late 19th century. Beyond this, James (2009) identifies the move toward an anti-migration sentiment in the early 20th century growing and precluding transatlantic migration in particular. The US had already precluded this with discriminatory acts in 1917 Immigration Act followed by Restrictive Acts in 1921 and 1924. Although there were significant intracontinental migrations within Europe particularly out of Italy into parts of Western and Northern Europe.

Price dynamics (government purchasing and foreign capital flows)

The excess demand emanating from Europe with an inability to address the production constraints during an all-encompassing war led to the natural rise of prices particularly within agriculture. Despite the rising productivity and increases in land under cultivation demand continued to exceed supply with Schumm (2018) stating that US domestic consumers were encouraged to reduce consumption of certain foods to aid the supply of exports during this time. As Kindleberger (1986) identifies there was a significant rise in prices during this period. The increase in consumption was enabled through US capital flows and foreign lending to Europe which enabled the purchase of the US exports and sustained the ability to consume at the higher price level. During the post war period the relief schemes enabled the price level to remain above expectations. In addition US foreign capital flows to Europe were maintained with the provisions of the Dawes Plan in 1924 which supported US capital and credit into Germany. Hence the increase in the supply of agricultural goods in Europe was softened partially through such schemes and other global policy agreements as well as Kindleberger (1986) highlights the increase in domestic storage, the US Farm board was further able to sustain the price of commodities such as wheat through purchasing and increasing stockpiling. Hence further distorting the clearing price and artificially maintaining a higher level relative to the decline in export demand which was particularly acute post 1925.

Global Policy Distortions

Post war there was a gradual recovery in European agricultural, here James (2009), indicates the role of tariffs in protecting domestic production from price adjustments, and that the Treaty of Versailles delayed the implementation of domestic production supporting tariffs within Germany until 1925. Once these restrictions were lifted Germany began to impose higher tariffs, across Europe attempts had been made in the earlier periods to introduce tariff protection but it was only in the post 1925 period in many cases after 1929 before the tariffs came into force by this time prices had already fallen substantially. Nelson and Wright (1992) postulate that the US was insulated from the events of WW1 and instead a relative 'autarky' meant that it received a boost from the decline in ability of other manufacturing nations after the impact of the war. Such that import barriers introduced in 1922 by the Fordney-McCumber Tariff were unopposed on an international trade level.

f. Component Analysis

In order to advance the empirical analysis of the interwar market distortions and policy uncertainty, the proceeding subsection considers the most prominent macroeconomic factors.

Key components

Considering the existing literature and earlier comparative analysis there emerges a number of components that allude to being of relevance to the interwar period macroeconomics changes and in particular the depth and length of depression that occurred in the US when compared to the UK. Hence in this section the following components are considered, with relevance of the specific literature and theoretical background, then a synopsis of the stylised facts that emerge, followed by a specific look into the peculiar market distortions and sectoral shifts that are apparent for the US, namely relating to agriculture.

The key components considered are

Analysis component	**Rationale**
Capital Flows	Significant shifts post war events such reparations
Trade dynamics and sectors	War disruption and market distortions
Stock market volatility	1929 crash
Sectoral productivity	Agricultural demand and price fluctuations

Component theoretical background

Capital Flows and Sudden stops

Accominotti and Eichengreen (2013) explore a relatively newly identified data set considering private capital issues in the global financial centres for the period 1919 to 1932 and identify that volatility increase in these centres could have had a impact on the reduction of capital flows and in particular the major stop of outgoing flows. In particular 1929 and then from 1931 onwards. As seen in the below figures.

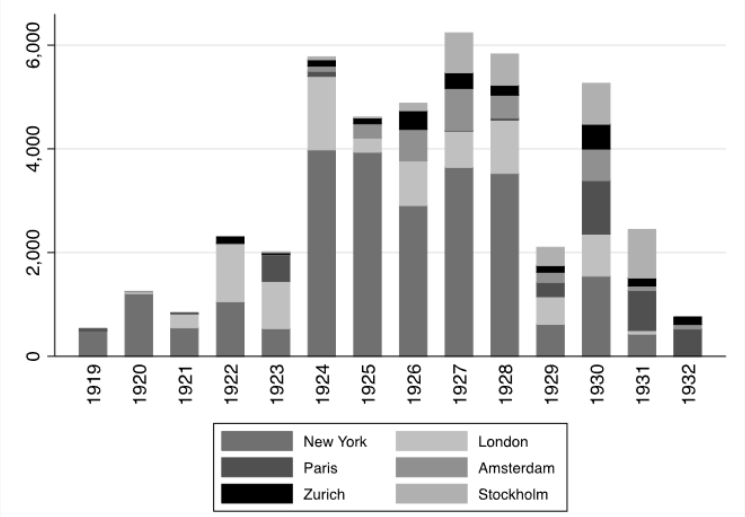


Figure 66: European Country Bond issuance by Financial Centre 1919-32 (Accominotti and Eichengreen 2013)

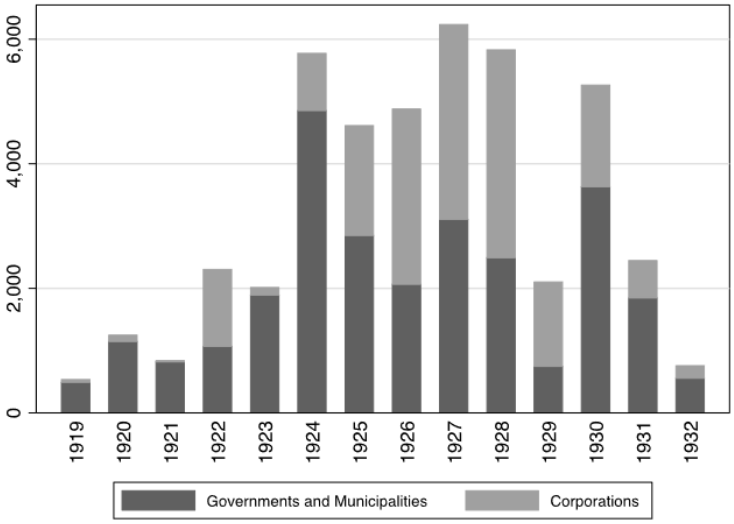


Figure 67: European Country Bond issuance by Borrower Type 1919-32 (Accominotti and Eichengreen 2013)

K̈ohler-Geib (2006) considers the role on uncertainty and the impact on the flows of capital due to the 'pull factors' hence more tradition perspective of the role of private investors and uncertainty over the fundamentals of the receiving sovereign. Julio and Yook (2016) also consider another dimension of the 'pull' factor disruption in terms of the increase in Political uncertainty during the election cycle and the decline in outward FDI flows from the US such that institutional quality plays a role in reducing the level of variation. Choi and Furceri (2019) in addition reinforce the relevance of push factor role such that specifically for bilateral cross border banking flows such that source country uncertainty is a 'predictor' in relation to flows.

Calvo (1998) studies the capital flows and capital-market crises with a particular focus on the impact of sudden stops and find significant concerns around the management of these flows as policy considerations. Overall the finding indicate that:

- Capital inflow being cut off as in 'sudden stops' are extremely precarious ('dangerous')

    - potential impact include company insolvencies, erosion of domestic lending channel and loss of 'human capital'
- Higher quantity of curet account deficit is very precarious regardless of the funding means
    - continuous funds or 'new money' is required to sustain the deficit and this may become very difficult to find when capital flows turn negative

Reparations and Dawes Plan

The US Office of The Historian outlines the key tenets of the global circumstances in which the US was owed significant sums of around $10bn from the UK and in part France in allied war debt; the UK was in turn owed debts from European allies and counterparts. Hence the stalemates over the repayments of war reparations mainly to France were in part resolved with the Dawes Plan which facilitated loan issue in the US to Germany which in turn allowed repayments of reparations and subsequently the allied debts to the UK and ultimately the US. The loans effectively 'dried up' by mid-1928 and the Young Committee formed to resolve the issues and this efforts was disrupted by the subsequent events of 1929 and 1931. Ultimately this reduced reparations owed but also later in in the 1932 established long terms repayment protocol for repayment of debts to the US.

Ritschl (2012) extends the analysis of the sudden stop with the major recipient of capital flows which was Germany. The period between 1924-129 was a period in which under the Dawes Plan Germany received significant capital inflows and effective to a certain extent enabling support for reparations through this foreign credit. This study identifies that the Young Plan which had stricter requirements in terms of repayment meant that the transition in 1928 to 1933 caused a significant shift in German fiscal policy.

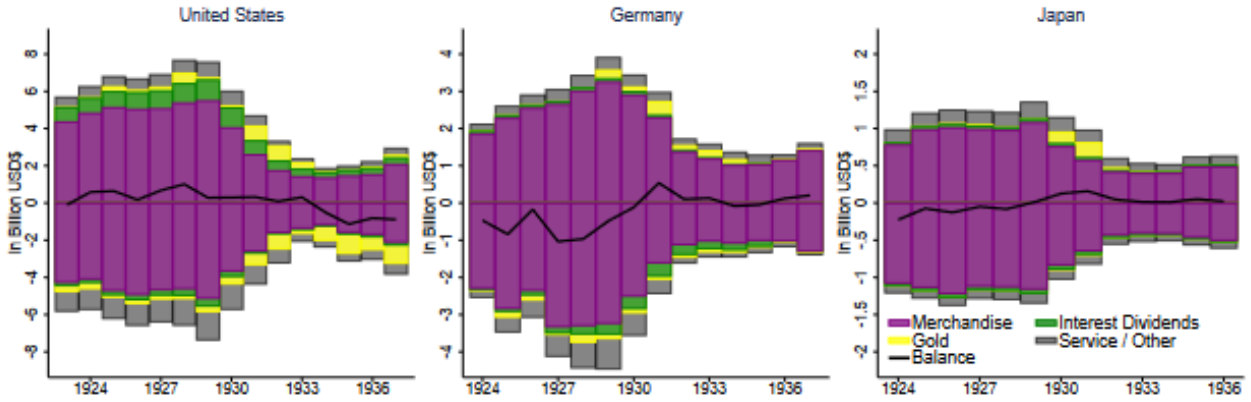
Capital debt defaults

In a study into the 'deterioration of foreign bonds issued in the US 1920-1930' Mintz (1951) comments that there were a number of attributable factors that may have caused foreign debts to default. Those considered include the 'transfer problem' such US foreign lending should be undertaken at a stable rate and with an increase in imports to allow for the increase in global dollar circulation. A view espoused by Lary (1946) and the UN (1949) study into interwar capital movements. Mintz (1949) in particular provides analysis of the potential relevance of time of issue in relation to defaults. Identifying the greater soundness of loans issue earlier in the 1920s as compared to the weakness of loans issued in the late 1920s which were 'boom years' and considered to be a general cyclical increase of speculative activity. Some notable findings of this analysis include:

- 6 per cent of loans issued in 1920 were defaulted upon in the 1930s
- 63 per cent of loans issued in1928 were defaulted upon
- for loans issued 1920-24 - 18 percent of borrowers defaulted in the 1930s
- for loans issued 1925-29 - 50 percent of borrowers defaulted

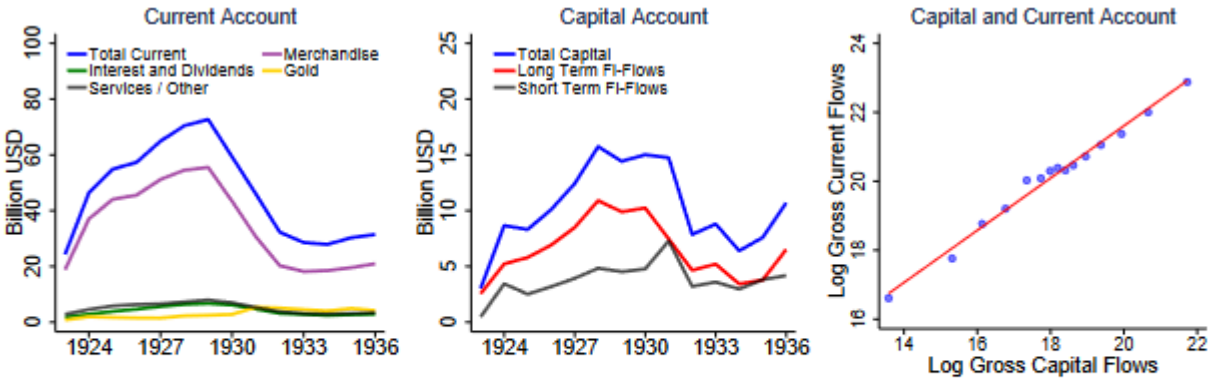
Overall Mintz (1951) finds that 82 per cent of the earlier period issued loan were 'sound' in spite of the conditions faced by borrowers in the 1930s hence attributing the profligacy of the later period as being a relative factor more significant than the other potential causes.

Diebold (2023) finds that the capital flow analysis based on balance of payments data identifies that the business cycle fluctuations are well represented by an interpretation of the capital inflows and shows that the downturn can be linked to a 'credit boom' going 'bust' in terms of capital inflows as opposed to only considering recipient positions. As capital inflows generated exposure to global uncertainty and capital flight risk. The below charts depict the composition of the current account for sample countries.



Notes: This figure shows the annual gross financial flows from the current account side of the balance of payments for the United States, Germany and Japan. Figures are in Billion US dollars based on the pre 1933 US dollar gold parity. Purple, green, yellow and gray represent flows in goods, secondary incomes (interest and dvidends), gold and services respectively. Black is the current account balance.

Figure 68: Interwar Current account Composition – US; Germany; Japan (Diebold 2023)



Notes: This figure shows in the left panel the total gross flows (Credit + Debit) for the individual parts of the current account in billion USD. Flows in trade (purple) make up by far the largest part, with secondary incomes (green), services (gray) and gold (gold) making up the remainder. The middle panel shows this decomposition for the capital account. While long-term capital flows (red) generally make up the largest share, short-term flows (gray) make up a sizable portion and gain in importance around the Great Depression. The right panel plots the log gross totals of current- and capital account against one another using 15 equal sized bins, confirming the visual impression of a high colinearity between the two.

Figure 69: Trends in Gross balance of Payments flows (Diebold 2023)

Trade dynamics

The below charts show changes with respect to global trade in particular there was a relatively significant drop in trade volume post 1930 as well as reduction in the value of exports relative to GDP.

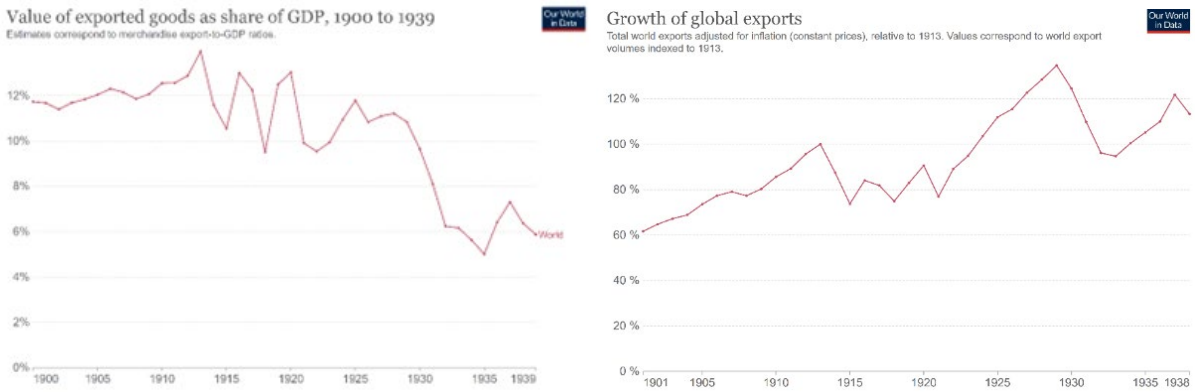


Figure 70: Values of exports as % global GDP & Growth of global exports (OurWordInData.org 2023)

Konya (2006) explores the potential for Granger causality between exports and GDP in 24 OECD countries between 1960-97, applying panel data methods and also considering the signs of the respective regression coefficients as a way to consider the export led growth vs growth determined export hypotheses. They find that there is a mixed result:

- export to growth one way quality - Belgium, Denmark, Iceland, Ireland, Italy, New Zealand, Spain and Sweden - all positive relevant parameters
- growth to export one way causality - Austria, France, Greece, Japan, Mexico, Norway and Portugal – relevant parameters positive except Norway and Portugal
- two way causality - Canada, Finland and the Netherlands
    - export to growth one way causality - all positive relevant parameters except Netherlands
    - growth to export one way causality - parameters positive except Canada and Finland
- no causality - Australia, Korea, Luxembourg, Switzerland, the UK and the USA

Hence the study indicates that for some countries there is a relation between exports and growth although for the sample period this was not the case for all countries. Furthermore the countries considered were all more developed relative the rest of the world. So then there is potential relevance of trade and exports in relation to impact on the macroeconomy.

