Essays on Globalisation, Inflation and Monetary Policy

by

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A thesis submitted for the degree of

Doctor of Philosophy

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2013

Declaration

I declare that this dissertation has not been submitted as an exercise for a degree at this or any other University and that it is entirely my own work.

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Summary

This thesis comprises three essays. The first examines the impact of factor, product and financial market integration on the labour share of income. In particular, we investigate how the changing composition of international trade towards trade in intermediate goods may weaken the bargaining power of labour and lead to greater wage restraint among workers. We approximate the extent of the "offshoring" of tasks in the production process with outflows and outward stocks of FDI. Moreover, we distinguish between total flows of FDI and those that are destined for emerging economies, which are more likely to be driven by labour cost differentials. We find that it is the magnitude of total FDI outflows, rather than the destination of those outflows, that is associated with lower labour shares in advanced economies. Our results also suggest that globalisation leads to lower labour shares by weakening the impact of labour market institutions

The second essay examines the role of international competition and global excess demand in the dynamics of domestic inflation. We modify the open-economy New Keynesian Phillips Curve (NKPC) to allow import competition to affect the desired markup of domestic firms. We find that higher levels of import penetration and lower relative import prices are associated with lower domestic inflation. We also augment the open-economy NKPC with a measure of foreign marginal cost and find that foreign marginal cost has a significant effect on domestic inflation. Finally, we show that globalisation affects domestic inflation through its impact on domestic marginal cost and find evidence of a global component in the domestic labour share.

The final essay examines the impact of financial globalisation on the effectiveness of monetary policy. In particular, we focus on the impact of global factors on the relation between short- and long-term yields in the US. We first examine how this relation changed during the "conundrum" period and find that there was a structural break in the middle of the term structure in mid-2004. We relate the behaviour of long-term yields during this period to foreign official holdings of US Treasury securities. Over a longer period we find that the US yield curve is characterised by two stochastic trends that affect its level and slope and suggest that this is evidence of a non-stationary term premium. However, once we remove the influence of global factors on US yields using a factor model, we find evidence in favour of the Expectations Hypothesis.

Acknowledgments

This thesis would not have been possible without the support of many people.

First and foremost, I would like to express my sincere gratitude to my supervisor Professor Philip R. Lane for his insightful comments and expert guidance. His research first inspired my interest in international macroeconomics and it has been an invaluable experience working with him. I am particularly grateful for his constant willingness to make time to discuss my research.

I would like to thank my examiners Michael Wycherley and Karl Whelan for many helpful suggestions on developing this research. I am also grateful to Frank Warnock for his comments on the fourth chapter.

I am indebted to the late Eoghan Garvey for his invaluable advice and encouragement and have fond memories of our long discussions on all aspects of economics. I would also like to thank my earliest mentor, Eithne Murphy, who has shown a deep interest in my professional development throughout the years and always encourged me to pursue further postgraduate study.

This research has benefitted from the comments of the International Macroeconomics research group at Trinity College Dublin and I would like to express my gratitude to all of its participants. In particular, I thank Agustin Benetrix for sharing his insights and for being so generous with his time.

I would like to acknowledge the financial support provided by the Irish Research Council for Humanities and Social Sciences (IRCHSS) through a postgraduate scholarship. I am also thankful to the staff of the Institute for International Integration Studies (IIIS) and the Department of Economics at Trinity College Dublin for providing such a supportive atmosphere for its Ph.D. students.

On a personal level, I thank Sharon for her patience, good-humour and, most importantly, for proof-reading.

Finally, the constant support and encouragement of my parents, Margaret and J.B, has brought me to this point.

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Chapter 1

Introduction

This thesis addresses three aspects of the globalisation, inflation and monetary policy debate. First, we examine one possible explanation for the decline in inflation in advanced countries, namely the impact of international competition on domestic wage-setting. Second, we investigate the impact of global factors on domestic inflation and consider the empirical relevance of the "global competition" and "global slack" hypotheses. Finally, we consider the impact of financial globalisation on the effectiveness of monetary policy.

One important channel through which globalisation can affect inflation and which has largely been neglected by recent academic studies is the impact of international integration on domestic labour markets. Chapter 2 of this thesis aims to fill this gap in the literature. The motivation for relating the decline in inflation rates to structural changes in the labour market derives from a report from the Bank of International Settlements (BIS (2005)), which observed that the correlation between unit labour costs and inflation had fallen in many advanced countries.

Although there are several possible explanations for the decline in this correlation, we suggest it is partly a result of the intensification of low-wage competition from workers in emerging markets, which has weakened labour's bargaining power and promoted greater wage-restraint among workers in advanced countries. In particular, two recent phenomena are likely to have altered the nature and extent of this competition. First, the integration of low-wage economies such as China and India into the global economy has led to a doubling of the global labour-capital ratio (Freeman (2008)). In addition, there has been a change in the composition of international trade. Historically, trade has taken the form of an exchange of final goods or commodities and reflected the concentration of countries in particular sectors. However, technological change means that agglomeration is increasingly occurring by task rather than by sector as the production of goods becomes "unbundled" into a series of tasks, some of which can be performed more efficiently in other countries (Baldwin and Venables (2010)).

Therefore, the "offshoring" of production to low-cost countries provides a new channel through which competition from foreign workers may moderate the wage demands of workers in advanced countries and potentially reinforces the impact on wages of import competition in final goods. Increasing trade in intermediate and final goods has important implications for domestic inflation if it leads to a reduction in the elasticity of wages with respect to domestic output or to the output gap. A weaker relation between wage growth and aggregate demand means that wage growth will not accelerate as the economy approaches the natural rate of output, as is implied by the traditional Phillips curve. This is one of the ways in which globalisation can lead to a "flatter" Phillips curve and is likely to be one of the factors driving the decline in the correlation between inflation and unit labour costs, first observed in BIS (2005).

Chapter 2 addresses this question of how globalisation has affected labour in advanced countries and provides evidence, at the macroeconomic level, of the impact of globalisation that complements firm- and plant-level studies. In particular, we focus on how trade and financial flows have contributed to the decline in labour's share of national income controlling for the impact of other potentially important determinants of the labour share such as technical change, the relative supply of capital and the strength of labour market institutions.

The main channels through which globalisation affects the labour share in our model is via changes in the price of exports relative to imports and increases in import penetration. The former captures the Stolper-Samuelson effects of trade, whereby an increase in the relative price of exports raises the relative price of the factor which is used most intensively in the production of export goods. If advanced-country exports are capital intensive, then this will imply a reduction in the relative return to labour. We use the share of imports in GDP to approximate the extent of import competition in the domestic market. If imports are labour-intensive, then rising import penetration may increase the elasticity of labour demand and encourage wage-restraint among workers. Both of the channels are associated with a lower labour share of national income. We find that, although the relative price of exports and the import share have a negative and statistically significant effect on the labour share, there is considerable cross-country heterogeneity in the quantitative impact of both of these variables. In general, we find that the impact has been strongest in economies that are small and open.

We also contribute to the literature on the impact of offshoring on the domestic labour market in advanced countries. Our use of the share of Foreign Direct Investment (FDI) outflows to non-advanced countries to approximate the extent and threat of offshoring to low-wage locations is novel to the literature that studies the relation between globalisation and the aggregate labour share. However, we find that it is the size, rather than the destination, of the outflows that matters. This suggests that it is the outward mobility of capital, and not purely wage-competition from low-wage emerging economies, which leads to wage-restraint in advanced economies and that labour cost differentials will be arbitraged even across countries at similar stages of development given the "footloose" nature of capital.

One particular advantage of adopting a macroeconomic approach relative to the studies that use microeconomic data is that it allows us to consider the role of labour market institutions in the determination of the labour share. This enables us to construct an index of labour's bargaining power at the macroeconomic level. Moreover, we can examine how globalisation may strengthen or weaken the influence of these labour market institutions on the labour share. The indirect impact of economic integration on the labour share that operates via this channel has largely been neglected by previous studies. We find that import penetration and the relative price of exports tends to weaken the influence of trade unions, the labour tax wedge and employment protection legislation, while import penetration alone strengthens the negative association between the benefit replacement ratio and the labour share.

Finally, Chapter 2 considers whether the inclusion of country effects to capture time-invariant cross-country heterogeneity, which is typical in panel-data studies of the determinants of the labour share, may be too restrictive. Instead, we consider an alternative fixed effect that groups countries according to particular features of the labour market. We find that the impact of labour market institutions on labour share dynamics depends on the particular fixed effect that is included in the regression, with country fixed effects absorbing much of the explanatory power of these variables.

Chapter 3 examines the impact of globalisation on the aggregate supply relation, which relates inflation to real economic activity. Borio and Filardo (2007) argue that traditional models of inflation are misspecified due to the omission of global factors that influence domestic product and factor prices. Intuitively, if both product and factor markets are internationally integrated, then both product and factor prices will be determined by the balance between global, rather than domestic, supply and demand. The "global slack hypothesis" has potentially important implications for inflation dynamics and the ability of central banks to influence domestic inflation. For example, a decline in the sensitivity of inflation to domestic capacity constraints will imply a higher "sacrifice ratio" and thus increase the unemployment and output costs associated with achieving any desired reduction in inflation. In addition, the increase in competition resulting from the integration of product and factor markets may imply that wages and prices are less responsive to domestic demand and more responsive to those set in foreign markets. A failure on the part of a central bank to incorporate the influence of global factors could lead to significant policy errors, particularly if the policy rate is a function of the domestic, rather than global, output gap.

The main contribution of chapter 3 is to test the "global slack" or "global competition" hypotheses in the context of the New Keynesian Phillips Curve (NKPC). Previous studies have used the traditional or "accelerationist" models of inflation to examine the empirical relevance of the global output gap and have obtained mixed results (Ball (2006), Pain (2006), Ihrig et al (2007)). However, models of inflation that are derived from the accelerationist Phillips curve, have recently tended to overpredict inflation, possibly due to the inherently backward-looking nature of inflation expectations that these models assume. By contrast, the inflation in the New Keynesian Phillips Curve is primarily forward-looking and results from the optimising price-setting behaviour of domestic firms. The variable driving inflation in these models is real marginal cost, usually measured by the deviation of the labour share, or real marginal cost, from its steady-state level.

Chapter 3 augments the open-economy NKPC model of Batini et al (2005) with a measure of foreign marginal cost, approximated by the labour share in the country's trading partners. We also incorporate the effect of international competition on price-setting behaviour by allowing firms' desired markup to vary inversely with relative import prices and the level of import penetration. We find that both foreign marginal cost and these strategic complementarities in price-setting have a statistically significant effect on domestic inflation, although the quantitative impact is small.

The other contribution of this is to show that domestic marginal cost has a significant global component. The motivation for the statistical decomposition of the labour share into an idiosyncratic and common component derives from the studies of Monacelli and Sala (2009) and Ciccarelli and Mojon (2010), which find that inflation has a significant global component. We find that both the idiosyncratic and common components have significant effects on inflation. The latter finding provides a further reason why central banks need to incorporate international factors when forecasting domestic inflation.

Chapter 4 examines the implications of financial market integration for monetary policy. In particular, we focus on how financial globalisation affects the interest rate channel of the monetary transmission mechanism. This channel relates changes in the policy instrument, the Federal Funds Rate for example, to changes in an intermediate target, in this case, long-term interest rates. This means that the central bank can influence the interest-sensitive components of aggregate demand and thereby control a final target such as the inflation rate or the output gap. If these variables are non-stationary, then the instrument, and intermediate and final targets should be cointegrated. The Expectations Hypothesis suggests that long-term interest rates should reflect future expected short-term interest rates and a constant, although potentially maturity-specific, term premium.

However, there is some evidence that the correlation between the short- and long-end of the term structure has fallen, while the cross-country correlation between long-term interest rates has risen (Byrne et al (2010)). Indeed, from mid-2004 to the end of 2006, there appeared to be a complete decoupling of short- from long-term interest rates in the United States, an episode so unusual and lacking in an obvious explanation, that the chairman of the Federal Reserve, Alan Greenspan, labelled the behaviour of long-term rates a "conundrum". Although several hypotheses have been advanced to explain this episode, the strongest evidence appears to support the view that flows of financial capital were mainly responsible. In particular, foreign official holdings of US treasuries kept long-term interest rates between fifty and one hundred basis points lower than they would have been, absent these purchases.

The conundrum period is a striking illustration of how financial globalisation could reduce the effectiveness of monetary policy. Financial globalisation could also make the conduct of monetary policy more complex due to the economy becoming exposed to a wider range of shocks, making the future path of macroeconomic variables increasingly uncertain (Kamin (2010)). For example, if the Federal Reserve were faced with an exogenous fall in long-term interest rates, it is unclear what the appropriate policy response would be. Lower long-term interest rates may reflect a decline in the term premium demanded by global investors, in which case, the Federal Reserve should perhaps increase the target for the Federal Funds Rate in order to remove the additional stimulus to aggregate demand. However, if lower long-term interest rates reflect the expectation of lower inflation, then the appropriate policy response may be to lower the target in order to prevent the ex-ante real interest rate from rising. Globalisation may therefore complicate the signal that movements in long-term interest rates send to central banks. This suggests that adopting a closed-economy perspective in formulating monetary policy could result in significant policy errors.

Chapter 4 makes several contributions to the literature on both the conundrum and the impact of financial globalisation on the conduct of monetary policy. We test the Expectations Hypothesis over the conundrum period and find that it holds only if we allow for a statistical break in the relation between short-term yields, and medium- to long-term yields. Moreover, we find that the break in the relation affected the yields on bonds with maturities as low as one year. Whereas most of the previous studies on the conundrum have focused on the ten-year yield, we show that the decoupling of interest rates actually occurs near the middle of the term structure.

We also examine the impact of foreign official holdings on long-term yields and find evidence that accumulated shocks to the holdings were driving these yields. In this respect, our analysis complements the studies of Warnock and Warnock (2009) and Craine and Martin (2010), which use a different methodology to arrive at the same conclusion.

The focus of the remainder of chapter 4 is on the longer-term influence of financial globalisation on the US yield curve. We examine whether the Expectations Hypothesis holds using monthly data over the period 1990 to 2007 but find evidence of an additional stochastic trend in the yields over the period. This additional trend suggests that term premia are non-stationary. We interpret these trends as factors that affect the level and slope of the yield curve and thus our findings complement the studies of Shea (1992) and Giese (2008), which use data for an earlier period.

Having established that the Expectations Hypothesis does not hold at the monthly level, we test whether this may be due to the influence of global factors. We use a recent data set of monthly zero-coupon yields from Wright (2011) and a novel combination of a factor model with a Cointegrated VAR to show that the Expectations Hypothesis holds when we remove the yield factors that are common across our sample of countries and focus on the idiosyncratic factors. As far as we are aware, this is a new result in the literature on the Expectations Hypothesis. It suggests that the main impact of global factors is on the term premium and provides an interesting avenue for future research.

Chapter 4 also contributes to the debate on the impact of financial globalisation on the Federal Reserve's ability to control inflation. Woodford (2009) has shown that a central bank can achieve any desired inflation target regardless of the level of financial integration as long as it can affect short-term interest rates and, thereby, influence the opportunity cost of holding money. We show that changes in the target for the Federal Funds Rate, the policy rate in the United States, have a significant short-run effect on the yields of bonds with maturities of up to six months.

Finally, Chapter 5 presents the main findings and conclusions of the thesis and discusses how we intend to build on these findings in future work.

Chapter 2

Globalisation, Bargaining Institutions and the Labour Share

One of the most remarkable features of the global economy over the past two decades has been the almost ubiquitous decline in levels of national inflation. Figure 2.1 illustrates both the breadth and depth of this phenomenon. In addition, inflation in goods and services has remained remarkably stable even during a period of rapid growth in asset prices and global liquidity.[1] In an attempt to explain this, several hypotheses have been advanced (Rogoff (2003)). While better fiscal policy, accelerated productivity growth, and a more conservative approach to monetary policy may all have played some role in individual countries, the cross-country variation in these variables is too large to account for the common decline in inflation.

Rogoff (2003) contends that the unifying causal factor is increased product and labour market competition as a result of globalisation and deregulation. He suggests that competition should reduce an economy's 'inefficiency gap' and make prices more flexible, thereby reducing the efficacy of an unanticipated monetary expansion. This argument suggests that globalisation should increase the slope of the Phillips curve, whereas most evidence suggests that the slope has actually decreased. Indeed, it appears that inflation is becoming less responsive to domestic aggregate demand.

[1] See Borio (2005) and White (2011) for a discussion of historical episodes of low inflation and concurrent asset price booms, which were subsequently followed by a collapse in asset prices.

The flattening of the Phillips curve is compatible with the competitive effects of globalisation. A fall in the relative price of imports boosts workers' real wage without any cost to employers and therefore an increase in employment is compatible with stable inflation. In addition, the increased integration of product and factor markets may weaken the relation between domestic inflation and the domestic output gap, but strengthen the relation between domestic inflation and the output gap in a country's trading partners. Borio and Filardo (2007) find evidence that suggests this is the case. A third potential causal factor is the effect of increased competition on the bargaining power of labour. Facing competition from foreign workers through imports, the outsourcing of production and immigration, workers are more likely to moderate wage demands. This negates the need for firms to pass on wage increases via higher prices.