Kindleberger (1986) states that there was a significant number of factors that had led to the build-up of the crisis of events surrounding 1929 and 1931 these included the structure of international trade during the 1920s. Eichengreen and O'Rourke (2009) identify the significant collapse of international trade during the recent financial crisis was unprecedent since the fall during the Great Depression. As an indicator of the scale, US exports had collapsed by 1932 to 30% of the value in 1929 (UN Statistics 1962). Although the context and nature of trade has evolved from the period of the crisis perhaps at that time there was more trade in finished goods and commodities as opposed to the transformation described by Ravikumar, Shao and Sposi (2013). In which modern trade consists of supply chains with many intermediate goods being exported before final assembly.

The UK in the 1930s actually befitted from improved terms of trade to the rapid decline in the price of imports. Gowland (1983) identifies that due to the improved terms of trade the UK consumption per capita increased despite the wider adverse impact and perhaps more detrimental condition in Germany and the US. This can also be defined as the net barter terms of trade. An alternative measure is the gross barter terms of trade which is the quantity of imports over the quantity of exports.

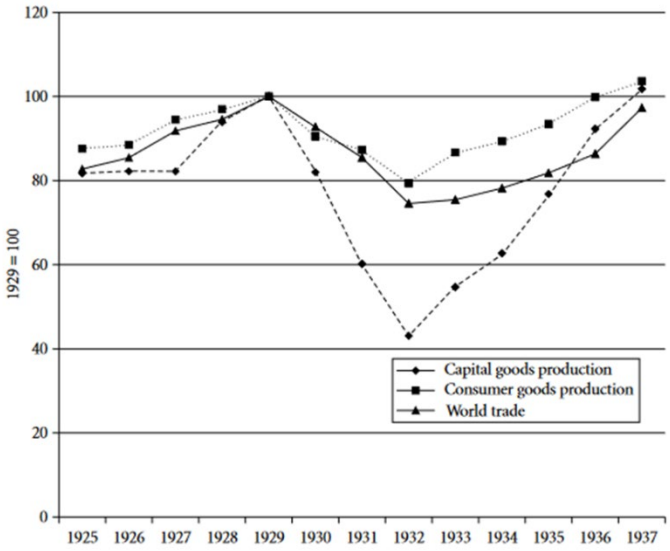


Figure 71: World production and trade, 1925–1937 (James 2009)

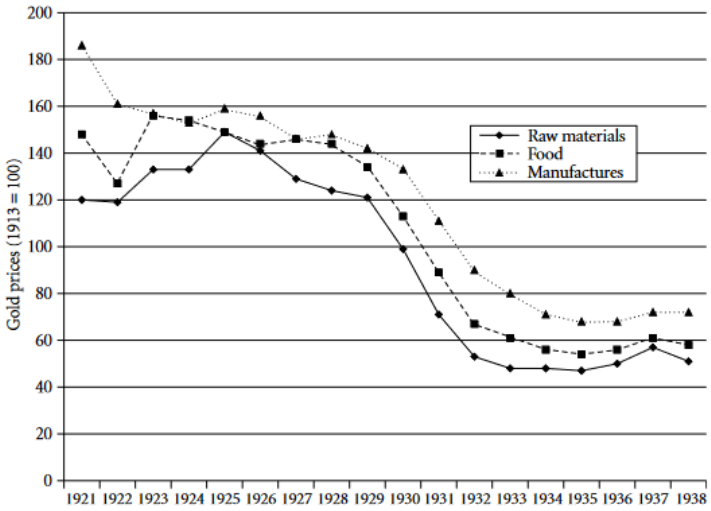


Figure 72: Prices in international trade, 1921–1938 (James 2009)

As depicted by James (2009) and seen in the above charts, the 1920s was a period of turbulent conditions for world trade and further a number of key areas which influenced the turbulence and then further shifts to trade patterns that took place over the 1930s period. The areas of concern include the changing dynamics between nations in terms of comparative advantage; the events of the war disturbing growth trajectories and significant alterations to national boundaries within Europe. Other key influence in the 1920s include the nature of capital flows and perhaps one of the most significant trade policies and the imposition of tariff

barriers. James (2009) estimates that if the pre-war trajectories of growth had continued by 1929 exports should have been 20% higher. There was also significant deflationary impact for trade as prices for agricultural goods rapidly declined. Although a portion of the changes can be linked to the increased industrial focus and development that was taking place globally. The UK for example the leading exporter suffered declines due to development of manufacturing in staple goods on a global scale with countries such as Japan, Latin America and India increasing exports in textile goods such as in for cotton and wool. From 1913 to 1929 the UK share of global exports declined from 30,2% to 22.4% whereas Japan's share of textile exports rose from 4,4% to 9.5%. Some pre-war trends were accelerated by the war especially for those countries such as the US which were distanced from events. Japan concurrently reduced imports of stable goods from the UK as well increasing imports of machinery from the US. The UK suffered more during the 1920s with even preferential commonwealth reducing imports. India in 1913 purchased 85% manufactures from the UK by 1937 this had fallen to 14%.

The export declines in trade for UK contrasted with the US during the 1920s as Kindleberger (1986) explores the US benefited from a significant rise in exports of agricultural goods and other production related to the war. Although there was a mild post war slump the subsequent period was a boom for US exports and industrial output. Industrial production by 1929 had risen 75% since 1913 for France this was 40% and for Britain 9%, although German production only rose 10% from 1924 Germany had a higher rise than any other industrial nation. The domestic expansion in the US was partly built around Automobiles and related industries such as tires, roads, petroleum refineries and other components. In addition, consumer electrical appliances became widespread.

Meltzer (1976) has argued that the passage of the 1930 Smoot-Hawley Tariff Act as a significant shock that converted a "sizable recession into a severe depression" Irwin (1998) identifies that in two years since June 1930 since the Act was passed into legislation, the US trade volume declined by 40%. However, Irwin (1998) argues that the 50% reduction in prices raised the 'real effective tariff'. Further factors include the impact of retaliatory tariffs and the inability of importing nations to earn dollars combined with declining incomes. The accession of the Democrats to government began a gradual process of Reciprocal Trade Agreements between 1934 until 1939. Canada the largest trade partner and France signed agreements in 1936 but the UK the second largest trade partner only signed an agreement in 1939.

Stock market volatility, fluctuations and EPU

Schwert (1989) finds a relation between of stock market prices and the business cycle, identifying that volatility increases after prices fall and the onset of a recession. Pastor and Veronesi (2012) utilise a general equilibrium model to explore the impact that policy change can have upon stock prices with indications of finding that prices should fall with new announcements on 'average' and larger fall are precipitated by more significant policies as well as under a economic downturn. Based around the 'volatility of the stochastic discount factor' which raise risk premia and this raises volatility. Liu and Zhang (2015) consider the impact of

EPU upon stock volatility using high frequency return data and realized volatility modelling to identify that incorporating EPU to the models has potential improvement to the forecast potential and greater uncertainty leads to greater volatility.

Baker et al (2016a) develop an EPU index and compare this to a 30 day VIX index and find that the EPU indices is a 'useful proxy' as a measure of uncertainty against the VIX which is a standard metric for uncertainty in the financial sector and although there are variations between the two when considering types of events, there is additional explanatory power in the EPU index for firms that have more 'exposure' to government policy amongst other elements. Mathy (2016) considers historical return jumps and undertakes and analysis of key policy episodes and other events as being 'responsible' for fluctuations in uncertainty and return jumps in the 1930s. Baker (2021) extend this to consider a longer period of stock return jumps since 1900 for the US and 1920 for the UK as well as later periods for 14 other national stock markets.. They consider newspaper articles on the next day after a large jump and find:

- monetary and fiscal related policy news generate more upward jumps than downward
- inverse relationship between prior 3 months and upward jump
- monetary policy news related jumps induce lower volatility in the following periods
- the 'clarity' of the account on the jump has a similar pattern of lower volatility in the following periods
- US 'developments' are attributable to a third of other country jumps

Hence the research in to stock market volatility and uncertainty yields two further avenue's which are volatility spill over between markets and studies which use volatility as a proxy for income uncertainty and hence identify an impact upon consumer expenditure.

Stock market spill over

A relevant aspect as per the work of Galbraith (1954) alludes to the potential impact of the UK Hatry Crisis upon the events in the build up to the US 1929 crash as well as in general there being potential contagion in financial markets between new debt issuance and other securities. Stuart (2017) considers the co-movement of the stock markets in Ireland with the UK using a BEKK GARCH model for monthly data between 1869 to 1929. Further Stuart (2018) studies spill overs between UK, US and Ireland for the period 1869 and 1925 using a 'trivariate DCC-GARCH' framework.) also The study finds more correlation between the UK and Ireland. Which fits into the close ties between the two markets including political as well as between enterprises. The work of Choudhry (1995) finds persistence of volatility shocks in five European countries in the interwar period. Further Choudhry (2004) identifies volatility clustering in the 1925-1944 period between six stock markets with GARCH(1,1) and GARCH(1,1)-X models. This leaves the question as to whether there were any spill over in the 1920 to 1940 period between the UK and US given the changing dynamics for capital flows and connection between the two economies given the increasing uncertainty and particular events that occurred in both stock markets such as the UK Hatry Crisis and the 1929 US Crash.

Income uncertainty and consumer expenditure

Choudhry (2003) considers the impact of stock market volatility on US consumer expenditure, for four different series of real expenditure: durable goods, non-durable, services, total using Johansen multivariate cointegration procedure and the error correction method. The results how indication of a relations ship with long run for consumer expenditure and its determinants with long run and ECM results. The causality indicates one way from volatility to consumption. The hypothesis is predicated on the theory that stock volatility represents wealth effect which leads to consumer reluctance to spend. Greasley et al (2001) explore the interwar period and extend the theory of Romer (1990) which contents that stock market crash generated uncertainty that led to a reduction in durable goods. They consider that non-durable goods expenditure is also impacted. They consider four different measures of uncertainty as per the below figure and find that there variation amongst each measure however overall find the post 1930 increased uncertainty reduced consumer spending across all disaggregated measures until 1932 and spending on the measure and various types of goods during 1934 as well.

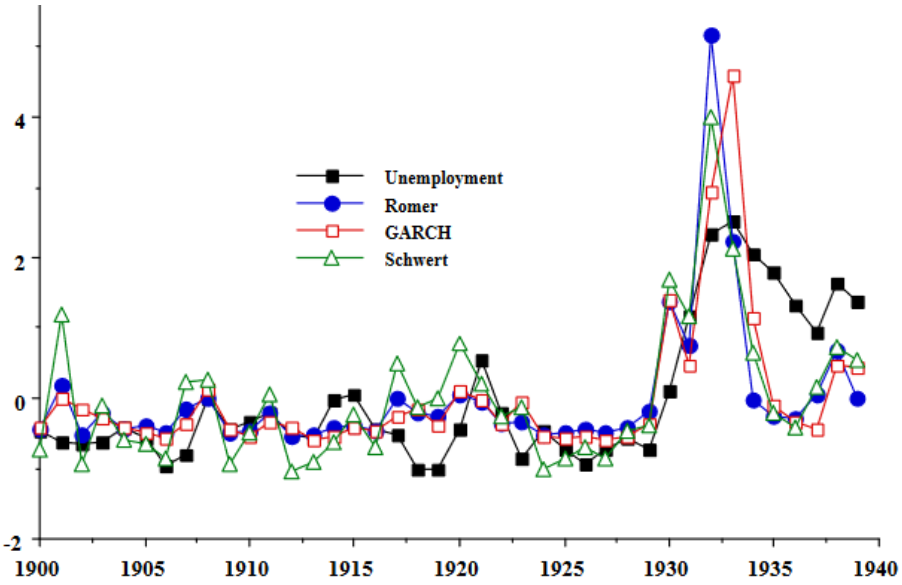


Figure 73: Alternative measures of Uncertainty (Greasley et al 2001)

Sectoral shifts - agriculture

US producers and global exporters of grains and other agricultural products benefited from a 'crest of a wave' in the war period. Europe was still a major producer of wheat (major grain and farm product) but was also the key buyer of wheat, hence the war disruption to output combined with the exit of Russia generating a significant opportunity for exporters to increase capacity and benefit from returns to scale with prices rising.

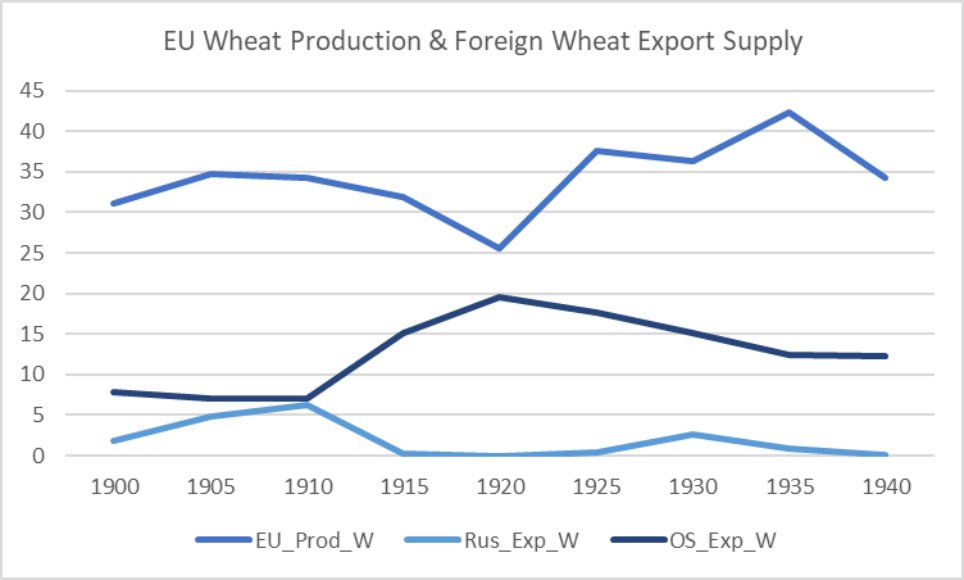


Figure 74: Wheat production – 1900-40 (based on Svennilson 1954)

Kindleberger (1986) notes that up until the mid 19th century agricultural output was driver behind US business cycles however in Europe it had declined in significance especially in the UK. Although for the US agricultural goods were more than 50% of exports throughout the period (UN statistics 1961). By 1929 the continuing importance of agriculture to the US economy is indicated by a quarter of employment being within the farm sector and 28% of farm income relating to exports. The post war European recovery meant there was an increase in agricultural production combined with the US rise in productivity created excess of supplies between the mid-1920s until the last quarter of 1929 prices dropped by 30% and stockpiles increased by 75%. This deflation was a significant issue and combined with agrarian bank institutions facing loan defaults. Farm mortgages had risen from $3.3 billion in 1910 to $9.4 billion in 1925. The Federal Farm Board attempted to purchase and stockpile, but the fall of prices was a global phenomenon and this crisis combined with the 1929 stock market crash.