Table 2.1 presents evidence that the correlation between wage and price inflation may be falling. It is clear that the relation between inflation and unit labour costs has weakened over time for the majority of the countries in the sample. One explanation for the decline in this correlation may be the increase in competition in the product and labour markets that is associated with globalisation.[2] As product markets become more competitive, firms are more likely to absorb increases in labour costs through a reduction in desired markups. Similarly, international competition may reduce the bargaining power of labour leading to increased wage moderation by trade unions. Increases in firms' costs that are passed through to prices are therefore less likely to be due to union wage demands.

Figure 2.2 illustrates the origin of advanced country imports and thus the potential competition facing workers in those countries.[3] It is clear that a significant majority of imports originate in other advanced countries. However, the trend of a rising import share from emerging economies, particularly China, is clear. Trade linkages, however, are not the only source of competition. Freeman (2008) estimates that increased openness in India, China

2 See (BIS, 2005) for an early discussion of this weakening correlation and how it may be related to the integration of product and factor markets.

3 Note: Countries are classified as "advanced" according to the IMF World Economic Outlook database.

and the former Soviet Union has led to a doubling of the global labour supply. This positive supply shock has resulted in a significant decline in the global capital-labour ratio and a concomitant rise in the relative return to physical capital, as described by Broadbent and Daly (2009).

Figure 2.3 illustrates that advanced countries engage in substantial Foreign Direct Investment (FDI) in non-advanced countries although the overwhelming majority of direct investment takes place in other advanced countries. In addition, as Figures 2.4 and 2.5 show, the destination of FDI outflows matters for the "wage competition" hypothesis. It is clear that the outflow-weighted wage in FDI partner-countries falls significantly when advanced partners are excluded.[4] This suggests that there may be considerable scope for labour-cost arbitrage through the "offshoring" of production, whereby the performance of certain "tasks" is transferred to production facilities abroad where they can be performed more efficiently.

Further, actual outward stocks and outflows may not capture the full degree of competition felt by advanced country workers. What matters in terms of worker insecurity is the "threat" of the relocation of production. This may be correlated with existing investment linkages with non-advanced countries. Figure 2.6 shows the evolution of the "adjusted" and unadjusted labour share for advanced countries.[5] However, the downward trend of the aggregate conceals significant variation across countries. Figure 2.7 shows that amongst the advanced countries, the labour share has fallen significantly in Continental Europe and moderately in Scandinavian countries, but has remained broadly constant for Anglo-Saxon countries. This suggests that features particular to a labour market are important in determining how supply shocks like globalisation affect the labour share.

The aim of this chapter is to examine not only the direct impact of openness on the labour share, but also the indirect impact through its effect on reducing workers' bargaining power. We focus particularly on the outflow of FDI and its possible role as an indicator of the extent

[4] The outflow-weighted wage is calculated by weighting the destination country's manufacturing wage (in US dollars) by its share in the source country's total outflows.

[5] The adjusted labour share imputes a labour income for the self-employed. See Gollin (2002).

of offshoring. This chapter thus seeks to measure and confirm the macroeconomic effect of openness, and offshoring in particular, and complement the existing firm- and worker-level studies. The hypothesis that increased global competition is responsible for the decline in the labour share is tested for a panel of 20 advanced countries from 1980 to 2007. We also test this hypothesis for the manufacturing sector. As the extent of labour mobility is limited, this chapter concentrates on the role of trade and financial integration.

Our results show that relative export prices, total FDI outflows and imports all have negative and significant effects on the labour share. We also find that labour and product reform tends to benefit labour and so the decline in measured bargaining power does not adversely affect workers. Finally, although it is not the central focus of the chapter, we find that technical change has a non-linear relation with respect to the labour share, so that over time, labour gains from increased investment in Information and Communications Technology (ICT).

The remainder of the chapter is structured as follows. The next section reviews the relevant literature on the effects of openness and bargaining institutions on labour market outcomes. Section 2.2 describes the offshoring phenomenon. Section 2.3 discusses aggregate GDP and cost functions. Section 2.4 discusses the translog function and outlines our econometric model. Section 2.5 outlines variable definitions and data sources. Section 2.6 presents our results and section 2.7 concludes.

2.1 Literature

This chapter seeks to establish a link between globalisation, the bargaining power of workers and the labour share of income. Of most relevance to this chapter is the literature on the effect of international trade and investment on labour market outcomes such as employment and wages. The most recent studies in this area focus on the global fragmentation of production or offshoring. A separate strand of literature examines the effect of international competition on particular measures of worker bargaining power and this chapter provides some evidence of this through the interaction effects in the model.

International Trade, Offshoring and the Labour Market

One approach to addressing the question of whether globalisation affects labour market outcomes is to estimate the effect of a change in the net factor content of trade on domestic wages. This methodology gained popularity among trade economists in the 1990s, culminating with Feenstra (2000). Criticisms of this approach center on the underlying assumptions of homothetic preferences, constant technological differences between countries and the nature of trade, particularly the role of intermediate inputs. The second approach sought to calculate the Stolper-Samuelson elasticity of changes in the prices of tradable goods with respect to labour's share of output. Traditionally, much of this research focused on wage inequality between skilled and unskilled workers rather than on the overall returns to labour relative to capital.[6]

More recently, the third approach seeks to model the nature of offshoring and thus illuminate the role played by intermediate goods. The focus of this literature turned towards the increasing trend of offshore outsourcing and the apparent shift in favour of skilled or non-production labour within sectors, rather than simply between manufacturing sectors, particularly in the United States. The nature of offshoring is likely to be determined by the characteristics of the tasks workers perform in the production process. Blinder (2009) argues that increasing imports of intermediate goods is reducing the earnings of workers who perform tasks that do not require geographical proximity or tacit knowledge. He ranks the "offshorability" of US occupations according to how personal the service is (the degree to which it requires human contact or interaction) or how closely tied it is to a specific geographical location.[7] Feenstra (2007) also underlines the need for a new paradigm capable

[6] Generally, these studies find a modest effect (between three and seven percent) of trade on the skilled-unskilled wage ratio in the United States. However, as Krugman (2008) points out, the data analysed in these studies only extend to the mid-1990s, just when, according to the consensus view, global trade began to accelerate.

[7] It is not clear along which dimension the offshoring potential of a particular job should be measured. Autor et al (2003) suggest tasks should be grouped according to expert thinking, complex communication, routine cognitive tasks, routine manual labour, and non-routine manual labour. They argue that the dichotomy should be how "routine" the job is, while Blinder (2009) argues that the requirement for

of explaining the effects of globalisation on labour. He points out that skilled workers have gained in all countries, which is at odds with what would be predicted by the Hecksher-Ohlin theory of trade. Krugman (2008), however, argues that the increasing sophistication of imports from developing countries is an illusion of the data and that if industry data could be further disaggregated, imports from developing countries would be shown to be intensive in unskilled labour.

Grossman and Rossi-Hansberg (2008) propose that offshoring can be a positive development for domestic workers in spite of this. They decompose the possible effects of the offshoring phenomenon on wages into three components: a labour supply effect (offshoring increases the effective labour supply); relative price effect (improved terms of trade depresses wages of domestic unskilled); and a productivity effect (offshoring-induced fall in unit labour costs increases demand for domestic unskilled). The productivity effect benefits domestic unskilled workers. If the relative world output of the offshored labour-intensive good increases at initial relative prices and the terms of trade of the domestic economy improve, wages of the unskilled will fall relative to those of skilled workers similar to a Stolper-Samuelson effect.

The net effect of offshoring on domestic workers will depend on which effect dominates. For example, if the demand for goods is inelastic then the movements in relative prices as a result of supply changes will be substantial. Similarly, the productivity effect is likely to dominate the negative labour supply effect if the share of low-skilled labour in total costs is large, the elasticity of substitution between low and high-skilled labour is high and if offshoring costs are convex. Grossman and Rossi-Hansberg (2008) draw an analogy between offshoring and factor augmenting technical progress: when firms offshore tasks and profitability increases there is an incentive to expand and increase the demand for labour that is used intensively in the production process. A proportion of this increase will go to domes-

personal contact provides the demarcation. Interestingly, Blinder finds that not only is the correlation between his subjective measure of a job's "offshorability" and the worker's educational attainment or wage (proxies for skill) small, it is actually positive. Further, Leamer and Storper (2001) classify tasks into those which can be codified and those for which tacit knowledge is necessary, with the former being more readily offshored.

tic workers who perform tasks that require geographic proximity. This process, they argue, is similar to the process whereby improvements in technology affect the productivity of a worker with certain skills. They find that imports of business, professional and technical services only account for 13 percent of total US imports of goods and services, although this number has increased significantly in the last decade. This may lead to an increase in demand for this type of worker.

It is important to emphasise, however, that trade in tasks occurs in both directions. For example, Amiti and Wei (2009) find that the United States, in particular, is actually a net "insourcer" of service sector jobs with trading partners sending more service jobs to the US than the US sends abroad.

Most of the evidence relating to the impact of offshoring on labour market outcomes is based on sectoral, firm and individual level data. Feenstra and Hanson (1999) use a general equilibrium model to examine the link between offshoring and wage inequality in the US manufacturing sector between 1979 and 1990. They impute the effect on the wages of production and non-production workers through the effect of outsourcing and technology investment on the evolution of prices and labour productivity. They find little evidence that the real wage of production workers has been adversely affected by offshoring and a small positive effect in the real wage of non-production workers. Molnar et al (2007) find a significant positive relation between the long-run wage elasticity and outward investment for a group of manufacturing sectors with strong links to non-advanced countries. The rate at which employment adjusts to changes in output or wages is also higher in these sectors. In contrast, the speed of adjustment is negatively related to an increase in outward investment for a corresponding group of service sectors. Molnar et al (2007) conclude that foreign workers are more likely to be substitutable for manufacturing firms with strong links to non-advanced countries, while their counterparts in the service sector are more likely to be complements. For all sectors, they find that employment growth in foreign affiliates of domestic firms tends to have a significantly positive relation with domestic employment in the US, but not in Germany or Japan. This suggests that employment in domestic and foreign affiliates in the latter two countries is likely to be relatively substitutable.

This chapter does consider the aggregate manufacturing sector but as we are unable to disaggregate the FDI data by destination countries we cannot consider the separate effects of FDI outflows to advanced relative to non-advanced countries. We can, however, consider this possibility for the total economy and then make some inference about what may be occurring in the manufacturing sector.

Amiti and Wei (2005) use data on 78 sectors in the United Kingdom to test whether services offshoring is associated with lower domestic employment growth and find no evidence that domestic employment is adversely affected. However, this finding may depend on the level of aggregation of the data. For example, Amiti and Wei (2009) find that, when the US economy is decomposed into 96 sectors there is no effect of service outsourcing on domestic employment, but when decomposed in to 350 sectors there is a significant and negative effect. This suggests that outsourcing may cause sectoral reallocation of employment, but that employment is not affected in the aggregate.

In terms of evidence at worker level, Liu and Trefler (2011) use matched Current Population Survey (CPS) data for the period 1996 to 2006 to examine the effects of offshore outsourcing and "inshoring" to China and India on unemployment duration, occupation and industry switching and earnings, while controlling for worker characteristics.[8] They find no evidence that offshore outsourcing and inshoring have affected industry-switching and some evidence that inshoring has actually reduced occupation-switching. In terms of unemployment duration (or the share of weeks the individual was unemployed in the total number of weeks spent in the labour force), Liu and Trefler find that the net effect of inshoring and

[8] Liu and Trefler define "inshoring" as the sale of services to unaffiliated entities in low-wage countries. Similarly, Slaughter (2004) describes "insourcing" as the investment in domestic subsidiaries of foreign headquartered multinationals. In addition, as emphasised by Liu and Trefler (2011), a distinction should be made here between the more general issue of "offshoring", which can occur between both affiliated and unaffiliated entities, and "offshore outsourcing", which occurs between unaffiliated parties. We explore this distinction below.

offshore outsourcing is likely to slightly reduce the duration of unemployment. They also find that inshoring and offshore outsourcing have had between negligible and small positive effects on earnings.

Similarly, Harrison et al (2011) exploit CPS data on wages and individual worker characteristics to examine the effect of both trade and offshoring (using data from the Bureau of Economic Analysis on MNC activity) on domestic labour market outcomes from 1982 to 2002.[9] At industry level, they find only a small effect of offshoring on wages for those who remain in the specific manufacturing sector, with virtually no effect from offshoring to low-wage countries and a small increase from offshoring to high-wage economies. In terms of employment, offshoring to low-wage economies and high-wage economies induces small negative and slightly larger positive effects, respectively, on manufacturing employment, while import competition has a much stronger negative effect. However, they find that globalisation has no effect on the evolution of wages in the same industry and conclude that perhaps, the specification is not capturing the general equilibrium effect of globalisation on wages.[10] Using occupation-specific measures of offshoring (low-income and high income affiliate employment), import penetration and export shares, they find that a 1 percent increase in employment in affiliates in low income countries reduces domestic wages across all occupations by 0.19 percent, while a 1 percent increase in employment in affiliates in high income countries increases wages by 0.16 percent. They also estimate large and significant effects for import penetration and export shares, with a 1 percent increase in import penetration reducing wages by 1.36 percent and a 1 percent increase in the export share increasing wages by 2.4 percent.[11]

[9] The BEA data on offshoring is compiled from firm-level surveys of direct investment abroad by US headquartered (non-bank) Multinational Corporations (MNCs) and contains information relating to employment in foreign affiliates.

[10] If workers are relatively mobile between sectors, then any sector-specific study does not capture the effect of globalisation on the wages of workers in that occupation who have left the sector. Blinder (2009) also raises this industry versus occupation effect in relation to estimating the "offshorability" of a job.

[11] Harrison et al (2009) create occupation-specific measures of globalisation by multiplying the share of workers of a particular occupation in an industry in 1979 by the exposure of that industry to the globalisation measures (employment in high- and low-income affiliates, import penetration and export shares) and summing across industries.

Globalisation and Worker Insecurity

The main effect of the increased substitutability of foreign and domestic labour will be to increase insecurity among workers (Rodrik (1997)). Jensen and Kletzer (2005) find that service jobs that are potentially tradable have become less secure. They find that between 2001 and 2003 annual job-loss rates for displaced workers were significantly higher for those working in tradable as opposed to non-tradable services. Scheve and Slaughter (2004) relate workers' perceptions of economic insecurity to FDI activity within an industry as reported in the British Household Panel Survey. Trade and Foreign Direct Investment raise the elasticity of demand through a scale effect, where a given increase in wage costs translates into larger declines in output and demand for all factors, and through a substitution effect, where firms can substitute domestic labour through offshoring. Using a panel of 5,000 households and 9,000 individuals for the period 1991 to 1999 they find that individuals employed in FDI sectors systematically feel less "secure".

Similarly, Brock and Dobbelaere (2006) examine a panel of 12,000 firms in the Belgian manufacturing industry for the period 1987 to 1995 and find that increased FDI activity in a firm tends to reduce an estimated measure of workers' bargaining power.

However, for the threat of relocation to exist, it must mean that it has not been executed. Kaplan and Spiegler (2001) point out that for the "threat effect" to exist there needs to be both "push" and "pull" factors affecting the firm's location decision. Factors such as plant-specific skills in the existing plant location will positively influence the decision to remain domestically. Conversely, the prospect of significant productivity benefits from locating abroad will entice the firm to relocate.

Offshoring versus Offshore Outsourcing

While the main focus of this chapter is on offshoring, or the relocation of production between affiliated entities, studies often combine this phenomenon with that of offshore outsourcing, or the relocation of production between unaffiliated enterprises. At the microeconomic level, what determines whether an individual firm will engage in offshoring or offshore outsourcing? The decision whether to integrate production or outsource in the offshore location will depend on the size of transaction costs. Holmes and Snider (2009) model the decision to outsource in the framework of the firm's structure.[12] Integrated firms that produce both a labour-intensive intermediate good and a capital intensive intermediate good tend to pay higher wages than firms that are specialised in the production of the labour intensive intermediate good, as labour in the former holds a degree of market power. The ability of the integrated firm to outsource the labour intensive component of production to a specialised firm, and reduce labour-union rent-extraction will depend on the presence and magnitude of an "outsourcing friction".[13] The key mechanism driving this result is that labour demand is more elastic, the greater the share of labour in total production costs, as there is less rent to appropriate.

This framework can also capture Grossman and Rossi-Hansberg's (2008) "productivity effect". By fixing the level of outsourcing, technical change will raise the efficiency of this level of outsourcing. Any reduction in the outsourcing friction will raise wages as workers gain from this increase in efficiency. Thus, it is only increasing the level of outsourcing that will adversely affect wages. Importantly, in this model, rent-seeking activity by workers (the union) absorbs labour and therefore increases wages by reducing the effective labour supply. Outsourcing weakens union monopoly and thus reduces rent-seeking activity.

However, it is likely that offshoring will predominate as contracting problems prevent arm's length relationships from being formed. This is particularly the case in non-advanced countries. The nature of Foreign Direct Investment is also likely to vary with the development

[12] From Industrial Organisation theory, the choice of organisational form between outsourcing or vertical integration will depend on the importance of agency costs. Outsourcing via a joint-undertaking will be preferred if the producer of an intermediate input is important to the production process as this structure aligns the incentives of the producer of the intermediate input and the producer of the final good. (See Grossman and Hart (1986) and Hart and Moore (1990)).

[13] Outsourcing frictions may relate to agency costs, rule of law difficulties, a technological mismatch between supplier and producer, and more generally, costs related to international voice and data transfer.

of the country. As Nocke and Yeaple (2008) show, investment in non-advanced countries is more likely to take the form of greenfield investment as the ability of advanced country firms to invest through cross-border acquisitions is decreasing with the relative supply of corporate assets in the developing country. In their model, FDI takes the form of greenfield investment when there are differences in production costs and takes the form of cross-border acquisitions when there are differences in entrepreneurial abilities.[14] Hanson et al (2005) find evidence that this is the case as US multinational firms tend to concentrate production in low-wage developing countries.