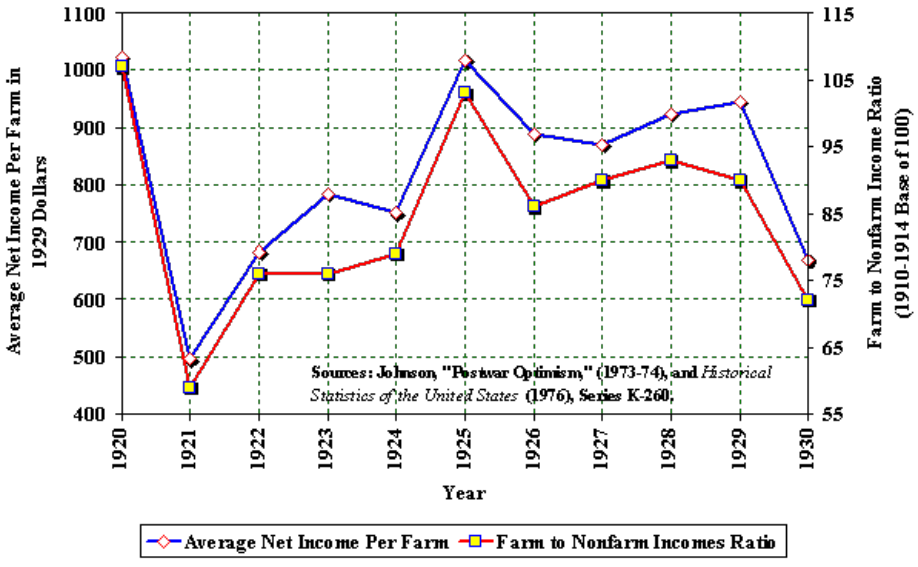


Figure 75: US Real avg. income per Farm 1920-30 (Smiley 2023)

As shown in the chart above and explored by Smiley (2023) the war period provided a significant increase in farm incomes which initially fell partly given that there was and expansion of crop land and machinery. The level of farm income recovered but never reached the level the war period. The rising productivity combined with declines in propensity to consume restricted the returns to scale. Svennilson (1954) considers these aspects with respect to the context of the European market which was the main driver behind demand for global exporters.

Svennilson (1954) reports the agricultural market trends noted by Smiley (2023) per the following overview.

Europe & International Market for Agricultural Products Context

With respect to International price and trends in European production, there was a high degree of price instability, they doubled between 1913 to 1920 and agriculture is a sector for which it is difficult to adjust output based on such rapid shifts. As shown by the below chart of the Liverpool Wheat price index which can be utilised as a benchmark for grains and agricultural prices in general for the period.

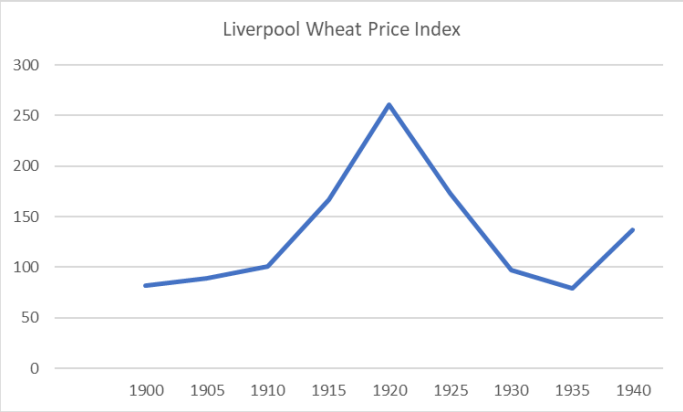


Figure 76: Wheat prices – 1900-40 (Svennilson (1954)

European (EU) demand was the most significant determinant of international prices as 90% of exporters output, went to EU pre-war, this reduced to 75% in interwar period as it was a protected and subsides industry during the post war rebuilding efforts.

Five Grains - European Imports 1909-13 to 1948/49 (Mn. Of tons)				
Country	1909-13	1925-29	1934-38	1948/49
Net Imports				
W. Europe	16.4	17.1	10.5	13.5
UK & Ire.	9.9	9.1	10.4	8.5
Total	**26.3**	**26.2**	**20.9**	**22.0**
Net Exports (main)				
E. Europe	2.7	0.6	2	
Russia	10.5	0.8	1.2	
US & Canada	6.4	15.1	5.4	23.8
S. Hemisphere	7.5	13.6	13.9	9.7
Total	**27.1**	**30.1**	**22.5**	**33.5**

S. Hemisphere - Argentina, Uruguay, South Africa, Australia, New Zealand

Figure 77: Grain trade – 1900-40 (Svennilson (1954)

As the above figure demonstrates the wartime collapse of EU output combined with Russian export supplies being cut meant that N. American and S. Hemisphere exporters increased supplies to meet the increased demand. Given the incentives due to the increase in prices which also then led to an increase in productivity. As shown in the tables below there was reduction in labour hours and increase in outputs.

	Labor-Hours Per Unit							Per Acre Yields			
Period	Wheat 100 Bush.)	Corn 100 (Bush)	Cotton (Bales)	Hay (Tons)	Milk (Cwt)	Beef (Cwt)	Hogs (Cwt)	Wheat (Bush.)	Corn (Bush.)	Cotton (Lbs.)	Hay (Tons)
1915-19	98	132	299	10.4	3.7	4.5	3.6	13.9	25.9	168	1.25
1920-24	90	122	296	10.2	3.6	4.5	3.5	13.8	26.8	155	1.22
1925-29	74	115	268	9.8	3.3	4.3	3.3	14.1	26.3	171	1.22

Figure 78: Selected US farm productivity – annual avg. 1915-30 (US GPO 1976)

The US in particular had more fertile land in N America comparative to other regions and hence alongside productivity increases was able to expand farm acreage. During the mid 1920s the constraints on demand were also appearing as Svennilson (1954) shows there were changes to the marginal propensity to consume with the pattern declining in comparing the 19C to the beginning of the 20C as indicated in the figures below.

Propensity to consume		
Percent change	1881/90 - 1901/05	1910/13 - 1934/38
Population	16	13
Consumption pp. - wheat & rye	8	-9
Total Consumption - wheat & rye	**25**	**3**

Figure 79: Marginal propensity to consume for farm goods (Svennilson (1954)

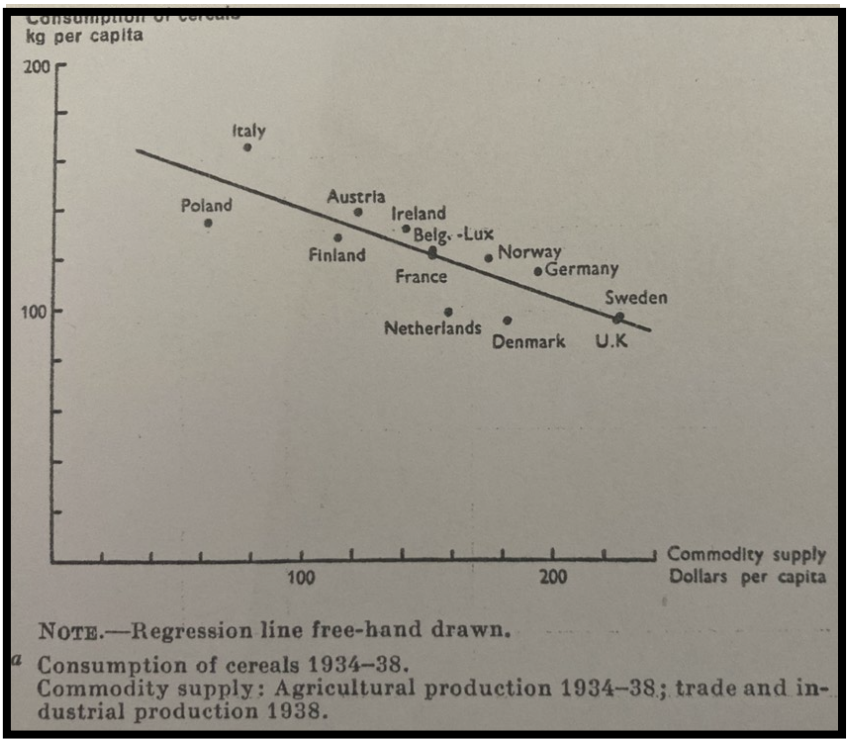


Figure 80: Consumption of cereals at different levels of supply 1934-8 (Svennilson 1954)

The reduction in demand and increased supply dynamics inevitably led to a reduction in prices which meant there were effects on terms of trade and balance of payments. These were detrimental to the US and other exporters but beneficial to the UK for which interwar fall of prices improved terms of trade. In the post war period the trade balance for many European nations was influenced heavily by grain imports.

War & Crisis context

With respect to the general characteristics of Agricultural production, the post war attempts to support domestic output through protective measure to support farm income, also indirectly then the balance of payments, according to Svennnilson (1954) eventually backfired as they lacked coordination. Hence led to continuation of inefficient production methods in Europe, given they reduced incentives to migrate sectors and adopt more mechanisation to reduce labour cost. As the table below shows that EU output dell due to war disruption but post war aggregate increase in grain production was only marginally better in 1940 than the level in 1900 compared with overseas exporters being able to increase output by more than 50%.

Production - Exports - Wheat / Five Grains - Wheat Price									
Date	Total production				Exported production				W price
	EU_Prod_W	EU_Prod_G	OS_Prod_W	OS_Prod_G	Rus_Exp_W	Rus_Exp_G	OS_Exp_W	OS_Exp_G	
1900	31.1	96.4	23.2	111.8	1.8	5	7.9	15.5	82
1905	34.7	102.3	27.7	133.1	4.9	10.5	7	12.9	89
1910	34.2	111.8	27.2	125.8	6.3	12.8	7	1.5	101
1915	31.9	95.9	47.6	160.2	0.3	0.4	15.2	24.3	167
1920	25.6	85	38.3	159.6	0	0	19.6	27.5	261
1925	37.6	114.6	37.3	152.6	0.4	1.2	17.6	24.7	173
1930	36.4	114.1	47.7	149.2	2.6	4.8	15.2	21	97
1935	42.3	117.5	32.5	136.1	0.9	1.9	12.4	21.1	79
1940	34.3	106.9	47.3	156.1	0.1	0.9	12.3	16.4	137

Five grains – Wheat; Rye; Barley; Oats; Maize
Millions of tons; Price index – Liverpool Wheat price 1913 = 100
OS – United States; Canada; Argentina; Australia
Rus – Russia/USSR
EU – Europe
Prod – Production
Exp – Exported production

Figure 81: Production of Grains & Wheat price 1900-40 (Svennilson (1954)

The wheat price is a standard benchmark the 'Liverpool wheat price' which was an indicator for general price trends although national prices varied and there was some countries facing more pressure than others.

The overall European trends in Agricultural activity in the war and early post war periods was for falling output as can be seen by the chart below in particular for the two major EU economies both France and German production was low throughout the period and slow to recover. They were both recipients of US exports in particular German output was falling until 1928 and hence provided a export channel for US exporters as well as contributing to the significant capital flows in the period with the exchange of long and short term credit within the US capital markets taking place.

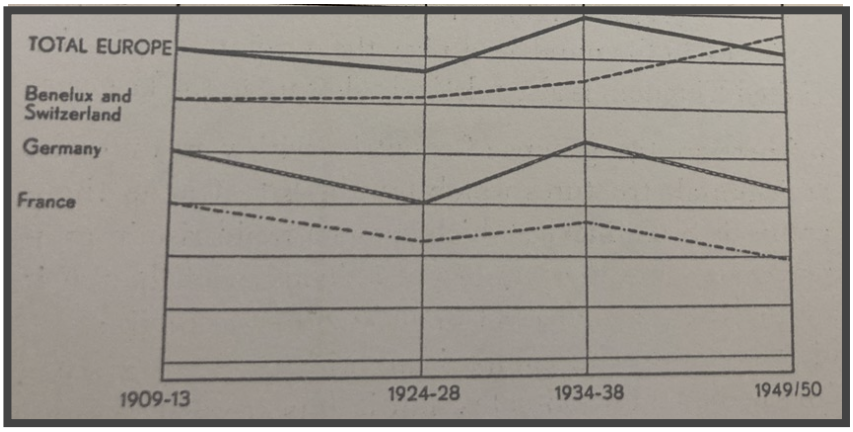


Figure 82: EU output of Seven crops 1909-13=100 (Svennilson 1954)

Aspects of agricultural productivity

As seen in the figure below the 1920s period saw a rapid increase in productivity for particularly US producers including within the agricultural sector.

Period	Average Annual Labor Productivity Growth	Average Annual Capital Productivity Growth
1899-1909	1.30%	-1.62%
1909-1919	1.14	-1.95
1919-1929	5.44	4.21
1929-1937	1.95	2.38

Figure 83: Avg. annual rates of labour productivity and capital productivity growth 1899-1937 (Devine 1983)

In the farm sector there were a number of Labour saving methods being used and in particular the increase in tractor usage which has a number of regional differences in speed of adoption leading to varying productivity trends. The US being the most rapid adopter and with the largest scale, as seen in the figure below.

Tractors	US	UK	EU
1915	21,000	~	~
1920	203,000	~	~
1930	1,020,000	20,000	130,000
1939	1,597,000	55,000	270,000

Figure 84: No. of Tractors 1915-39 (based on Svennilson 1954)

The increase in farm output meant that in the US wages were falling and this was accelerated by the 1929 post-crash depression. In contrast the UK agricultural sector benefited from the increase in mechanisation and improvements in technology given it became more specialised with rising wages, albeit the sector already being a much smaller share of aggregate employment.

Ratio of Wage Index - Agriculture to Industry 1914-45 (1913 =100)						
Country	1914	1920	1924	1932	1938	1945
UK	100		87	101	103	133
US	100	101	79	61	61	86

Figure 85: Ratio of Wage index – Agriculture to Industry 1914-45 (based on Svennilson 1954)

Component stylised facts and further analysis

The above analysis has considered a number of components that allude to being of relevance to the interwar depression that occurred in the US and also when comparing to the UK. The four main component that were considered at outset are identifiable as being relevant and explain to a certain extent the difference between the fluctuations experienced by the US when compared to the UK

The key components considered are as considered below.

Analysis component	Stylised facts
Capital Flows	*US capital flows had links with the post water treaties such as the Dawes Plan as well as the export demand particulate from Germany.*
Trade dynamics and sectors	*US exports increased significantly during the war and agriculture was significant to EU demand and capital flows. The EU and the UK were the largest markets outside of North America for US goods, whereas the UK had more diversity in trade partners globally. Hence the fragility of the EU post war treaties had a lesser impact of foreign export demand. A highlight by the figure showing a snapshot of interwar trade.*
Stock market volatility	*There are potential stock market spill overs that may be relevant for further analysis given the significant role of the market crash in the US.*
Sectoral productivity	*US productivity increases were significant in agricultural and industrial sectors but the global market changes led to declining demand and supported farm incomes in particular. Th UK as a net importer of farm goods benefited from the decline in prices through improved terms of trade. The US agriculture sector was larger in terms of labour and suffered from wage deflation particularly post 1929 whereas the UK had a more mature economy overall and hence much smaller agricultural sector, the increase in mechanisation appears to have increase wages.*

Selected World Trade						
Exports to / Exports from	Year	WORLD	United States	Canada	Cont. W. Europe	United Kingdom
United States	1913	2466	1	420	819	597
	1928	5127	-	924	1298	848
	1935	2283	-	329	486	433
	1938	3064	-	462	621	514
United Kingdom	1913	2556	144	120	757	-
	1928	3504	227	175	823	-
	1935	2073	114	109	525	-
	1938	2421	230	115	554	-
Cont. W. Europe	1913	7677	442	35	4038	1382
	1928	9281	630	76	4046	1485
	1935	5579	310	34	2521	811
	1938	6952	339	37	3191	914
(f.o.b. value in million US dollars)						

Figure 86: Direction of World Trade 1900-40 (UN 1960)

Hence it emerges that significant aspects for further investigation include the relationship between policy uncertainty trade flows and exports for the US is of relevance as well as considering the stock market spill over between the US and UK over the whole interwar period, which is yet to be covered in the existing literature.

The proceeding section present the methodology, modelling set up, data and results of the econometric analysis to consider US EPU and capital flows/exports and volatility spill over between the UK and US stock markets.

g. Methodology

Bounds testing with ARDL Methodology

An econometric approach of relevance to this study is the utilisation of the autoregressive distributed lag formulation with time series that are potentially cointegrated, for which the bounds testing procedure of Pesaran et al (2001) provides a suitable method to enable the modelling of such time series data sets. ARDL model is applied due to the ability to incorporate variables with a mixed order of integration both of order zero and order one.

Cointegration

The error correction mechanism which is related to the aforementioned GETS analysis which developed upon the work of Sargan (1964) and with the work of Davidson et al (1987) and Kiefer and Salmon (1982) amongst a number of other studies. The basis of this analysis as depicted by Engle and Granger (1987) is that over the course of time from one period to another a disequilibrium in one variable may be partially corrected in the following period and this could for example be for the price of a good in be related to the excess of demand prior to the period. Granger (1981) developed the notion of analysis with error correcting models with the characteristics of having 'long-run components of variables' moving towards an equilibrium whilst simultaneously in the short run the 'components' can be of a dynamic nature. In order for this to occur one of the conditions is co-integration. Engle and Granger (1987) give the example of real economic variables which operate in such a relationship like long term and short-term interest rates as well as for consumption and income.