International Trade and the Translog Function

Several studies have addressed the effect of trade on the labour share using the translog functional form. In one of the earliest applications of the translog cost function to international trade, Kohli (1978) decomposes output into traded and non-traded goods and includes imports, capital and labour as inputs in the aggregate cost function. Using data on the United States between 1948 and 1969, he finds that traded goods are capital intensive while non-traded goods are labour intensive. Further, imports are found to constitute a higher share of traded goods costs than non-traded goods and thus the cost of traded goods is more sensitive to the price of imports.

Studies by Kohli (1978) for Canada and Kohli (1990) for the US specify four output shares and a factor share equation.[15] He finds positive Rybczynski elasticities for the labour factor with respect to exports and imports, while the elasticity for the capital factor with respect to consumption is also positive. He concludes that exports and investment are most intensive in labour, while consumption goods tend to be capital intensive. The signs are similar for the Stolper-Samuelson elasticities. However, Kohli (1990, 1993) finds the opposite when

14 However, they also find that the decision of the parent firm to engage in greenfield investment is negatively related to the distance between the "home" and host country. The coefficient on the level of country development (approximated by log real GDP per capita) is on average twice as large as the coefficient on log distance.

15 The output share equations relate to the five components of GDP: consumption, investment, government spending, exports and imports (which have a negative share). The factor share equations comprise capital and labour. One equation from the output and input system can be dropped, as the shares sum to one, the excluded equations can be easily determined.

using a symmetric quadratic functional form. These findings question the modelling of the GDP function as being group-wise additive in its components. This suggests the use of an alternative method of aggregation such as an aggregate cost function.

Harrigan (2000) estimates a translog GNP function for the US from 1967 to 1995 with two output and three import categories and four primary factors (three types of labour and capital). He finds that the increase in wage inequality between the different types of labour is mainly driven by domestic relative prices rather than foreign prices. Harrison (2005) and IMF (2007) also use translog functions to assess the impact of globalisation on the labour share and these studies are considered below.

Relation to Trade and Offshoring Literature

This study is closest in objectives and methodology to Guscina (2007) and IMF (2007). Guscina (2007) examines the effect of increased trade, technological progress and employment protection on the labour share of national income for a panel of 18 countries from 1960 to 2000. This period is arbitrarily split in 1985 into a "pre-globalisation/ pre-IT revolution" period and a "globalisation/IT revolution" period. The author uses GDP per hour and GDP per worker as crude measures of technological progress, assuming that a negative coefficient on these variables indicates that 'technological change' has been labour-saving. "Openness" is measured by several variables, including the average of inflows and outflows of foreign direct investment. The "bargaining power" of labour is measured by the strictness of employment protection, while union density is used as a corollary measure.

Guscina finds that while productivity growth increases the labour share in the period prior to globalisation and the IT revolution, it tends to reduce this share in the later period. In addition, openness tends to have a negative effect on the labour share, particularly after 1985. Employment protection is found to have a positive effect on the labour share, although Guscina finds some evidence that globalisation has weakened this effect. Interestingly, given the objectives of this chapter, an increase in Foreign Direct Investment flows (inflows and outflows) has a much greater negative effect on the labour share in the pre-globalisation/ pre-IT revolution period. A 1 percent increase in the ratio of FDI inflows and outflows to GDP in the pre-globalisation/pre-IT revolution period reduces the labour share by 0.5 percent before 1985 but by only 0.1 to 0.15 percent after 1985.

A number of issues arise with Guscina's methodology. First, the sample size is too small to allow for the additional incorporation of country effects. Second, Guscina includes lagged productivity in the specification although cyclical effects have already been eliminated by taking five year averages. Third, employment protection does not exhibit much variation over the sample period and thus would not reflect the variation in labour's bargaining power over the period. In addition, although Guscina does include union density as an alternate measure, there are several other channels through which globalisation may affect "institutional" bargaining power. Finally, using GDP per worker (or hour) as a measure of technological progress has several problems. For example, a change in the composition of output towards sectors that are high value-added, and in which the capital intensity of production is much larger (for example, financial services), will reduce the labour share. However, this reduction will not be due to technological progress or the "IT Revolution".

Our study differs from Guscina's in that we seek to specify an underlying cost function so that the econometric specification is more theoretically grounded. Second, we allow for the possibility that the use of country fixed effects may be too restrictive and we experiment instead with grouping countries according to labour characteristics. Third, we consider a wider range of variables which may approximate bargaining power. Fourth, following Jorgensen and Vu (2005) we consider the share of Information and Communications Technology (ICT) in the capital stock to be a more reliable indicator of technical change than growth in output per worker. Finally, we focus on the role of FDI outflows, rather than inflows and outflows, as our focus is on approximating the degree of, or potential for, offshoring.

IMF (2007) examines the impact of the increase in the global labour supply on the labour share for Industrial countries between 1982 and 2002. The broader role of globalisation in labour cost determination is emphasised by the joint testing of the effect of the larger pool of global labour, technological change and institutional reform of labour markets. It asserts that the actual extent of offshoring has so far been quite limited. For example, IMF (2007) estimates that imports of intermediate manufacturing and services inputs comprised only 5 percent of gross output and about 10 percent of intermediate inputs in advanced economies in 2003, although these estimates are marginally higher for the manufacturing industry. In addition, imports of services in the overall economy have remained low, although they have increased significantly in some countries. The IMF also suggests that offshoring matters more for skilled than unskilled inputs, as the latter are more likely to be imported as final goods than as intermediate goods.

This study uses an econometric model to analyse the relation between the labour share and several "openness" channels, namely terms of trade, offshoring and immigration. The model also controls for technological change and changes in labour market policies. The terms of trade should capture the Stolper-Samuelson effect on the returns to labour. Exports are assumed to be capital intensive, while imports are assumed to be intensive in labour. A terms of trade improvement will thus reduce the labour share. The impact of offshoring on the labour share is captured by the import share of intermediate inputs as measured by Input-Output tables. The study finds that both technological progress and labour globalisation (the effect of terms of trade, offshoring, and immigration) have reduced the labour share, while changes in labour market policies have had a broadly positive effect on the labour share.

This chapter differs from IMF (2007) primarily in our focus on the outflows of FDI as a measure of offshoring, or the potential threat of offshoring. We introduce a role for the degree of import penetration to complement the effects of relative import competition. We also examine whether the assumption of country fixed effects may be too restrictive by grouping together countries with similar labour market characteristics. In contrast to IMF (2007), a primary aim of this chapter is also to consider the interaction between openness and bargaining and whether openness weakens the relation between bargaining institutions and the labour share.

Finally, Harrison (2005) uses a translog function to analyse the impact of globalisation on the labour share for 100 countries over the 1960 to 1997 period. She finds that changes in the labour share are driven primarily by the capital-labour ratio and therefore that the elasticity of substitution between capital and labour is low. She also finds significant effects for capital controls (positive), the nominal exchange rate (negative), trade shares (negative), the relative price of capital intensive goods (positive), financial crises (negative) and government spending (positive).

Considering the focus of this chapter, Harrison's findings for both trade shares and FDI are of particular importance. Her results indicate that trade shares are only significant for poor countries and that FDI inflows have a negative effect on the labour share while FDI outflows are insignificant. Our study differs from Harrison in virtually all of the regressors except the labour-capital ratio and FDI outflows and some of the instruments. In addition, our sample period extends to 2007. Harrison does not control for the effects of technical progress, which are often difficult to distinguish from those of globalisation. Finally, in contrast to Harrison, we consider the role of bargaining institutions in determining changes in the labour share.

Labour Costs and Bargaining Institutions

The literature examining labour costs and labour market institutions, as opposed simply to wages, is relatively scarce. Daveri and Tabellini (2000) examine the empirical relation between unemployment and labour taxation. They show that the ability of labour to shift increases in the tax wedge onto firms is related to the particular type of labour market. The increase in unemployment from this tax-shifting, increases the capital-labour ratio thus reducing the rate of return on capital and leading to a slowdown in economic growth. The authors find a high positive correlation between tax rates on labour income and unemployment only for countries which belong to one labour market model, namely Continental Europe.

In their wage equation, Daveri and Tabellini regress changes in real wage earnings in manufacturing on labour taxes, which are interacted with each labour market group, replacement rates, growth, unemployment, consumption taxes and employment protection. They find that labour taxes tend to shift on to wages in Continental Europe. There is some evidence for this in Nordic countries (although insignificant), but none for Anglo-Saxon countries.