Murray (1994) illustrates cointegration and error correction with a simple analogy of a drunk and the drunkard's dog, setting off on a walk from a given destination the drunk follows a 'nonstationary path'. Such that both may appear to be following random walks, if they were traced individually but the drunk for example may intermittently call out for the dog and then at times the dog barks in reply, as they maintain a certain gap and eventually draw closer, hence there is a 'error correction mechanism' to the walk. Differencing a nonstationary series *n* times can make it stationary and hence it is called *integrated of order n*. Murray (1994) defines that a 'set of series' can be classified as cointegrated with the condition that all are integrated of order *n* and also a linear combination of such a series is integrated of an order less than *n* with the weights being non-zero such a relationship can be defined as cointegrating. As Sims (1980) explains that often theory is unable to define relevant 'restrictions' upon a dynamic interactions and Murray (1994) puts forward that the

long run cointegrating relationship can however benefit from theoretical considerations. The benefits of the error correction approach are to avoid standardised distributions with the application of a more accurate distribution avoiding spurious regressions. Engle and Granger (1987) identify that a regression analysis of cointegrated variables should include the conditional elements of the cointegrating relationship along with the lagged 'levels' of the variables this allows for the error correcting mechanism to be observed.

Hence there has been a development in cointegration methods which explore and test for a relationship between variables with inclusion of lagged variables. Engle and Granger (1987) put forward a method to test the null hypothesis of 'no-cointegration' with a twostep process based on residual and an alternative framework is proposed in the work of Johansen (1995) with a method of 'reduced rank regression' which is system based. There are a number of other approaches including that of Stock and Watson (1988) using 'stochastic common trends' and also Shin (1994) also utilising a form of testing the null of cointegration through a residual based process. The basis of such work is to investigate scenarios in which the order of integration for the variables is one. Pesaran, Shin and Smith (2001) identify that this requires an element of 'pretesting' and find this creates an element of 'uncertainty' for the undertaking of the analysis in the relationship between the lagged levels. They put forward an approach which can test for relationships amongst variables whether the integration of order one or order zero and also 'mutually' cointegrated regressors. This bounds testing approach based within a Dicky-Fuller format regression in a 'conditional unrestricted' equilibrium correction model. They develop a procedure to obtain the 'critical value bounds' with 'two set of asymptotic critical value' produced through the two opposite cases of having the assumption that all regressors are all integrated of order 1 and also integrated of order zero. In this process if the F-statistic is within the bounds then an inference can be drawn however when the value of the F statistic is outside of the bounds then further investigation is required to check for 'underlying regressor' the order of integration or cointegration before being able to conclude. They apply this approach to macro model used by the UK Treasury in determining further upon the equation for earnings for which there are a number of factors for which the order of integration is unclear including the differential between the 'real consumption wage against the real earnings wage' and the 'unemployment benefit ratio' amongst others.

This is one of a number of bounds testing approaches in the literature which shall be considered further below within this section. The subsequent estimation of the chosen ECM for average earnings then utilise the autoregressive distributed lag method used by Pesaran and Shin (1999). Hendry, Pagan and Sarjan (1984) explore the development of the autoregressive distributed lag model. They identify that such dynamic models that utilise lags of dependent variables as a basis for modelling are relevant to the real economy due to the prevalence of 'adjustments costs' or in cases where there is a delay in perception for agents and hence a delay before the change in behaviour is enacted upon. They further indicate that such modelling is relevant without such transaction, optimisation or search costs involved given that there is often 'uncertainty engendered by the future' in addition to the prevalence of imperfect markets for capital and futures. Hence in our study of

the relevance of economic policy uncertainty in relation to trade and bank reedit during a period of crises the ARDL is a suitable method to approach in this exploration. The relevance is further espoused upon in the proceeding parts of this section.

ARDL method

Background to set up of ARDL

The Autoregressive Distributed Lag (ARDL) model has antecedents in the formerly used Distributed Lag models in such a time series estimation the lagged values of the dependent variable explain the 'current value' Giles (2013). Such that the following depiction presented by Giles (2013) as an example:

$$y_t = \beta_0 + \beta_1 y_{t-1} + ...+ \beta p y_{t-p} + \varepsilon_t$$

Eq. 4.g.1: DL model (based on Giles 2013)

The y_t is the variable of interest and the ε_t randomly distributed error or 'disturbance' term, such models can be estimated with the Ordinary Least Squares methods. However, there are some additional considerations when incorporating an independent variable within a model of the form:

$$y_t = \beta_0 + \beta_1 y_{t-1} + ...+ \beta p y_{t-p} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + ... + \alpha_q x_{t-q} + \varepsilon_t$$

Eq. 4.g.2: ARDL model (based on Giles 2013)

The above is a representation of a simplified ARDL model where the x_t is the dependent variable and again the ε_t randomly distributed error or 'disturbance' term, in this case the application of the OLS method can yield 'biased coefficient estimates' in addition for the case of the error term being autocorrelated the OLS method will yield an 'inconsistent' estimator. In viewing the above simple case of ARDL Giles (2013) depicts the construction as being of the form ARDL (p,q) with lagged values of both the dependent and independent variable included. The earlier approach taken to was to limit the lags of the independent variable in order to avoid multicollinearity. Such models are described as being distributed lag models of the form (DL(q), or ARDL(0,q)) by Giles (2013) in these instances the coefficients had a limited distribution of values in order to reduce the lags of the independent variable. There were a number of approaches developed, including the method used by Almon (1965) in a DL (q) model in which the 'Weierstass Approximation Theorem' to approximate the function with a polynomial of a given order and this order has to be selected. The Almon (1965) method placed restrictions on the values and slope of the decay path at the end points' and on the 'shape' of the path itself. The approach taken by Koyck (1954) was an early form of an ARMAX modelling approach which incorporated a disturbance term that followed a 'moving average process'. Koyck (1954) managed to develop such a DL model into an autoregressive model through the imposition of a 'polynomial rate of decay' on the coefficients. The modern variation of the DL is autoregressive in the sense that the combination of a dependent variable being explained by both lagged values of items in combination with the distributed lags of the independent variable.

In a traditional time series model estimation Giles (2013) identifies that the Ordinary Least Squares approach is suitable given circumstances in which either all of the timer series variables are stationary that is of integration order I(0) alternatively they are all integrated of order I(1) but there is no cointegration in this case the series can differenced and apply the OLS estimation and finally an OLS would still be applicable in a scenario in which all variables were integrated of the same order and cointegrated in this case two stages are required the first is the difference of the series is used for OLS estimation of the long run relationship and secondly the error correction model is estimated to infer the short run relationship. However as explored above in many circumstance economic variable time series are non-stationary, such that there could be a mixture of variables with order of integration I(0)and I(1) and also there may be cointegration amongst the explanatory variables.

In such circumstances the model of Pesaran et al (2001) is applicable, a basic variant of this ARDL model is as follows

$$y_t = \beta_0 + \beta_1 y_{t-1} + \ldots\ldots + \beta_k y_{t-p} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \ldots\ldots\ldots + \alpha_q x_{t-q} + \varepsilon_t ,$$

Where ε_t is serially independent, random error term.

Eq. 4.g.3: ARDL model with order of integration I(0) and/or I(1) (based on Pesaran et al 2001)

The procedure of Pesaran et al (2001) a ARDL bounds testing approach requires stages of implementation in order to estimate form a single equation set up a suitable modelling outputs that can be used to discover the dynamics of the short run relationship as well as the long run relationship. At the initial stage it is beneficial to undertake some form of Unit Root testing although the order of integration of the variables is not relevant to the procedure the variables must not be I(2) variables otherwise the method is invalidated.

ARDL approach set up

The ARDL approach is a cointegration technique useful for circumstances in which there exists a long run relationship amongst time series variables. The early approaches to test for cointegration were developed in Granger (1981) and Engle and Granger (1987). The Pesaran et al (2001) approach is an enhanced development of such cointegration methods as per earlier discussion and some generalised comparison points discussed further below. Nkoro and Uko (2016) give the generalised ARDL ($p,q_1,q_2.....q_k$) model specification as:

$$\Phi(L,p)y_t = \sum_{i=1}^{k} \beta_i (L,q_i) x_{it} + \delta w_t + u_t$$

where

$$\Phi(L,p) = 1 - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^p$$

$$\beta(L,q) = 1 - \beta_1 L - \beta_2 L^2 - \ldots - \beta_q L^q, \qquad for\ i=1,2,3\ldots\ldots k,\ \ \boldsymbol{u}_t \sim iid(0;\delta^2)$$

Eq. 4.g.4: generalised ARDL (based on Nkoro and Uko 2016)

- the lag operator L is defined *as* $L^0 y_t = X_t$, $L^1 y_t = y_{t-1}$

- w_t represents a *vector of deterministic variables such as the intercept term, time trends, seasonal dummies, or exogenous variables with the fixed lags.*
- *P*=0,1,2…,*m*, *q*=0,1,2….,*m*, *i*=1,2….,*k*
- hence the potential for (*m*+1)*k*+1 ARDL model variations
- period represented by *t* = *m*+1, *m*+2….,*n*. and the maximum lag length *m* is to be defined in application

ARDL - Pesaran et al (2001) bounds testing approach

There are a number of steps that should be taken in order to apply the ARDL bounds testing approach of Pesaran et al (2001). Giles (2013) provides a summary of the application of the method and to an appropriate model. The initial aspect is ensuring there are no variable integrated of order I(2) using and ADF or KPSS testing procedure. The next steps are as follows:

a. Formulation of the 'unconstrained ECM'
   - $\Delta y_t = \beta_0 + \Sigma \beta_i \Delta y_{t-i} + \Sigma \gamma_j \Delta x_{1t-j} + \Sigma \delta_k \Delta x_{2t-k} + \theta_0 y_{t-1} + \theta_1 x_{1t-1} + \theta_2 x_{2t-1} + e_t$
     - here the error correction term of a traditional ECM model is replaced with y_{t-1}, x_{1t-1}, and x_{2t-1} (first difference terms)
     - a standard ECM take the form $\Delta y_t = \beta_0 + \Sigma \beta_i \Delta y_{t-i} + \Sigma \gamma_j \Delta x_{1t-j} + \Sigma \delta_k \Delta x_{2t-k} + \varphi z_{t-1} + e_t$
     - here the error correction term is taken from the long run OLS cointegrating regression
       - $y_t = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + v_t$
     - hence the lagged residual series is as $z_{t-1} = (y_{t-1} - a_0 - a_1 x_{1t-1} - a_2 x_{2t-1})$
     - in effect the lagged levels are identical to the standard ECM however three is no limitation applied to the coefficients
     - the summation ranges in the unrestricted model are 1 to p, 0 to q_1, and 0 to q_2
b. Selection of the suitable values for maximum number of lags to be applied
   - An Information Criteria approach can be utilised such as the AIC ,Akaike Information Criterion or Schwarz Bayesian Criterion, SC
   - The basis of the criteria is the log likelihood value which begins from -2 log(L) and there is a penalty such that the 'smaller' the value of the criteria the lower the penalty
c. Pesaran et al (2001) apply a key assumption for the errors to be serially independent
   - An LM test can be applied
   - The null hypothesis of serial independence is tested against the errors taking a form of AR(m) or MA (m) with m = 1, 2, 3, …
   - An additional test for ensuring dynamic stability of the model can also be applied
d. Bounds testing application
   - F-test for test of the hypothesis that H_0: $\theta_0 = \theta_1 = \theta_2 = 0$ against the hypothesis of H_0 being untrue
   - Rejecting H_0 give indication of the presence of a long run relationship

- Bounds indicated by Pesaran et al (2001) for 'asymptotic distribution' of the F-statistic
- Th lower bounds assume that all variables are I(0) and the upper bounds assumes the variables are I(1)
- If the F-statistic is outside of the bounds then there is cointegration and hence a long run relationship, if the F-statistic is within the bounds the test is inconclusive.

e. The long run form and ECM can be estimated with the presence of cointegration:

- $y_t = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + v_t$
- $\Delta y_t = \beta_0 + \Sigma \beta_i \Delta y_{t-i} + \Sigma \gamma_j \Delta x_{1t-j} + \Sigma \delta_k \Delta x_{2t-k} + \varphi z_{t-1} + e_t$
  - $z_{t-1} = (y_{t-1} - a_0 - a_1 x_{1t-1} - a_2 x_{2t-1})$ *a*'s are OLS estimators of α's

Eq. 4.g.5: ARDL - long run form and ECM (based on Giles 2013)

Advantages and comparison between ARDL and other approaches to cointegration – Engle Granger method, Johansen method

The key advantages of the ARDL bounds testing approach are that it is it does not require 'pre-testing' of variables to determine the order of integration which according to Pesaran et al (2001) removes an element of uncertainty in regard to the model being applied. Alternate approaches such as that of Engle and Granger (1987) two step residual based process and the Johansen (1995) 'reduced rank regression' also that of the Stock and Watson (1988) using 'stochastic common trends' and also Shin (1994) which test as null hypothesis based on a modified residual rank process. Hence the benefit of the ARDL approach is application for either variable with I(0), or I(1) and for a mixture of both. In addition, given the single equation framework applied to each variable there is less concern for endogeneity as the assumption is for all variables to be endogenous and hence there is no residual correlation. The approach is also suitable for small sample sizes and is more efficient given a single long run relationship the error correction form is more effectual. In the case of multiple long run relationships, the ARDL application is no longer relevant instead an alternative multivariate approach such as that of Johannsen and Juselius (1990) is appropriate.

The Pesaran et al (2001) approach is also able to delineate between the explanatory and dependent variables given the assumption of a single long run relationship. The derivation of the ECM from the ARDL estimated model which incorporates the long run relationship and presence of short term dynamics. The ECM derivation is based on the general to specific approach and hence incorporates sufficient lags to suitable encapsulate the data generating process.

ARDL bounds testing approach and relevant application

As per the previous discussion on econometric approaches the base method for the analysis in this study is the ARDL bounds testing method of cointegration which is developed by Pesaran et al (2001). This approach has two key advantages compared to alternative cointegration approaches with respect to application in this

study. The first key feature is that this method is applicable without having to pre-test the stochastic structure of the variables before commencing. Such that a mixture of variables of an order of integration of one or of an integration of order zero are admissible and also if they are mutually cointegrated. Further it is also applicable in cases which the sample size is small as mentioned by Choudhry (2018). The second key aspect is that the approach has an assumption that the variables for inclusion are endogenous hence there is no issue of endogeneity and there is no relevant aspect of residual correlation. Further as Nkoro and Uko (2016) a major strong point of the approach is in the case in which a number of cointegrating vectors are present, given the method is able to identify the cointegrating vectors. As per the previous discussion of the benefits of the general to specific framework for quantitative empirical analyses, Launrenceson and Chai (2003) further identify that the approach can encapsulate a 'sufficient number of lags' that it is able to encapsulate the data generating process before proceeding to find a reasonable parsimonious form.

Katrakilidis and Trachana (2012) also find the advantages to the ARDL approach of in the form developed by Pesaran and Shin (1998) which is an advancement of the previous conventional approaches to cointegration and as previously mentioned can be used in small sample sizes as described by Romiliy et al (2001). The application of the ARDL allows a determination for longer run estimation and suitable inference due to the application irrespective of the order of integration. A useful variation of this approach is developed by Shin et al (2001) this allows for the implementation of the ARDL approach in nonlinear settings, subsequently for and also as the traditional ARDL approach is not applicable in cases where a variable has an order of integration is two. This development is a useful evolution of the approach and allows the analysis of nonlinear systems in the presence of nonstationary.

GARCH modelling

GARCH

The ARCH and GARCH modelling framework is prominent in the analysis of financial time series data in particular for the analysis of volatility. The basis of this modelling as described by Engle (2001) stems from the core assumption within the least squares model which is that the expected value of the squared error term is constant at any point. This quality is referred to as homoscedasticity, in the case of a time series for which the error terms within the least squares model do not have the same variance at any given point this quality is described as heteroskedasticity. In terms of the regressor for such a model it implies that the standard error and derived confidence intervals appear to be closer together and imply a 'false sense of precision' Rather than accept this as aspect requiring a corrective procedure the ARCH/GRACH modelling approach utilises this property as an aspect of variance for further exploration.