The classification of countries by labour market model in this chapter follows closely that of Daveri and Tabellini (2000), who use variables such as union density, union coordination and centralisation of wage bargaining as classification criteria. As they highlight, there is ambiguity regarding some countries which straddle two groups according to the classification criteria. They allow the ambiguous countries to change groups over time. A similar strategy is adopted in this chapter.

Alesina and Perotti (1997) analyse the effect of labour tax, the degree of centralisation in wage bargaining, total factor productivity and other factors on relative unit labour costs in a panel of 14 OECD countries from 1965 to 1990. Similar to Daveri and Tabellini (2000), the countries are divided into three groups, classified according to the degree of centralisation of wage bargaining. As Nunziata (2005) points out, this classification can be misleading when other features of the labour market institutions may change and put the country in a different labour market group.

Other features of the labour market, apart from centralisation, may be influential. Alesina and Perotti (1997) find that countries with intermediate levels of centralisation experience relatively higher unit labour costs as unions are large enough to have some bargaining power but too small to internalise the competitiveness consequences of their wage demands. We therefore include a measure of bargaining centralisation from Visser (2011) both as a component of a composite "bargaining index" in the baseline model, and as a separate bargaining variable in a specification that decomposes the bargaining effect.

Nunziata (2005) conducts a similar study in a closed economy context and looks at the impact of labour market institutions on labour costs for 20 OECD countries for the period 1960 to 1994. Labour market institutions are represented by employment protection legislation, the tax wedge, trade union density, union coordination in wage bargaining, unemployment benefits and their duration. He finds that these institutional variables lead to significantly higher labour costs. Nunziata's findings consider the effects of the institutions on labour costs only, and thus we cannot infer what the effects of the bargaining institutions will be on the labour share. His findings are complementary to those of IMF (2007) if labour demand is relatively elastic.

Blanchard (1997, 2006) examines the decline in the labour share in Europe from an institutional perspective. He argues that the initial decline in the labour share in Europe in the mid-1980s was a response to excessive wage growth relative to productivity in the 1970s. The resulting unemployment put downward pressure on wages and led to a reversion of the labour share to its earlier level.

Blanchard suggests that the more recent decline in the labour share may be due to capital owners capturing a higher proportion of rents or firms switching to more capital intensive technologies, which leads to a fall in the marginal productivity of labour for a given capital-labour ratio. Blanchard also points to the reduction of "feather-bedding" in European firms where workers were employed to the point where the product of the last worker was below his wage. As labour bargaining power has fallen, firms have been able to reduce such practices leading to a convergence between the marginal product of labour and the wage rate. We consider both of these explanations in our model where we include the capital-labour ratio, an index of regulatory reform and the bargaining variables mentioned above.

Having outlined the relevance of this chapter to the existing literature, we now provide an intuitive framework for understanding the offshoring phenomenon.

2.2 Offshoring

Following Feenstra (2004), we present a simple model of offshoring in order to provide intuition for the econometric analysis in the next section. To reflect the global fragmentation of production, there is one final good and a continuum of inputs, ordered according to their capital intensity ratio. There are two countries; one developed and one less developed. The capital per worker (K/L) ratio is higher in the developed country. Figure 2.8 illustrates how the range of intermediate goods produced in less developed countries increases as technical change and capital deepening confer the cost advantage over a new set of intermediate goods to less developed countries. Let Z represent a continuum of intermediate goods ordered by capital intensity.[16]

The set of inputs produced in less developed countries, Z_{LDC}, and in developed countries, $Z_{DC,}$ will depend on the ratio of unit costs for each intermediate good in each country. The line CC_{LDC} represents the locus of unit costs across Z in less developed countries holding factor prices constant, while CC_{DC} is the corresponding locus of unit costs for developed countries. Clearly, less developed countries will produce the set of intermediate goods for which unit costs are lower than in developed countries. The point of interaction between CC_{DC} and CC_{LDC}, Z^*, determines this set: less developed countries will produce Z^*_{LDC} intermediate goods while developed countries will produce the range of intermediate goods corresponding to Z^*_{DC}.

Consider a technology shock which reduces the cost of offshore outsourcing in less developed countries. This corresponds to a rightward shift of the unit cost curve in less developed

16 Instead of assuming intermediate inputs vary by capital intensity, the decision to offshore could also be modelled as the process of producing a final good that requires a knowledge and a production component, where firms are "teams" of workers with different skill levels, as in Antras et al (2006). In their model, one country has a skill distribution with a relatively higher mean (the "North") than the other (the "South"). The opportunity for offshoring, or the "formation of (international) teams", depends on the extent of the overlap in the skill distributions, as well as on the cost of communicating knowledge within a team as dictated by the level of communications technology. For example, an improvement in communications technology improves the ability of a manager to leverage his knowledge through communication and leads to larger teams (firms) of production workers. Changes in communications technology are similar to a shift in Z^*_{LDC} in Figure 2.8. When communication costs and the skills overlap are low, more high- skilled production workers in the developed country become "managers" of teams of low- skilled workers, while the best managers in the less developed country now improve their match by becoming workers in international teams with better managers from the developed country. Thus, output of the production component falls in the developed country and increases in the developing country.

countries from CC^*_{LDC} to CC'_{LDC}. The new intersection point Z' yields a new larger set of more capital intensive intermediate goods now being produced in less developed countries, Z'_{LDC}, and a smaller set being produced in developed countries, Z'_{DC}. Financial globalisation can reinforce this effect. As developing countries are generally characterised by relatively lower capital stocks and thus higher costs of capital, capital outflows from developed to developing countries can reduce this cost and shift the CC_{LDC} curve further to the right, thus widening the range of intermediate goods produced in the developing country.

On this basis, intermediate goods are produced in the location with the lowest costs. The fact that offshore outsourcing is enabled by technical progress means that disentangling the individual quantitative impact of both of these phenomena on the labour share of income is difficult.

2.3 GDP and Cost Functions

To quantify the effects of globalisation on the labour share, we adopt the GDP function as derived in Feenstra (2004). We consider an economy with two sectors, $i = 1, 2$. One sector produces a capital intensive good, y_1, that is exported at a price p_1, while the other sector produces a labour intensive, import-competing good, y_2 with a price p_2. There are two factors, capital, K, and labour, L, with endowments V_K and V_L. The production function for the economy can be written as:

$$Y(p_1, p_2, K, L) = \max_{v_i \geq 0} \sum_{i=1}^{2} p_i f_i(v_i) \tag{2.1}$$

where v_i is the total factor input in each sector and is subject to the following constraint:

$$\sum_{i=1}^{2} v_i \leqq V \tag{2.2}$$

where V is the total factor endowment in the economy. We can now obtain the nominal GDP (GDP_n) function by subtracting imports of y_2, denoted as y_2^*, from output:

$$GDP_n((p_1, p_2, K, L)) = \max_{y_i L_i, K_i} p_1 y_1 + p_2 y_2 - p_2 y_2^* \tag{2.3}$$

subject to the endowment adding up constraint. To obtain a measure of real GDP, GDP_r, we normalise by p_2, which yields:

$$GDP_r = GDP_n(\frac{p_1}{p_2}, K, L) \tag{2.4}$$

The corresponding short run dual cost function (with fixed output and capital) is:

$$C(w, r, K, Y, \frac{p_1}{p_2}) \equiv \min_L wL \tag{2.5}$$

subject to (2.4),where w is the return to labour and r is the return on capital. However, the inclusion of import prices does not capture the increase in offshoring and, thus the increase in the volume of trade in intermediate goods. Moreover, this cost function neglects other variables that may influence domestic costs such as technical progress, and labour market institutions that may affect the bargaining power of labour.

Let Z be a term that collects the variables that may shift the cost function so that we can rewrite the cost function as:

$$C(w, r, K, Y, Z) \tag{2.6}$$

In the long run, K and Y will vary and become choice variables and therefore, the long run cost function can be expressed as:

$$C(w, r, Y, Z) = Yc(w, r, z) \tag{2.7}$$

where it is assumed that the cost function is linearly homogenous so that c represents a unit cost function, while z represents the structural variables that affect costs. In keeping with the existing literature that investigates the relation between trade and the labour share, we assume that the cost function can be approximated with a translog function (see Appendix

A).

2.4 Econometric Model

The translog function form permits a very general specification of the GDP function. Following Feenstra (2004), we can write the GDP function as a function of product prices and factor endowments:

$$\ln Y = \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln P_i + \sum_{k=1}^{M} \beta_k \ln V_k + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln P_i \ln P_j$$
$$+ \frac{1}{2}\sum_{k=1}^{M}\sum_{l=1}^{M} \delta_{kl} \ln V_k \ln V_l + \sum_{i=1}^{N}\sum_{k=1}^{M} \phi_{ik} \ln P_i \ln V_k \tag{2.8}$$

where P_i is a $(1 \times N)$ vector of product prices, and V_k is a $(1 \times M)$ vector of factor endowments.[17] Differentiating the GDP function with respect to the factor endowment k yields the share of k in GDP:[18]

$$s_k = \beta_k + \sum_{l=1}^{M} \delta_{kl} \ln V_l + \sum_{i=1}^{N} \phi_{ik} \ln P_i \tag{2.9}$$

The endowment share is thus linear in the parameters and can be estimated by ordinary least squares. We now specify a "baseline" estimation equation comprising the determinants of the labour share in an open economy and the shift variables described above (including time subscripts):

$$s_{Lt} = \alpha_L + \beta_{XL} \ln \frac{P_{Xt}}{P_{Et}} + \beta_{ML} \ln \frac{P_{Mt}}{P_{Et}} + \gamma_{LL} \ln \frac{L_t}{K_t} + \phi_{LZ} Z_t + \varepsilon_t \tag{2.10}$$

where P_{Xt} and P_{Mt} are the price of exports and imports, respectively, and P_E is the deflator for domestic expenditure. L_t/K_t is the log labour-capital worker. Z_t is a vector of variables that shift the revenue function such as labour market institutions that affect labour's bargain-

[17] The translog GDP function is assumed to be homogenous of degree one in prices, so that $\sum_{i=1}^{N} \alpha_i = 1$ and $\sum_{i=1}^{N} \phi_{ik} = 0$, and in factor endowments, so that $\sum_{i=1}^{M} \beta_k = 1$ and $\sum_{k=1}^{M} \delta_{kl} = \sum_{k=1}^{M} \phi_{ik} = 0$). It is also assumed that the second-order parameters are symmetric: $\gamma_{ij} = \gamma_{ji}$ and $\delta_{kl} = \delta_{lk}$. Of course, these restrictions can also be tested.

[18] $\partial \ln G / \partial \ln V_k : (\partial G/\partial V_k)(V_k/G) = (w_k)(V_k/G) = S_k$, where w_k is the price of factor k.

ing power, offshoring (approximated by FDI outflows) and technical change (approximated by the share of Information and Communications Technology (ICT) capital in the aggregate capital stock).

2.5 Data

The labour share of income (or real unit labour costs) for the total economy and for manufacturing is calculated as total labour costs divided by nominal output and annual labour share data are taken from the OECD's Main Economic Indicators database. We take as a measure of the centralisation of wage-bargaining Visser's (2011) composite measure of both the centralisation and coordination of union wage bargaining, which takes into account union authority and union concentration at multiple levels. The strength of trade unions in wage bargaining is approximated by net trade union membership as a proportion of wage and salary earners in employment and is also taken from Visser (2011).

The tax wedge represents the wedge between pre-tax and post-tax labour income and is calculated using the methodology outlined in Mendoza et al (1994). The effective tax rate on labour, τ_l, is:

$$\tau_l = \left[\frac{\tau_w W + SST + P}{W + SSE}\right]$$

where $\tau_w W$ represents tax revenue from wages and salaries (W); SST are total social security contributions; SSE are employer's social security contributions, and P are payroll taxes.

The effective tax rate on consumption, τ_c, is computed as the ratio between consumption tax revenue and the consumption tax base:

$$\tau_c = \left[\frac{GT + E}{C + G - GW - GT - E}\right]$$

where GT represents general taxes on goods and services, E represents excise taxes; C

is final private consumption, G is final government consumption; GW is compensation of employees by producers of government services. Data on tax revenues is again from the OECD's Revenue Statistics database, while data on consumption expenditure and compensation is from the OECD's National Accounts database.

As consumption expenditure is reported in post-consumption tax prices in the National Accounts, revenue from this tax needs to be deducted in the denominator to give the taxable base. In addition, government consumption must be included in the denominator, as the national accounts database does not distinguish consumption tax revenues by source. As this relates only to a government's purchase of goods and non-factor services, the compensation of government employees needs to be deducted from government consumption expenditure.

Data on the strictness of employment protection are taken from the CEP-OECD database described in Nickell (2006). This variable has a [0,2] range and is increasing in the strictness of employment protection. The benefit replacement rate broadly captures the generosity of unemployment benefits and is constructed as an average across the first five years of unemployment for three family situations and two earnings levels. These data are taken from the CEP-OECD database and updated using OECD (2007).

We also consider whether the deregulation of product markets may have affected the labour share. We approximate this regulatory reform with an indicator from the CEP-OECD database that measures the extent of regulation in seven non-manufacturing sectors: telecoms, electricity, gas, post, rail, air passenger transport, and road freight. The index has a range [0,6] and is increasing in the degree of regulation.

Our econometric specification also tries to disentangle the separate impact of globalisation and technological progress on the labour share. The latter is measured by the share of Information and Communications Technology in the gross non-residential capital stock. These series are taken from the OECD's Productivity Statistics and EU KLEMS.

Similarly, changes in the labour share may be driven by changes in the capital intensity of production. We measure this change in factor endowments with (log) capital per worker, which is calculated by dividing the aggregate net capital stock by the employment of persons in all domestic industries. The series for the total economy is taken from the European Commission's AMECO database and the series for manufacturing is from EU KLEMS.

The translog function suggests that the key drivers of the labour share of income will be Stolper-Samuelson effects that arise from changes in the price of exports relative to imports. Our specification includes both the price of imports and exports relative to the price deflator for domestic expenditure and all price indices are taken from the OECD's Main Economic Indicators and Economic Outlook databases. The price of exports in the manufacturing sector is approximated using the producer price index for that sector, also from the Main Economic Indicators.

We also consider whether the extent of import penetration has a separate effect on the labour share via raising the level of competition in the domestic economy. Aggregate import penetration is measured as the share of imports in domestic expenditure and this variable is sourced from the Economic Outlook database. Import penetration in the manufacturing sector is the share of manufacturing imports in output and is from the OECD's Structural Analysis (STAN) database.

We approximate the extent of and potential for offshoring using both total FDI outflows and the share of these flows going to non-advanced countries. These data are taken from UNCTAD's Foreign Direct Investment database and the OECD's International Direct Investment Statistics.

2.6 Econometric Results

The baseline equation (2.10) is estimated for twenty advanced countries between 1980 and 2007.[19] Wooldridge's (2010) test for panel serial correlation rejects the null hypothesis

19 Our sample contains the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States.

of no serial correlation.[20] Equation (2.10) is therefore estimated by ordinary least squares with Newey-West autocorrelation and heteroscedasticity consistent standard errors. The assumption of individual effects could possibly be too restrictive. It is clear from Table 2.2 that there are significant cross-country differences in the means of several of the variables. Countries can, however, be broadly classified according to three different types of labour market models: those with more liberal/less interventionist labour markets as in "Anglo-Saxon" countries; those with high levels of bargaining coordination and employment protection legislation, which are classified as "European"; and those with high benefit replacement ratios and union representation but low employment protection, as the "Nordic" countries.[21] Therefore, in addition to a specification with country fixed effects, we also estimate a specification with these three groups as dummy variables.

2.6.1 Baseline Model

Table 2.3 presents the results of the baseline specification which includes total outflows of Foreign Direct Investment as a measure of offshoring, the share of ICT capital in the aggregate capital stock as the measure of technical progress, and a bargaining index, which is constructed by combining the union density, centralisation, benefit replacement, employment protection and the labour tax wedge variables.[22] Columns 1 and 2 show the results of specifications without time effects, while columns 3 and 4 show the results when time effects are included. It is clear that the statistical significance of variables is dependent on the inclusion of time and country fixed effects.

In column 1, coefficients have the expected sign and are generally statistically significant. An increase in the price of imports increases the labour share, reflecting the labour intensity

[20] This test involves including the estimated lagged panel residual as a regressor in the model and performing a t-test on whether the coefficient on the residual is statistically different from zero. We also test for heteroscedasticity in the panels using a likelihood ratio test on generalised least squares estimation of the baseline with and without the assumption of panel-wise heteroscedasticity. We reject the null hypothesis of homoscedasticity.

[21] It is clear from Table 2.2 that the classification could be ambiguous for several countries. In addition, some measures changed significantly between the two sample periods shown in the table, which could also reclassify the country if that measure were to be given a larger weight. We consider different classifications in the sensitivity analysis.

[22] The bargaining index is a composite index of bargaining power comprising centralisation, union density, the tax wedge, employment protection legislation and the benefit replacement ratio. Each variable is transformed into a unit-free index and aggregated.

of imports. Similarly, if exports are capital intensive, an increase in the price of exports is associated with a reduction in the labour share. The coefficient on regulatory reform is positive and significant, indicating that the elimination of rigidities through economic restructuring has actually benefitted labour through higher employment and productivity. We find no evidence that the composite index of labour market institutions has a significant effect on the determination of the labour share. We find that, while the direct effect of technical change is negative, the relation is non-linear. This confirms the IMF (2007) finding that, as workers adapt to technical change the latter has a positive effect on the labour share. The relation between offshoring (as measured by outflows of FDI) is also found to be significant and negative, indicating that domestic and foreign workers are, to some extent, substitutes.