The ARCH/GARCH models (autoregressive conditional heteroskedasticity and generalized form) are intentionally utilised to consider the case of a model of returns within a financial time series and to consider the variance of the returns over time as representing volatility (also a form of 'risk' in the return). Financial

returns exhibit the quality of 'volatility clustering' in which there is autocorrelation in the variance of the returns over certain periods rather than being a random spread.

Engle (2001) considers by way of illustration the financial application for consideration of returns of an asset:

- dependent variable is represented by r_t
    - as in the return on an equity stock
    - with mean value *m*
- variance *h* is based on prior set of information
- so then the present value of *r* present is equivalent to
    - the expectation (or mean) of *r* + the standard deviation of *r * error* (in present period)

Engle (1982) introduced an ARCH model with weights for the 'average squared residuals' for a given period of the model as parameters that were to be determined as estimable parameter whilst allowing the best suited values relative to the data. Prior to this the utilisation of process similar to ARCH applied 'equally weighted averages' Bollerslev (1986) proposed a generalised version of the model, the GARCH version utilises 'weighted average' of the prior squared residual terms with an application of reducing weights for earlier residuals but never going to zero for any weight value. This provides a more accessible estimate and provides 'parsimonious model'. One of the most prevalent specifications of the GARCH model is akin to a 'Bayesian updating' approach such that it identifies the optimum forecast of the next period variance as:

- lates information for the present period which is the latest squared residual
- forecast variance for the current period, and
- taking a weighted mean of the long run mean variance

Engle (2001) illustrates a typical GARCH model set for financial time series the GARCH (1,1) with the first '1' in parentheses representing the number of ARCH terms / lags of squared returns applied within the equation and the second term represents the number of GARCH terms / the number of lags of the moving average. The usual GARCH (1,1) set up is with:

- $r_t = m_t + \sqrt{h_t}\ \varepsilon_t$, - where h_t represents variance of residuals (with ε = 1)
- GARCH model for variance - $h_{t+1} = \omega + \alpha\ (r_t + m_t)^2 + \beta h_t = \omega + \alpha h_t \varepsilon_t^2 + \beta\ h_t$
- objectively the model user seeks to estimate the constant parameters ω, α, β -
    - so in order to update the prior forecast *h* and residual are required
    - weights are given by (1 – α - β, β, α)
    - mean variance in long run is $\sqrt{\frac{\omega}{1-\alpha-\beta}}$
    - this application is valid if α + β < 1
    - useful when ω > 0, α > 0, β > 0

- directly the model set up is to provide a one period ahead forecast however
    - based on this forecast a two period forecast can be made
    - the two period forecast is then closer to the mean variance in the long run
    - if $\alpha + \beta < 1$ holds then then the forecast for the far horizon is the same in all periods
    - hence it provides the 'unconditional variance'
    - hence Engle (2001) indicates that the models have 'constant unconditional variance' as well as being 'conditionally heteroskedastic' and revert to the mean
- in terms of estimating the model equations the utilisation of maximum likelihood estimation can be applied
    - by utilising h_t as a substitute for σ^2 within the normal likelihood, and
    - then maximise for the parameters
- essentially the GARCH updating process for forecasting the variance of the next observation utilises:
    - initial variance, with
    - initial observation squared residual, and
    - weighted mean d of unconditional variance and initial variance
    - to then iteratively use the above for the estimate of the proceeding variance
    - this leads to building a time series of the variance estimates
    - with the 'systematic' approach to adjustment of the parameters being the likelihood function to provide the best fit for the given data sample
- in order to undertake diagnostic testing of the forecast given that the 'true' process for the variance is unknown and could therefore be different than specified by the model the following approaches can be utilised
    - to check for a 'correctly specified' model by building a series of $\{\varepsilon_t\}$ which should and constant mean and constant variance
    - Other testing includes 'autocorrelation in the squares for which a Ljung Box test can be used (often with 15 lags)

GARCH BEKK

In considering the multivariate case, Engle and Kroner (1995) propose the BEKK GARCH (1,1) approach and this has been applied by Stuart (2017) as per the extract of the bi-variate model set up shown below.

- the model:

$$y_t = \beta x_t + \varepsilon_t$$
$$\varepsilon_t \sim N(0, H_t)$$
$$H_t = A' H_{t-1} A + B' \varepsilon'_{t-1} \varepsilon_{t-1} B + C' C$$

Eq. 4.g.6: BEKK GARCH (1,1) (based on Stuart 2017)

- with

- dependent variables presented by the vector y_t
- parameter coefficients presented by the matrix β
- independent variables presented by the vector x_t
- error terms presented by the vector ε_t, these have mean, 0 and follow normal distribution
- the structure of the variance-covariance is given by H_t

For the model with two assets *K* and *S* (bi-variate case), H_t is expressed as:

$$H_t = \begin{bmatrix} h_{K,t} & h_{KS,t} \\ h_{SK,t} & h_{S,t} \end{bmatrix}$$

Eq. 4.g.7: BEKK GARCH (1,1) – variance and covariance (based on Stuart 2017)

- here
  - the diagonal elements of the matrix represent the variances of the assets h_K and h_S
  - the off-diagonal elements of the matrix represent the covariances h_{KS} and h_{SK}
  - here the covariances are symmetric with $h_{KS,t} = h_{SK,t}$

So then as outlined by Stuart (2017) with

$$H_t = A' H_{t-1} A + B' \varepsilon'_{t-1} \varepsilon_{t-1} B + C' C$$

Eq. 4.g.8: BEKK GARCH (1,1) – variance and covariance (based on Stuart 2017)

'the lagged variance, lagged residuals and a constant term' determines the present variance H_t

Within this set up, the lower triangular matrix of the constant terms, *C*, has the property of being lower triangular. Which leads to being able to present the model for the case of two asset (bivariate representation) as follows:

$$H_t = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \begin{bmatrix} e^2_{K,t-1} & e^2_{K,t-1} e^2_{S,t-1} \\ e^2_{S,t-1} e^2_{K,t-1} & e^2_{S,t-1} \end{bmatrix}$$
$$\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} + \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}$$

Eq. 4.g.9: BEKK GARCH (1,1) – variance and covariance & bivariate matrix representation (based on Stuart 2017)

Analytically solving this gives the following,

$$h_{K,t} = a^2_{11} h_{K,t-1} + 2a_{11} a_{21} h_{KS,t-1} + a^2_{21} h_{S,t-1} + b^2_{11} e^2_{K,t-1} + 2b_{11} b_{21} e_{K,t-1} e_{S,t-1} + b^2_{21} e^2_{S,t-1} + c^2_{11}$$

$$h_{S,t} = a^2_{22} h_{S,t-1} + 2a_{22} a_{12} h_{KS,t-1} + a^2_{12} h_{K,t-1} + b^2_{22} e^2_{S,t-1} + 2b_{22} b_{12} e_{K,t-1} e_{S,t-1} + b^2_{12} e^2_{K,t-1} + c^2_{21} + c^2_{22}$$

Eq. 4.g.10: BEKK GARCH (1,1) – variance and covariance & bivariate representation (based on Stuart 2017)

Hence this can be applied to consider the volatility spill over for the return of two assets with

- the present 'own variance' is impacted upon by
    - the ARCH term (*own squared residuals*) and
    - the GARCH term (*own lagged variance*)
- the variance of the other series is impacted by
    - the ARCH spill overs (*squared residuals*) and the GARCH spill overs (*lagged variance*) of one series and
    - the residual cross product and lagged covariances
- the applies 'vice versa' for the bivariate model

So then the covariance can be represented by:

$$h_{KS,t} = h_{KS,t} = a_{11}a_{12}h_{K,t-1} + (a_{11}a_{22} + a_{12}a_{21})\, h_{KS,t-1} + a_{22}a_{21}h_{S,t-1} + b_{11}\, b_{12}e^2_{K,t-1} + (b_{11}b_{22} + b_{12}b_{21})e_{K,t-1}e_{S,t-1} + b_{22}b_{21}e^2_{S,t-1} + c_{11}c_{22}$$

Eq. 4.g.11: BEKK GARCH (1,1) – covariance spill over bivariate representation (based on Stuart 2017)

Hence the covariance has dependence on:

- the lagged covariance and lagged variances of time series of both assets
- also the lagged residuals and the cross-product of lagged residuals again of time series of both assets

h. Econometric modelling

ARDL - data and model estimation

The period of interest is the interwar years of 1920 until 1930 as per the work of Accominotti and Eichengreen (2013) to consider the impact of capital flows and the business cycle with a focus on the US and consider the impact of economic policy uncertainty amongst other variables. The ARDL set up used follows the work of Morley (2006) and Khan et al (2020) in which this approach is used to test the relationships between growth and immigration; and FDI and infrastructure respectively. Here consideration is given to a number of factors that may have impacted the changing dynamics between US export fluctuations the explanatory variable and a number of factors relating to capital flows, financial market volatility and economic policy uncertainty.

The expectation is that there will be a negative impact on exports and hence US growth from capital flows reducing, decline in stock market values and from increase to policy uncertainty. Increases to the level of exports should also increase domestic investment and production Whereas there is potential for a positive impact upon growth from increase to new capital markets issuances, while decline in policy uncertainty may also increase 'confidence' and hence 'credibility' as explored by James (1992) for the Interwar period.

GUM set up

The modelling approach is utilise an autoregressive distributed lag, as per the methodology specified in Chapter 4, set up with the dependent variable Y_t with the value of total exports the US, a lag length of five is selected. The explanatory variables are denoted by X_j for each log differences are taken denoted by Δ. Such that the model equation is as follows:

$$\Delta Y_t = \alpha_i + \sum_{i=1}^{4} \beta \Delta Y_{t-1} + \sum_{j} \sum_{i=0}^{4} \gamma_j \Delta X_{j_{t-1}}$$

Eq. 4.g.12: ARDL representation of GETS model (based on Hendry and Nielsen 2007)

The variable selection is further influenced by the work of Kindleberger (1986) in the analysis of the crisis events occurring in 1929 and 1931 and also Eichengreen and O'Rourke (2009) in the analysis of the shifts to international trading dynamics. Both studies focus on the interwar period, although both studies give less explicit consideration to exploring policy uncertainty in a econometric approach.

Summary of variables of interest

The explanatory variables of interest selected for the ARDL includes those based upon existing literature and theory as well the inclusion of variables relating to uncertainty.

The study of Khan et all (2020) takes the approach of utilising the ARDL model set up to explore FDI (a form of capital flow) and infrastructure as well as a number of components of these elements, with application of cointegration analysis and granger causality testing. In this manner the proceeding exploration of US fluctuations utilises the total esports of the US which impact the business cycle, exports are relevant as per the work of Kindleberger (1986) and James (2002). Konya (2006) has explored the potential for causality between exports and GDP in the post war period hence it is considered as part of this interwar study. In relation the capital flows these are considered relevant based on the study of new foreign debt issuance in the US as per Accominotti and Eichengreen (2013), further Ritschl (2012) considered the relevant fluctuations of the flows in relation to the major US trading partners of the period in particular Germany. Further there is potential impact generated from the deterioration of foreign bonds per the analysis of Mintz (1951) hence the debt defaults are also considered as part of the set up. A number of studies have identified the potential for contagion in financial markets. The work of Galbraith (1954) and Schwert (1989) identify the relevance of the stock market fluctuations and hence this is also considered a s variable of interest. Further Baker et al (2016a) consider the potential impact uncertainty has upon volatility in the stock markets and also interwar period. As per the prior chapters uncertainty is taken into consideration with relation to the significance of historical episode clusters in relation to the fluctuations during this period.

The source for the data used includes the FRED database held by the Federal Reserve Bank of St Louis, USA and the NBER Macro history database. The table and charts below in section 4.9 depict the key variables considered as part of the GUM.

The frequency is quarterly.

GARCH BEKK - data and model estimation

In order to further explore the spill over between UK and UK stock market returns and volatility the GARCH BEKK set follows the work of Stuart (2017) in the analysis of monthly stock return data for the US and UK between 1920 to 1940.

GARCH BEKK set up

As detailed within section 4.7 the approach is again to use a BEKK GARCH (1,1) as follows:

- the model:

$$y_t = \beta x_t + \varepsilon_t$$
$$\varepsilon_t \sim N(0, H_t)$$
$$H_t = A' H_{t-1} A + B' \varepsilon'_{t-1} \varepsilon_{t-1} B + C' C$$

Eq. 4.g.7: BEKK GARCH (1,1) – UK & US spill over (based on Stuart 2017)

- with
  - dependent variables presented by the vector y_t (monthly equity returns)
  - parameter coefficients presented by the matrix β
  - independent variables presented by the vector x_t
  - error terms presented by the vector ε_t, these have mean, 0 and follow normal distribution
  - the structure of the variance-covariance is given by H_t

For the model with the UK stock market represent by *K* and the US stock market represented by *S* (bi-variate case), H_t is expressed as:

$$H_t = \begin{bmatrix} h_{K,t} & h_{KS,t} \\ h_{SK,t} & h_{S,t} \end{bmatrix}$$

Eq. 4.g.8: BEKK GARCH (1,1) – UK & US spill over - variance-covariance (based on Stuart 2017)

- here
  - the diagonal elements of the matrix represent the variances of h_K and h_S
  - the off-diagonal elements of the matrix represent the covariances h_{KS} and h_{SK}
  - here the covariances are symmetric with $h_{KS,t} = h_{SK,t}$

Summary of variables of interest

The UK and US Stock market indices are used to identify the respective monthly equity returns which are the primary variables of interest.

The source for the data used includes the Bank of England Millennium of macroeconomic data compilation, the FRED database held by the Federal Reserve Bank of St Louis, USA and the NBER Macro history database. The table and charts below in section 4.9 depict the key variables considered as part of the GARCH analysis.

i. Results

US export fluctuations, capital flows and policy uncertainty - ARDL

Variable table

Variable	Description	Notes	Source
US_EXP	**US Total Exports**	$mn, nsa	*NBER*
US_FBDE	**Default Index of Foreign Government Bonds Publicly Offered in United States for United States**	Per cent, nsa	*NBER*
US_EPU	**US Economic policy uncertainty index**	Average 1920-38 = 100	*EPU Historical policyuncertainty.com*
US_FBNE	**Foreign Bond Issues, Government and Government Guaranteed or Controlled for the United States**	$mn, nsa	*NBER*
US_S_P	**Index of All Common Stock Prices, Cowles Commission and Standard and Poor's Corporation for United States**	Index 1935-1939=100, nsa	*NBER*

Figure 87: US Export Fluctuations – key variables

Within the charts and results presented below for the variable names the prefix 'L' represents the natural log and the suffix 'Q' represents quarterly data. Hence for all variables in the table above the prefix and suffix are present within the below.

Variable chart and descriptive statistics

The log of the variables is presented below.

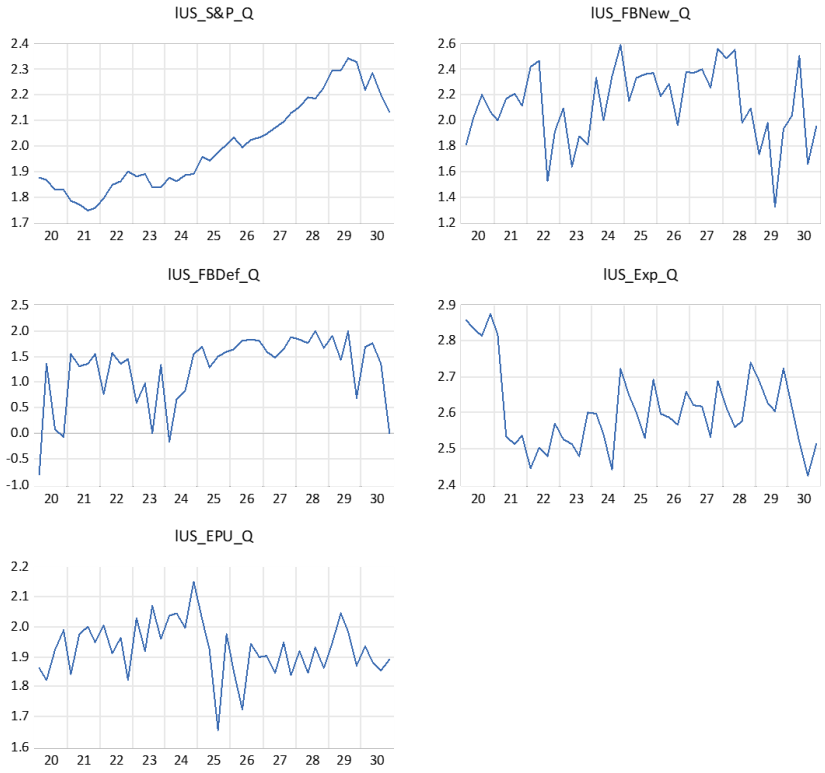


Figure 88: US Export Fluctuations – Chart of key variables 1920-30

The summary of descriptive statistics is presented below.

Date: 07/25/23 Time: 19:47
Sample: 1920Q1 1940Q4

	LUS_S_P_Q	LUS_FBNE...	LUS_FBDE...	LUS_EXP_Q	LUS_EPU_Q
Mean	1.965294	1.110279	0.654067	2.470961	2.058693
Median	1.947636	1.575991	0.000000	2.510609	2.017289
Maximum	2.340246	2.584331	1.984122	2.875756	2.435196
Minimum	1.578639	0.000000	-0.795880	2.022016	1.652714
Std. Dev.	0.157063	1.085623	0.791310	0.191028	0.178796
Skewness	0.316532	0.010427	0.378039	-0.194015	0.189742
Kurtosis	2.931175	1.120235	1.444880	2.667796	2.064722
Jarque-Bera	1.419279	12.36882	10.46518	0.913242	3.565634
Probability	0.491822	0.002061	0.005340	0.633420	0.168164
Sum	165.0847	93.26346	54.94161	207.5607	172.9303
Sum Sq. Dev.	2.047519	97.82192	51.97220	3.028801	2.653343
Observations	84	84	84	84	84

Figure 89: US Export Fluctuations – Descriptive stats of key variables 1920-30

The above charts show the sharp post war decline in exports followed by gradual rise although they did not reach the same levels as would be expected given the European return to production. Following the 1924 period (indicatively the time of the Dawes Plan) there was an increase in corporate borrowing issuance in the US and there was a continued foreign government bond issuance in the US market. A fall in both corporate

and government backed foreign bond issuance occurs in around 1928/9 which is also indicative in the transition away from the Dawes Plan hence there was considerable uncertainty prior to the eventual completion the revised Young Plan of 1930/1 this also occurs at the time of the UK 1928 Hatry Criss and the 1929 US stock crash. The defaults were elevated after 1924 although there was an indicative increase in fluctuations in the pr 1929 periods.

Variable testing – Unit root

Unit roots are taken to test for stationarity and the results indicate that all of the variables are stationary at first difference.

Series	Prob.	Lag	Max Lag	Obs
D(LUS_S_P_Q)	0.0000	0	11	82
D(LUS_FBNEW...	0.0000	1	11	81
D(LUS_FBDEF_Q)	0.0001	0	11	82
D(LUS_EXP_Q)	0.0318	3	11	79
D(LUS_EPU_Q)	0.0000	2	11	80

Figure 90: US Export Fluctuations –key variables unit roots

Model testing – Correlation, Heteroskedastic and CUMSUM stability

The following test were performed satisfactorily to check the model specification.

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.095801	Prob. F(2,16)	0.9092
Obs*R-squared	0.461502	Prob. Chi-Square(2)	0.7939

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.441435	Prob. F(20,18)	0.9602
Obs*R-squared	12.83398	Prob. Chi-Square(20)	0.8844
Scaled explained SS	3.007601	Prob. Chi-Square(20)	1.0000

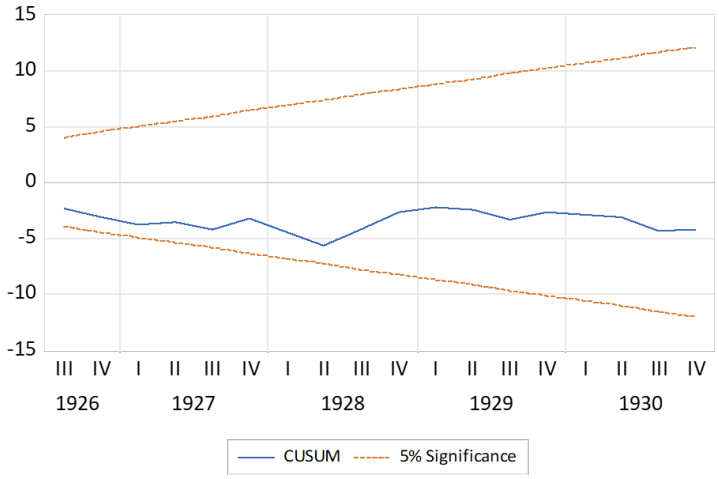


Figure 91: US Export Fluctuations –ARDL model testing

- The F-statistic p-value of 0.9092 indicates that there is no serial correlation.
- The F-statistic p-value of 0.9602 indicates that there is no heteroskedasticity
- Recursive stability results indicate there is stability with the CUMSUM test at the 5% significance level bounds.

ARDL model – estimation

The below model estimation indicates that there is at least one lag for each of the explanatory variables that has an indicative impact on the dependent variable based on the p-values.

Dependent Variable: LUS_EXP_Q
Method: ARDL
Date: 07/25/23 Time: 19:59
Sample (adjusted): 1921Q2 1930Q4
Included observations: 39 after adjustments
Maximum dependent lags: 5 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (5 lags, automatic): LUS_FBDEF_Q LUS_FBNEW_Q LUS_S_P_Q LUS_EPU_Q
Fixed regressors: C
Number of models evaluated: 6480
Selected Model: ARDL(5, 4, 4, 0, 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LUS_EXP_Q(-1)	0.255141	0.125912	2.026347	0.0578
LUS_EXP_Q(-2)	-0.340484	0.140160	-2.429252	0.0258
LUS_EXP_Q(-3)	0.208181	0.153509	1.356148	0.1918
LUS_EXP_Q(-4)	0.223661	0.140980	1.586470	0.1300
LUS_EXP_Q(-5)	-0.345850	0.111848	-3.092139	0.0063
LUS_FBDEF_Q	0.034195	0.024922	1.372101	0.1869
LUS_FBDEF_Q(-1)	-0.030758	0.029229	-1.052296	0.3066
LUS_FBDEF_Q(-2)	0.033837	0.025818	1.310569	0.2065
LUS_FBDEF_Q(-3)	-0.066191	0.026609	-2.487591	0.0229
LUS_FBDEF_Q(-4)	0.036269	0.021416	1.693521	0.1076
LUS_FBNEW_Q	0.114716	0.033379	3.436721	0.0029
LUS_FBNEW_Q(-1)	-0.094553	0.044691	-2.115690	0.0486
LUS_FBNEW_Q(-2)	0.024632	0.048672	0.506071	0.6189
LUS_FBNEW_Q(-3)	-0.006597	0.051784	-0.127390	0.9000
LUS_FBNEW_Q(-4)	0.152513	0.045469	3.354255	0.0035
LUS_S_P_Q	0.191376	0.087799	2.179701	0.0428
LUS_EPU_Q	0.127238	0.100266	1.269005	0.2206
LUS_EPU_Q(-1)	0.118413	0.113011	1.047798	0.3086
LUS_EPU_Q(-2)	0.239972	0.107249	2.237530	0.0381
LUS_EPU_Q(-3)	-0.148516	0.097291	-1.526522	0.1443
C	1.126749	0.663959	1.697017	0.1069

R-squared	0.859374	Mean dependent var	2.578415
Adjusted R-squared	0.703122	S.D. dependent var	0.079672
S.E. of regression	0.043410	Akaike info criterion	-3.132499
Sum squared resid	0.033920	Schwarz criterion	-2.236735
Log likelihood	82.08374	Hannan-Quinn criter.	-2.811107
F-statistic	5.499935	Durbin-Watson stat	2.161711
Prob(F-statistic)	0.000312		

*Note: p-values and any subsequent tests do not account for model selection.

Figure 92: US Export Fluctuations –ARDL model selection

ARDL model – Long Run and Bounds Test

In order to test for the presence of cointegration, the Long Run Form and Bounds Test he following output is considered. Analysis and ARDL outputs based on EViews (2017).

Levels Equation
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LUS_FBDEF_Q	0.007357	0.051629	0.142488	0.8883
LUS_FBNEW_Q	0.190834	0.083435	2.287223	0.0345
LUS_S_P_Q	0.191500	0.087845	2.179983	0.0428
LUS_EPU_Q	0.337326	0.216826	1.555743	0.1372

EC = LUS_EXP_Q - (0.0074*LUS_FBDEF_Q + 0.1908*LUS_FBNEW_Q + 0.1915*LUS_S_P_Q + 0.3373*LUS_EPU_Q)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	16.01721	10%	2.45	3.52
k	4	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06
Actual Sample Size	39	Finite Sample: n=40		
		10%	2.66	3.838
		5%	3.202	4.544
		1%	4.428	6.25
		Finite Sample: n=35		
		10%	2.696	3.898
		5%	3.276	4.63
		1%	4.59	6.368

t-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif	I(0)	I(1)
t-statistic	-6.708251	10%	-2.57	-3.66
		5%	-2.86	-3.99
		2.5%	-3.13	-4.26
		1%	-3.43	-4.6

Figure 93: US Export Fluctuations – ARDL Long Run Form and Bounds Test

The F-statistic value 16.01721 is evidently greater than the I(1) critical value bound. Hence indicates that it is possible to reject the null hypothesis that there is no equilibrating relationship. Further, since this rejects the null and since the model selection does not include a constant or trend in the cointegrating relationship, this indicates that the t-Bounds Test critical values can be used to determine which alternative emerges. In this instance, the absolute value of the t-statistic is $|-6.708251|=6.708251$, and it is greater than the absolute value of either the I(0) or I(1) t-bound. Hence indicates that it is possible to reject the t-Bounds test null hypothesis, and conclude that the cointegrating relationship is either of the usual kind, or is valid but degenerate.

ARDL model – ECM (error correction) / parsimonious form

The parsimonious form of the model is shown below.

ARDL Error Correction Regression
Dependent Variable: D(LUS_EXP_Q)
Selected Model: ARDL(5, 4, 4, 0, 3)
Case 3: Unrestricted Constant and No Trend
Date: 07/25/23 Time: 20:04
Sample: 1920Q1 1930Q4
Included observations: 39

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.126749	0.114843	9.811235	0.0000
D(LUS_EXP_Q(-1))	0.254492	0.096473	2.637961	0.0167
D(LUS_EXP_Q(-2))	-0.085992	0.096734	-0.888948	0.3858
D(LUS_EXP_Q(-3))	0.122189	0.096457	1.266768	0.2214
D(LUS_EXP_Q(-4))	0.345850	0.094209	3.671101	0.0017
D(LUS_FBDEF_Q)	0.034195	0.017290	1.977708	0.0635
D(LUS_FBDEF_Q(-1))	-0.003914	0.016794	-0.233089	0.8183
D(LUS_FBDEF_Q(-2))	0.029922	0.019188	1.559459	0.1363
D(LUS_FBDEF_Q(-3))	-0.036269	0.015707	-2.309138	0.0330
D(LUS_FBNEW_Q)	0.114716	0.027655	4.148080	0.0006
D(LUS_FBNEW_Q(-1))	-0.170548	0.033147	-5.145226	0.0001
D(LUS_FBNEW_Q(-2))	-0.145916	0.034969	-4.172712	0.0006
D(LUS_FBNEW_Q(-3))	-0.152513	0.034403	-4.433134	0.0003
D(LUS_EPU_Q)	0.127238	0.077611	1.639431	0.1185
D(LUS_EPU_Q(-1))	-0.091456	0.085940	-1.064192	0.3013
D(LUS_EPU_Q(-2))	0.148516	0.074923	1.982252	0.0629
CointEq(-1)*	-0.999351	0.101010	-9.893580	0.0000

R-squared	0.912899	Mean dependent var	-0.007727
Adjusted R-squared	0.849552	S.D. dependent var	0.101234
S.E. of regression	0.039266	Akaike info criterion	-3.337628
Sum squared resid	0.033920	Schwarz criterion	-2.612485
Log likelihood	82.08374	Hannan-Quinn criter.	-3.077453
F-statistic	14.41121	Durbin-Watson stat	2.161711
Prob(F-statistic)	0.000000		

* p-value incompatible with t-Bounds distribution.

Figure 94: US Export Fluctuations – ARDL ECM

Overall the above results indicate that, the EC term, above represented as CointEq(-1), is negative with an associated coefficient estimate of −0.999351. This implies that about 99.9% of any movements into disequilibrium are corrected for within one period. Moreover, given the very large t-statistic, namely −9.893580, it is possible to infer that the coefficient is of significance.

UK and US Volatility spill over – GARCH BEKK

Variable table

Variable	Description	Notes	Source
UK_Share	**UK Share price index**	BoE spliced series with Banker's magazine, 1921-1956_365 security values weighted by market capitalisation, Dec 1921=100;	*A millennium of macroeconomic data for the UK, BoE*
US_SP	**Index of All Common Stock Prices, Cowles Commission and Standard and Poor's Corporation for United States**	Index 1935-1939=100, nsa	*NBER*

Figure 95: UK & US stock market spill over – key variables

Within the charts and results presented below for the variable names the initial prefix 'L' represents the natural log and the secondary prefix 'R' represents returns data. Hence for all variables in the table above the prefixes are present where relevant below.

Variable chart and descriptive statistics

The 12 month moving average and volatility of the UK and US stock indices are respectively presented below.

Figure 96: UK & US stock market 12m MA returns & Volatility

The 12-month moving averages are used for ease of interpretation show. The UK series is indicative of four potentially notable episodes. Initially, the series increases in the post war period, then declines as with the post war recessions. Secondly, there is a relatively stable period in the mid-1920s although no significant growth, which is in line with the period of industrial rationalisation and return to the Gold Standard. The post 1930/31 period is indicative of the increased volatility, followed by a return to growth phase which could be linked with the end of the Gold standard regime. Finally the return to War again bought about another crisis period and subsequent closure of the exchange markets.

The US data, is indicative of the milder post war recession, with the mid 1920s representing the known boom and growth phase. The subsequent drop in the post 1929 crash period was considerably greater and volatility in the 1930s was indicatively more persistent and the onset of the second war provided as per Greenwald et al (2012) an increase in industrial output and the resounding end to the travails of the depressionary period.

The summary of descriptive statistics for log of monthly returns between 1920- 1940 is presented below.

	LRUK_SHARE	LRUS_SP
Mean	-0.001598	0.000494
Median	0.001672	0.009419
Maximum	0.116914	0.395743
Minimum	-0.153607	-0.288621
Std. Dev.	0.032225	0.066642
Skewness	-0.948752	0.092282
Kurtosis	6.890946	10.74952
Jarque-Bera	195.9890	628.4321
Probability	0.000000	0.000000
Sum	-0.401104	0.123986
Sum Sq. Dev.	0.259617	1.110283
Observations	251	251

Figure 97: UK & US stock market returns - descriptive statistics

The above charts indicate the heightened volatility post 1929 and also indicative of the greater volatility level in the US markets. The fall of the US stock market was considerably greater than the fall in the UK markets.

Model testing – Variance, Covariance, Correlation and Likelihood contribution

The following figures present the asset returns variance, covariance, conditional correlation and likelihood contribution.

The below charts show the variance of the UK stock return series, the variance of the US stock retune series and the covariance between the two series, which is indicative of the relationship of the volatility between the two markets.

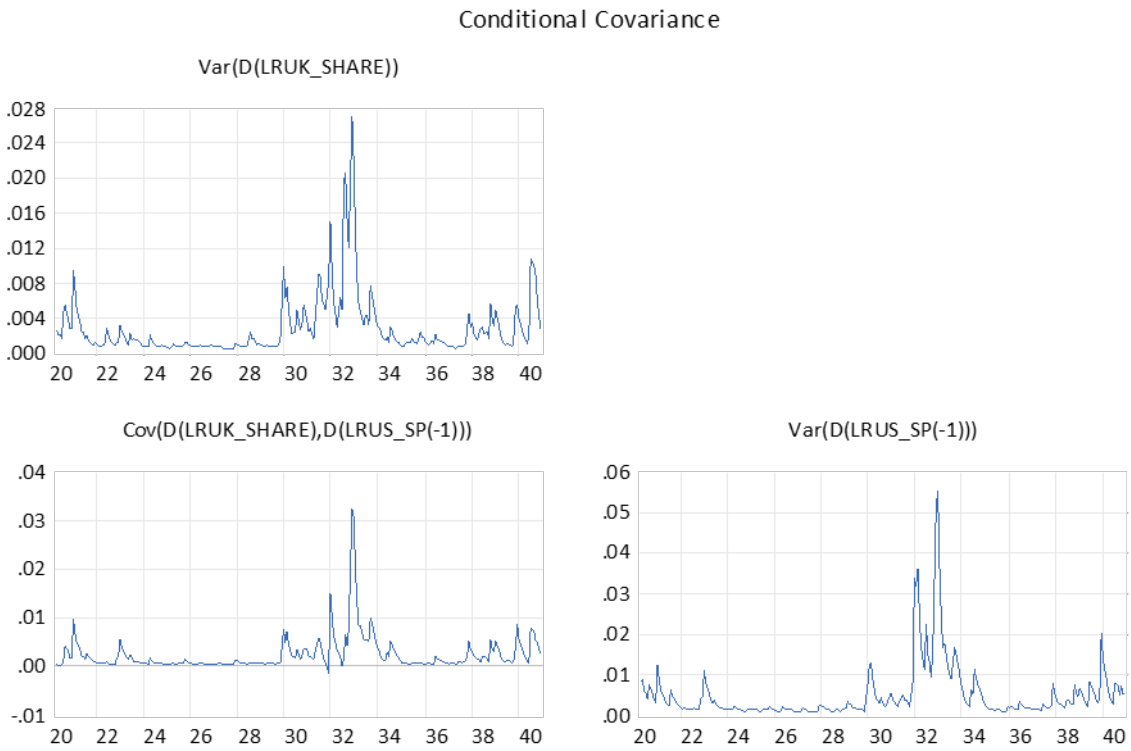


Figure 98: UK & US stock market returns – conditional covariance

The below chart shows the conditional correlation graph between the two series indicates the volatility spill over. This indicative of positive spill over effect given as the volatility increase in one market there is also increase in the other market.

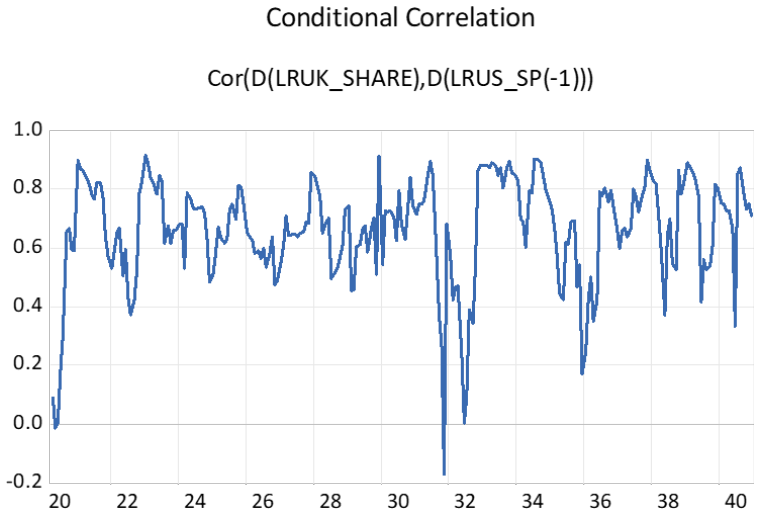


Figure 99: UK & US stock market returns – conditional correlation

The below chart show the log likelihood contribution of the BEKK GARCH setup.

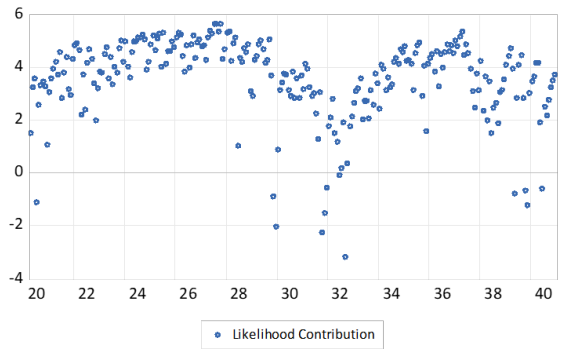


Figure 100: UK & US stock market returns – likelihood contribution

GARCH model – bivariate

The results of the model are shown below.

System: BEKK2
Estimation Method: ARCH Maximum Likelihood (BFGS / Marquardt steps)
Covariance specification: Diagonal BEKK
Date: 07/10/23 Time: 15:20
Sample: 1920M04 1940M12
Included observations: 249
Total system (balanced) observations 498
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 75 iterations
Coefficient covariance computed using outer product of gradients

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	-0.003060	0.001905	-1.606553	0.1082
C(2)	-0.433855	0.065023	-6.672339	0.0000
C(3)	-0.006354	0.002593	-2.450288	0.0143
C(4)	1.029254	0.060618	16.97927	0.0000
Variance Equation Coefficients				
C(5)	0.000162	6.09E-05	2.653816	0.0080
C(6)	0.000150	5.99E-05	2.508550	0.0121
C(7)	0.000306	9.48E-05	3.229208	0.0012
C(8)	0.463140	0.075308	6.149986	0.0000
C(9)	0.300142	0.073122	4.104680	0.0000
C(10)	0.622206	0.125477	4.958722	0.0000
C(11)	0.734556	0.108873	6.746882	0.0000
C(12)	0.778669	0.034420	22.62233	0.0000
C(13)	0.808085	0.030274	26.69202	0.0000

Log likelihood	889.9563	Schwarz criterion	-6.860184
Avg. log likelihood	1.787061	Hannan-Quinn criter.	-6.969907
Akaike info criterion	-7.043826		

Equation: D(LRUK_SHARE) = C(1) + C(2) * D(LRUS_SP(-1))

R-squared	-0.206182	Mean dependent var	-2.09E-05
Adjusted R-squared	-0.211065	S.D. dependent var	0.045057
S.E. of regression	0.049585	Sum squared resid	0.607289
Durbin-Watson stat	2.314180		

Equation: D(LRUS_SP(-1)) = C(3) + C(4) * D(LRUK_SHARE(-1))

R-squared	0.244794	Mean dependent var	0.000379
Adjusted R-squared	0.241736	S.D. dependent var	0.078729
S.E. of regression	0.068556	Sum squared resid	1.160884
Durbin-Watson stat	2.604088		

Figure 101: UK & US stock market returns – BEKK GARCH model

Within the output above the C(1) – to C(4) represents the main equation parameters and then C(5) to C(13) represent the variance coefficients. These can be considered as per the supplementary output format shown below. In which C(8) corresponds to A1(1,1) up until C(13) corresponding to B1(2,2) as shown below.

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + D1*(RESID(-1)*(RESID(-1)<0))*(RESID(-1)*(RESID(-1)<0))'*D1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
D1 is a diagonal matrix
B1 is a diagonal matrix

Transformed Variance Coefficients

	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	0.000162	6.09E-05	2.653816	0.0080
M(1,2)	0.000150	5.99E-05	2.508550	0.0121
M(2,2)	0.000306	9.48E-05	3.229208	0.0012
A1(1,1)	0.463140	0.075308	6.149986	0.0000
A1(2,2)	0.300142	0.073122	4.104680	0.0000
D1(1,1)	0.622206	0.125477	4.958722	0.0000
D1(2,2)	0.734556	0.108873	6.746882	0.0000
B1(1,1)	0.778669	0.034420	22.62233	0.0000
B1(2,2)	0.808085	0.030274	26.69202	0.0000

Figure 102: UK & US stock market returns – BEKK GARCH variance coefficients

The outputs may be interpreted as follows:

- A1(1,1) represent the news effect of UK on the US market – the p-value indicates significance as the news is impacting the conditional covariance of the two markets.
- A1(2,2) represent the news effect of US on the UK market – the p-value indicates significance, again is impacting the conditional covariance.
- B1(1,1) and B1(2,2) represent the persistence effect or (GARCH effect) – again respectively as the p-values indicate significance, again both impacting the conditional covariance.
- D1(1,1) and D1(2,2) represent the asymmetric effect – again respectively the p-values indicate significance, hence the negative shock in one market increase the conditional covariance between the two markets.

Hence then there are three types of volatility spill overs shown to be of relevance based on the BEKK GARCH model set up analysis.

j. Concluding remarks

This chapter has explored the relationship between business cycles, uncertainty and market distortions. The analysis was undertaken by way of comparison between the UK and US interwar period fluctuations .

The outcomes of the economic and econometric analysis of the current study include the following aspects:

- empirical analysis of the differences between UK and US during 1920-40 period show that the relative boom in the US 1920s and subsequent fall exhibited much greater fluctuations for the US when compared to the UK
- the sectoral imbalance theories for the US explain in part the rationale for the depth and duration of the depression and hence as shown within this study the comparative lack of such sectoral imbalances within the UK may provide some rationale as the lower peaks and troughs of the UK fluctuations
- the potential Interrelationship between sectoral imbalance and capital flow given the role of agricultural export demand from Europe has also been explored based on ARDL Bounds testing approaches
- the significance of the market distortions and in particular the policy uncertainty surrounding the Dawes Plan arrangements is apparent in respect of capital flows and subsequently the business cycle given the US sectoral imbalances
- the study also extended the literature considering financial market volatility spill overs which found that there was significance between the UK and US based on the BEKK GARCH analysis

Chapter 5: Conclusion

This study has analysed economic fluctuations and policy uncertainty. Through the consideration of interwar historical episode clusters and fluctuations in uncertainty, especially various components. Which supplements the existing literature and theories of crises particularly relating to the great depression period. A specific focus of the study has been the business cycles and economic policy uncertainty for the UK and US respectively as well comparative analysis and spill over analysis.

Research Findings

The preceding chapters have explored the relevance of the EPU index to the interwar business cycle fluctuations and also with regard to potential explanations for the comparatively deeper and longer US depression as well as spill over effects in particular with the UK and US.

In studying the empirical relationship between uncertainty and the business cycle of the UK and US some of the following findings have emerged:

- policy uncertainty as measured through the EPU index is a relevant explanatory variable for UK and US business cycle fluctuations in the interwar period
- UK and US economic uncertainty did Granger Cause (linear and non-linear variants) economic activities of the major global economies of the interwar period, namely the US (UK) and France, although less significant results for Germany (less significant results for non-linear causality with respect to Germany)
- the US experienced much greater business cycle fluctuations compared to the UK
- the sectoral imbalance theories may explain for the depth and duration of the depression and the consideration of the open economy context considered in this study supplements these studies
- the build-up of sectoral imbalance has potential links to capital flows and policies like the Dawes Plan which supported the export demand including for sectors like agriculture
- financial market volatility spill overs have been identified through empirical analysis between the UK and US

Within the thesis the definition of uncertainty applied is that of 'Knightian uncertainty', or Immeasurable risk. A conceptualisation of this approach is presented within Chapter 2 as the following:

- Homogeneous class of events – *known knowns*
    - for which as probability distribution is known for example
- Measurable / quantifiable risk elements – *Known unknowns*
    - Estimation of a probability distribution function can be reasonably assumed
- Uncertainty with immeasurable elements – *unknown unknowns*
    - No systematic way of accurately quantifying/estimating risk

Within chapter 3, consideration has been given to the literature on business cycles and recessions. For example Schumpeter (1939) considers changes and cyclical waves with more transformative impact. There is indication of sectoral shifts in the US with Gatti et al (2012) identifying trapped labour in US agrarian regions as a further restraint upon the transition towards the manufacturing sector. Bernanke's (1994) question over 'why nominal wages did not adjust more quickly' as wage rigidities have been studied as a significant factor in dampening the recovery. As well as Greenwald et al (2012) identifying uncertainty over future employment stability reducing the marginal propensity to consume.

This analysis leads towards an indication of distortions within the market which are generated by fluctuations in uncertainty. Such that as depicted under conditions of general market uncertainty some market participants are able to earn above normal returns and this in turn leads to the acceleration of sectoral imbalances which may cause further uncertainty. The Chapter 4 theoretical analysis shows how an uncertainty shock generated due to the onset of War in Europe generated a market distortion with the US agriculture sector able to achieve abnormal levels of incomes and employment unexpected with the levels of rising productivity, with the government funds sustaining the rising price level. Hence the study provides the theoretical context along with the historical episode narrative of the uncertainty as a precursor to the sectoral imbalances. The underlying uncertainty fluctuations are then investigated within an empirical set up.

The study has identified suitable analytical tools and methods, to empirically explore the role of uncertainty in relation to economic fluctuations and crises. Further has utilised the identified approaches to explore the role of uncertainty during the interwar period.

Chapter 2, explores the components of the Economic Policy Index to identify fluctuations in uncertainty during the period 1914-1938 and the narrative approach to compare such components of uncertainty with clusters of historical episodes.

Next in Chapter 3, consideration is given to as to whether EPU is a relevant explanatory variable within a model of output as well as potential granger causation in relation to interwar business cycles within the UK and US. The results show that uncertainty for both UK EPU and US EPU is a relevant explanatory variable for UK output. As well as showing uncertainty both US EPU and UK EPU is a relevant explanatory variable for US output. Further the results indicate there is linear granger causality of UK EPU to UK output and US EPU to US output.

This analysis is extended to consider the significance of the uncertainty in the US and UK economies respectively with business cycle spill over impact upon Europe, as part of this analysis the two largest interwar European economies of Germany and France are analysed. There emerges from the results, some indication of greater causality from UK EPU and US EPU respectively to the other country business cycles when the crisis period is included in the analysis. This is shown within elements of the linear and non-linear causality analysis.

Then in Chapter 4, the theoretical analysis within the study demonstrates the role of uncertainty with respect to generating market distortions which may have accelerated the sectoral imbalance that occurred in the build-up of the 1929 great crash and subsequent depression. Further extending the chapter 2 exploration of EPU component fluctuations compared to the historical episode clusters, which provides explanation for the spikes in the time series. Overall, the empirical analysis results, provide indication of statistical significance of the impact of EPU on the activity of the UK business cycle and US business cycle as well as the spill over to other business cycles.

Significance and implications of findings

The thesis has identified gaps within the existing literature and puts forward findings that supplement the current body of research. These contributions are made within the three key topics or papers presented, in relation to uncertainty fluctuations, business cycle spill over and sectoral imbalances.

In terms of context, the research utilises the prevailing definition of uncertainty but further seeks to develop upon the work of Knight (1921) through considering the comparison with role of the entrepreneur in terms of taking advantage of disruption at the micro level and the work of Schumpeter (1939) in relation to creative disruption leading to the formation of macro level business cycles. Subsequently, there is analysis to consider the potential causal precedence between fluctuations in economic policy uncertainty and business activity. The study also gives extended treatment to cover the pre 1929 period which has typically been given less consideration in the existing macro literature. Though this period is of importance, given the significant episodes relating to economic policy adjustments, capital flows, trade shifts and wider macro movements.

As an initial step the thesis (in chapter 2), provides a look into the relevance between historical episode clusters and the fluctuations in uncertainty, which has been demonstrated in part by utilisation of an index in particular, for the interwar period using the respective EPU indices for the UK and US. This analysis supplements existing studies in covering the 1920-40 period, as well as the development of relating the changes to global episodes, as opposed to only domestic events as has been more prevalent in recent studies like Lennard (2018) .

As an additional development the proceeding chapter analysis has addressed the following topic related questions which are relevant given that they are typically given less coverage by the existing literature. Especially as there is a dearth of studies considering the entire 1920-40 interwar period, respectively for both the UK and US. The thesis has empirically:

- explored whether policy uncertainty as measured with the EPU index respectively for the US and UK is a relevant explanatory variable for UK/US business cycle fluctuations in the interwar period
- considered whether UK/US EPU granger caused the business cycles of the significant economies of the interwar period, including the US/UK, France, and Germany

The findings of the empirical analysis of uncertainty in addressing the above, utilised the following approach in seeking to answer the respective questions. The initial stage was to identify that there was a (granger) causal relationship between UK (US) EPU and the economic activity of the US (UK), France and Germany. This covered the period between 1920 and 1938 with monthly data, and given limitations of data availability, for Germany from 1920 to 1935. As shown by Choudhry et al (2020) the precedence for the causal relationship is based upon the 'interdependence and integration' that was prevalent between each of these countries, in particular given the relative levels of capital flows, foreign investments and bilateral trade.

The next stage was to identify the presence of nonlinearity within the causal relationship. This aspect of nonlinearity in time series has previously been explored in a number of works such as Hiemstra and Jones (1994), Shiller (2005), also including Shin et al (2014). So the thesis engaged with this nonlinearity causality testing approaches to consider the presence of nonlinear granger causation between EPU indices and spill over to the business cycle fluctuations.

The later stage was to consider the significance of the critical episodes for the US and UK respectively. Hence given that the 1929 Stock market crash was perceived within the existing literature as a precursor to the US great depression. This theme was taken as a further aspect of analysis, so results were considered for granger causality in the pre-1929 crash and post 1929 crash period. As an extension other time frames could also be analysed such as for example, in particular for the UK, critical junctures include, 1926 return to the Gold Standard and furthermore the 1931 departure from Gold anchoring. Also in a global context, one possible extension is to also look at the 1931 Credit Anstalt crisis. In this study the empirical analysis finds some indication that uncertainty linked with the 1929 crash had an impact to escalate the spill over to the business cycles of the major global economies.

As a further stage the thesis then develops upon the existing crisis literature from which two prominent themes were identifiable with respect to the underlying causes and also the depth of the 1930s depression. The topics taken forward were in relation to the sectoral imbalances and the capital flow shifts. Hence this study provides an initial insight into the potential overlaps with the two perspectives. This is an area of interest which is underdeveloped amongst the existing research studies, both in general discussions with respect to economic crisis periods and in relation to the interwar period. Hence in this regard the thesis provides further analysis into the 1920s episodes that increased sectoral imbalances and could be linked to the shifting capital flows prior to the 1929 crash period.

In this area of interest, the study has as made contributions towards the identified gaps within the existing literature. One area includes the relation to the Sectoral imbalances theories including Greenwald (2012), here the notion of domestic aspects of mobility constraints has been extended to consider the drivers of demand, which link to the relevant of international capital flows. So this provides a context of influences for export demand and this in turn may have supported the resilient or 'sticky' domestic levels of employment within

farm sectors, which may have been unexpected given rising levels of productivity. Then going further with the Capital flow literature such as Accominotti and Eichengreen (2016) the context of the sectoral shifts and structural macro changes occurring globally is supplementary to the explanation for US domestic sectoral shifts.

Another aspect of the study includes the consideration and empirical analysis of the relevant difference between the depth of depression between regions, such as the UK and US. This study finds that a potential explanation can be in part attributed to the relative levels of sectoral shifts that occurred. For example a prominent factor is the shift between agriculture and industry which was occurring in the US, whereas this shift had already occurred in previous periods in the UK, demonstrated by the much lower proportion of labour employment within agrarian sectors. This comparative aspect has not been given treatment to any considerable extent in the prior literature.

Hence then the contributions of the research study include the exploration of the similarities and implied differences between the economies of the UK and US during the early to mid-1920s period and subsequently the relevance to the evolution of events during the post 1929 crash period. This is of relevance given that these economies remained the most prominent for global trade and investment and yet the relative impact of the 1929 crisis was materially different across both economies. As demonstrated with the US experiencing a deeper and longer lasting depression.

A subsequent aspect which was identified was the spill over between financial market volatility in the UK and US, which may then be interrelated to generate further impact upon policy uncertainty and in turn also capital flows, trade and the business cycle.

Limitations

One of the difficulties in conducting time series research over longer durations or for periods prior to the 1950s, is inevitably the availability and accessibility to the requisite quantitative data. This is particularly relevant to global macro studies and for when the intentions may include comparing the current or recent time periods with more historic (fifty years or more) prior periods.

The focus of this study was the interwar period and that particular juncture was also an interesting period in terms of the development of the econometric field and more generally the collation of statistical data. Following the second world war, international standards for national accounts data began to emerge as explored by Bos (2011). Prior to this there were a limited number of countries which produced data on macro indicators as mentioned by Solomou and Vartis (2005), they explore in the particular context relating to exchange rate estimates. For the given period of this study data is accessed predominantly for the US and UK, as well as some comparative business cycle data for France and Germany. The current thesis notes the limitations on the data availability in particular for Germany, the wider context of which is insightfully explored by the Tooze (2001) analysis, which reflects the limitations in this case. Also the potential for the objectives of

data collation to take a more political means with various ministries almost acting as rivals. Never the less the data series during this period for other countries were equally prepared by research led and private institutions for other potentially more apolitical purposes such as investment decisions and forecasting. As described by Bos (2011).

Although there are inevitable limitations to the study of the interwar period, the predominant analysis has been undertaken for the US and UK which draws on time series that are published by highly reputable institutions, National Bureau of Economic Research (NBER) and the Bank of England respectively which are in turn derived from series that have been diligently prepared by a number of academic researchers, as previously noted within the source table listings. The time series that have been drawn upon are those which have been utilised in a number of peer reviewed journals and other such academic studies. Hence albeit there are limitations, they still provide a reasonable level of comparative robustness with respect to being utilised in the field over a significant period of time. Also during the period there were significant advances made both to the collation and utilisation of time series and econometric data, in the US the Cowles Commission for Research in Economics (1932). Which began to integrate economic theory with suitable statistical and mathematical techniques and in doing so developed instrumental variable and enhanced maximum likelihood approaches to regression analysis. The Commission, as per Malinvaud (1988) in US set about to bring a more consistent rigorous approach to econometric and time series data for economic analysis.

In terms of the considered approach taken for the sources of data utilised in the study, as mentioned they have been drawn from respected sources. The UK data was based on the BoE 1,000 years of Macroeconomic data archive and particular series prepared by Capie and Collins (1983) and also Capie and Webber (1985). Hence in a way these series are not as subject to the Tooze (2001) implied concerns with respect to policy drivers behind German data agencies. Further the US data was based on the ALFRED archive of the Federal Board of St Louis, although these are vintage series they are still subject to revisions, as 'economic data for past observation periods are revised as more accurate estimates become available' mentioned on the site, ALFRED (2023). Some of the US data series is compiled in part, by NBER and a particular strength is the availability of disaggregated time series, as well as state and federal series which make allowance for comparison and verification of individual time series. This is a long established reference point 'several decades of its existence, the National Bureau of Economic Research (NBER) assembled an extensive data set that covers all aspects of the pre-WWI and interwar economies' NBER (2023). Discussion of some merits and constructive points on accessibility are considered further by Feenberg and Miron (1997). Additionally in this study for cases of comparison with other countries where appropriate there was utilisation of industrial production series as a proxy for GDP for example, to compare across the US, UK, Germany and France, given there was not a singular GDP type of measure available for all four nations during this period.

In the context of more recent time series data, in general macro data revisions are a conspicuous part of the research process, and recent episodes such as with ONS (2023) media criticism bringing about an Office for

Statistics Regulation (OSR) review with regards GDP estimates and revisions. Also previously the Independent Review of UK Economic Statistics (2016) conducted by Sir Charles Bean which considered challenges, capacity and governance of key measures such as GDP. Furthermore OBR (2021) analysis highlight the significant impact even post 1950 measurement revisions can take for example when measuring more recent recessions. An interesting point is put forward by Solow (2023) in that actually much of the 'predominant' time series data in of itself may be culpable in missing a significant element, that of the impact of natural resource depletion and/or environmental costs, such measures have been put forward in the U.N. national systems of accounts approaches. In the long experience of Solow (2023) such a system would be 'superior' however there is value in considering access to both these more complete measures as well as the existing series given they provide the 'possibility of having long time series to study'. Despite the limitations utilising such data is not a futile endeavour in the of itself, as provides an indication and basis for further exploration. Hence in utilising the prior historical data as undertaken within this study, can also in a similar vein be of relevance to analytical endeavours.

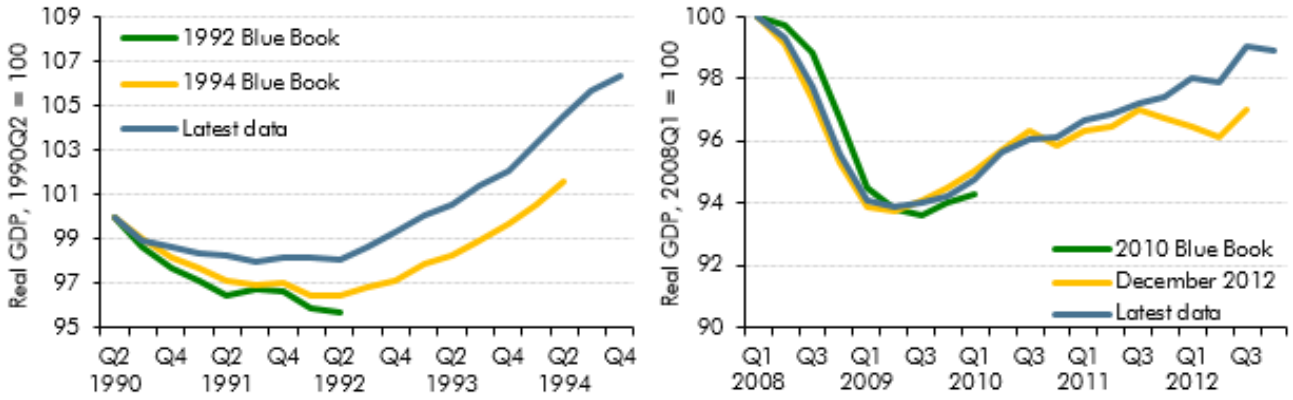


Figure 103: The changing profiles of the 1990s and 2000s recessions – OBR and ONS (2021)

Furthermore in this research study, the possible limitation question of reliance or controversy over any one particular modelling method, is addressed in a similar vein to that proposed by Granger (1997). Which is to consider alternate methods and allow for comparison. Hence for the analysis of time series components, analysis is undertaken through application of different techniques to verify findings, such as using unobserved components methods as well as HP filters. In addition, a grounded approach is taken to the identification problem, such as considering historical episode clusters through the narrative analysis method to consider relevance of spikes in uncertainty, which in a sense is bridging between quantitative and qualitative aspects of empirical analysis. Further, in using alternate frameworks of econometric analysis to supplement empirics such as granger casualty both linear and nonlinear, as well as VAR which does not impose a model, and also the GETS approach to find a parsimonious representation of the General user model (GUM).

Another potential limitation exists in comparing the UK Policy Uncertainty Index, historically for the 20C and also for measures since the period of the Russian Crisis / LTCM both to a more recent episode of EPU fluctuations as identified by Baker et al (2016b). In particular the matter of the Brexit spike is 'striking' in

comparison, hence shows greater movement in the index than even the 2008/09 crisis, yet the impact, if any was not immediately apparent. Through looking at GDP or other such business cycle components as well as compared to a lack of a shock in volatility of the stock market. Baker et al (2016b) estimate in part that the concentration may be in part related to the matter of the Brexit situation being a national event hence UK news was more closely following this when compared to a global financial crisis. As shown in the charts below.

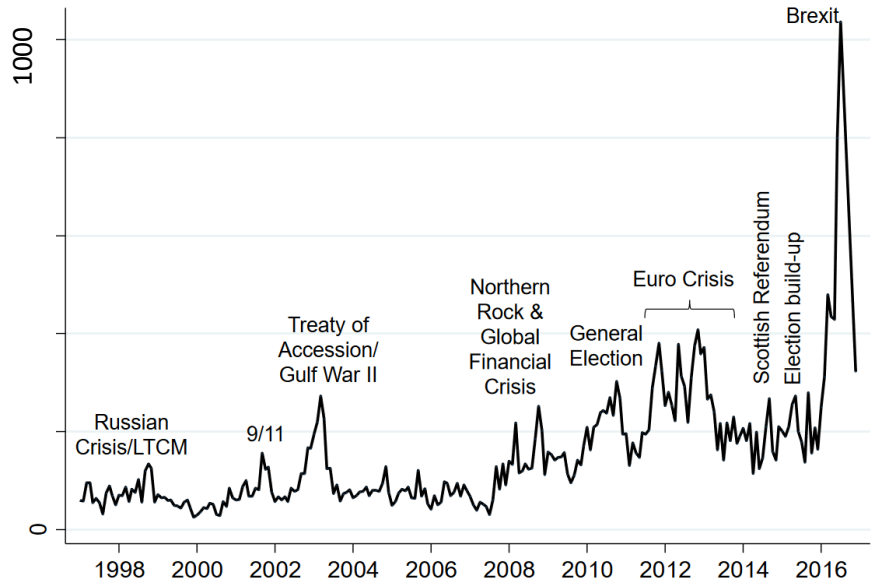


Figure 104: UK Policy Uncertainty Index – striking Brexit spike – Baker et al (2016b)

Also there is potential for more persistence in the impact upon economic data, measurement of which is also somewhat obscured in terms of the pandemic which followed. Another explanatory factor could be the evolution of news reporting and media in general in which economic and political events such as Brexit combine with other 'social media' to consume more elements of 'zeitgeist'. Than they would in isolation especially given that it was such a politically polarising matter. Such that media played a greater part in the build-up in the means of being the primary source of public information and so writers may have been more 'invested' and possibly partisan across departments to give more prominence, as well as an evolution of report style due to the rise of other forms of media. Baker et al (2016b) also mention that there are two historic components to negative shock in uncertainty, a 'direct' element and an 'uncertain' element, with Brexit having a potential greater lag for the uncertainty component to emerge. Overall they have compared and run 'detailed human audits' of the index to compare results to automated article coding with similar results for the large sample sizes.

Further research

In summary the findings indicate that relevant historical episode clusters can be linked with the fluctuations in the economies of the US and UK during the interwar period which contribute towards the economic

fluctuations. The application of the economic policy uncertainty index could hence be applied in a number of further directions:

- conceptualising uncertainty – considering the variations in how Knightian uncertainty is interpreted between theoretical models and in terms of econometric applications
- further exploration of consumption and considering whether there are relative levels of uncertainty in generating 'dissaving'
- investigating whether there is any precedence of either consumer demand shifts or firm investment decisions under uncertainty
- considering further the macro level precedence between uncertainty and feedback with other shocks
- other aspects for which the study has given some consideration but which could be extended upon in further studies also include the indicative similarities between the 2020s pandemic and the 1920s post 'Spanish flu' period in relation to the global macro changes.

Additionally the study has found relevance to exploring uncertainty and economic policy uncertainty fluctuations with respect to sectoral shifts and subsequent macro indicators such as capital flows.

Hence this study has attempted to consider the relevance of significant past fluctuations. This is potentially relevant given the number of parallels which can be observed through some stylised facts and consideration of major episode clusters, as indicated by the figure below.

#	1920s - episodes	2020s - episodes	Summative narrative
1	great world war	global pandemic	*social impact + economic impact - supply chain disruption*
2	Spanish flu		
3	government debt	recovery + support schemes	*necessary to support economy*
4	UK + US short recessions immediately post war	recession brink for many G20 countries	*many countries have been stuttering on edge of recession*
5	international treaties	international treaties + trade	*Brexit + US/China trade disputes ongoing*
6	strikes	industrial action	*renegotiation due to rationalisation + changes to social pact*
7	prices / commodities	wheat/oil/gas	*supply constraint generates excess price rises*
8	inflation	inflation	*given supply challenges and monetary policy changes*
9	gold standard	digital currencies	*seeking to restore confidence*
10	war reparations	sanction on Russia	*geopolitical upheaval generates economic impact*
11	agriculture sector productively shifts	manufacturing sector automation + AI	*sectoral shifts impact on employment and income security*

Figure 105: 1920s & 2020s - Summative historical episode clusters

As considered within this chapter, further development and analysis with regards the EPU index could also be undertaken in terms of comparing the structure of recent EPU index fluctuations to more historic movements over longer time periods of more than fifty years. Exploring potential explanations of differences with the more recent UK EPU spikes and delayed impact of events relating to Brexit for example. In terms of the interwar period the historic index is thus far only available for the US and UK, hence the development of an EPU index for Germany and France for the 1920-1940 period could be a relevant endeavour, as neither one is currently unavailable for further comparison between the largest trading partners of the US and UK.

Another aspect which could be given more treatment is the sectoral imbalances, a research theme could be to look at sectoral shifts over the long run across countries with both time series and panel data methods. In addition there could be the developed application of a model to explore the market distortions, in the agricultural sector and combining with export dynamics. Such as to provide productivity overshooting exploration, such as in the case of the US which led to sectoral imbalances escalating. As with the current research focus, which has led into the analysis of the interrelationship between the developing sectoral imbalances and capital flow shifts that occurred in step with export demand changes. An extension of which is analysis into the level of uncertainty and policy episodes that may have contributed to the decline in financial flows. The intuitive implications, are that market distortions and policy uncertainty combined, as linked with government interventions that were made during the period, which also had alignment to the international economic policy changes that occurred.

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