When we assume unobserved heterogeneity is determined by labour market type rather than by country borders, only relative export prices, regulatory reform and FDI outflows retain statistical significance. The bargaining index, however, has a positive and significant effect on the labour share. This finding contrasts with that of the IMF (2007) study, which finds that these labour market institutions are sources of rigidities, which actually reduce the labour share as a result of firms economising on labour inputs. Columns 3 and 4 include time effects in the country and group specifications. Although an increase in the relative price of exports is unambiguously negative for the labour share, the statistical significance of the coefficients on the variables is more sensitive to the inclusion of fixed effects.

However, there are some regularities. Our index of bargaining power has a positive and significant effect on the labour share when we control for labour market type. Similarly, FDI outflows have a negative effect on the labour share in three of the four specifications. Comparing columns 1 and 3 indicates that the time effects are capturing trends in technological progress and deregulation that are common to countries over the sample period. The time effects are jointly significant at the one percent level.

2.6.2 Bargaining Institutions

We now replace the bargaining index with its individual components: trade union density, the labour tax wedge, employment protection, the benefit replacement ratio, and bargaining centralisation. Table 2.4 presents these results. It is clear that the significance of the coefficients is again sensitive to the inclusion of both time and country fixed effects. However, two of the openness variables, the relative price of exports and FDI outflows, have a negative and significant effect on the labour share, even after the fixed effects are included. The time effects absorb the effects of regulatory reform as in Table 2.3, but the non-linear relation between technical change and the labour share is robust to the inclusion of both time and country effects.

The bargaining variables are most sensitive to the inclusion of country effects or the group dummy variables. Most notably, employment protection and the tax wedge are associated with higher labour shares, when we control for cross-country heterogeneity. Therefore, the conclusion of IMF (2007) that these bargaining variables are sources of rigidity that reduce the labour share appears to depend on this assumption of heterogeneity.[23] In addition, the statistical significance of the group variables suggests that this classification does have empirical support.

2.6.3 Openness

We now examine further the effects of global competition on the labour share. One important question is whether it is the total volume of FDI outflows that increases the elasticity of labour demand, or whether it is the destination of these outflows that matters. We have argued that the offshoring phenomenon is driven by technological change and the integration of low cost countries into the global economy. Therefore, it is the outflow of FDI to non-advanced countries that should have a negative effect on the labour share in advanced

[23] The difference in findings may also be attributable to the use of slightly different datasets. For example, our data on union density measures net membership of trade unions and is available for a longer time period and a larger set of countries than the OECD measure used by the IMF. As a result, the sample size in our study is significantly larger than that in IMF (2007).

countries.

Table 2.5 presents the results of including FDI outflows to non-advanced countries in the estimating equation.[24] FDI flows to non-advanced countries do not have a statistically significant effect on the labour share and the inclusion of this variable does not affect the significance of total outflows. The latter finding suggests that outflows of FDI have a general negative effect on the domestic labour share by increasing the elasticity of labour demand and increasing the substitutability of foreign for domestic workers.

The absence of a significant effect for FDI outflows to non-advanced countries appears to be a surprising result considering some of the findings of the literature discussed above. However, it may be the case that FDI outflows to non-advanced countries are too small or too recent to have had a significant effect within the sample period. In addition, offshoring may occur primarily through the outsourcing of production to non-affiliates in non-advanced countries, and therefore FDI outflows will not capture this phenomenon. In this case, competition from workers in non-advanced countries will be reflected in the imports of goods and services. Although we control for the price of imports, there may be a separate "volume" effect due to a significant increase in import penetration. We now consider this possibility.

Table 2.6 presents the results of the model which now includes the volume of imports.[25] Columns 1 and 2 include the total volume of imports, while columns 3 and 4 include both total imports and imports from non-advanced countries.[26] The relative price of exports, technical change and total FDI outflows remain significant in all specifications. It is clear that the effect of import competition is more sensitive to the inclusion of time effects. Although we do not find any evidence that imports from non-advanced countries have a significant effect on the labour share, we do find that both the volume and price of imports have significant ef-

[24] Outflows of FDI to non-advanced countries have a negative and significant effect on the labour share when total outflows are omitted. This may reflect the general effect that outflows have on the labour share. The more relevant question, given the focus of this study, is whether outflows to non-advanced countries have a separate effect.

[25] We do not present the separate results for the regressions with the group dummy as the results for the openness variables are similar to those shown in Table 6. The only difference is the significance of the bargaining variable.

[26] Imports from non-advanced countries are deflated by the import price deflator as a separate index for these countries is not available. This could partly explain our finding that imports from non-advanced countries do not significantly affect the labour share.

fects when time dummies are not included. In this case, the time effects seem to capture the increase in import penetration that is common across countries in the sample. Interestingly, the effects of both of the technical change variables are not diminished by the inclusion of time effects.

2.6.4 Interaction Effects

We now consider the possibility that the effect of bargaining institutions on the labour share varies according to openness. Table 2.7 presents the results of including interactions between the index of bargaining power and the openness variables.[27] Only statistically significant terms are reported. Estimating a single regression equation with all interaction terms is not feasible given the sample size. We therefore estimate separate regressions for the interactions of each bargaining variable with the different measures of openness.[28] In the first column of the table we find that both the relative price of exports and the volume of imports significantly reduce the ability of trade unions to generate a higher labour share of income. In the second column we find that, although the size of the labour tax wedge has a significant effect on the labour share, this relation is weakened by both an increase in the relative price of exports and the volume of imports. However, this relation is strengthened by an increase in the relative price of imports.

Similarly, the results in the third column indicate that an increase in the relative price of exports or the volume of imports has a significant effect on weakening the positive relation between employment protection and the labour share. Imports also strengthen the negative relation between the benefit replacement ratio and the labour share, while an increase in the relative price of exports weakens the positive, although not significant, association between bargaining centralisation and the labour share. We find almost identical results when time effects are included (not reported). The only difference is the negative and weakly significant

27 For conciseness, we omit the specifications with the group dummy variables. These results are available on request.

28 Of course, this means that we are assuming that the coefficients on the interactions terms of one bargaining variable are not biased by the omission of the interaction terms of the other bargaining variables.

coefficient on the relative price of imports in the regression with tax wedge interactions.

2.6.5 Manufacturing

Our analysis thus far has focused on the labour share for the total economy. Since a significant share of the economy is non-traded and thus broadly sheltered from the direct effects of international competition, it is likely that openness may play a stronger role in the determination of the labour share if we focus on the manufacturing sector, which is generally the most traded sector. Table 2.8 contains the results of our baseline specification for the manufacturing sector in 13 countries over the period 1985 to 2003.[29] The data are taken from the OECD's Main Economic Indicators, Structural Analysis (STAN) and International Direct Investment Statistics databases, and from EU KLEMS.[30] Each regression includes country fixed effects and columns 2 and 4 include time effects.[31]

Our results suggest that openness and technical change have significant effects on the labour share in manufacturing. As before, increases in the relative price of exports, in the share of ICT capital in the aggregate capital stock and in the outflows of FDI tend to reduce the labour share, while an increase in the price of imports has the opposite effect. We also find that there is no evidence of a non-linear relation between the labour share and technical progress and the latter is thus less likely to be Harrod-neutral in the case of manufacturing. In addition, as colums 3 and 4 show, the impact of import penetration is particularly sensitive to the inclusion of time effects. When we control for these time effects, an increase in the import share in production is associated with a higher labour share. This suggests that the model may not be capturing some of the productivity effects related to competition. In summary,

[29] The countries are: Australia, Austria, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, United Kingdom and United States.

[30] The main limiting factor is the availability of manufacturing FDI data from the OECD's International Direct Investment Statistics database. We also replaced FDI outflows in the manufacturing sector with outflows for the total economy in order to increase the sample size. The correlation coefficient between the two series is 0.83. The coefficient on total outflows in our baseline regression is negative and significant at one percent but it has little effect on the other coefficients.

[31] For conciseness, we omit the specifications that include the group dummy variables. Including these variables instead of the country effects makes the coefficient on ICT insignificant and the bargaining coefficient positive and significant. The coefficients on the openness variables vary little with the alternate fixed effects.

openness, along with technical change, clearly plays an important role in the determination of the labour share of output in manufacturing.

2.6.6 Sensitivity Analysis

It is possible that some of the regressors may have effects on the labour share due to the presence of nominal rigidities. Table 2.9 presents the results of our baseline model when the contemporaneous values of the independent variables are replaced by their lags. Our findings from the model with contemporaneous regressors are broadly confirmed, with the relative price of exports, technical change and FDI having a negative and significant effect on the labour share. The inclusion of time effects (columns 3 and 4) has no effect on these coefficients. In addition, the lags of the benefit replacement ratio and the tax wedge are also associated with a lower labour share. In contrast to current relative import prices, the lagged relative price of imports does not have a significant effect on the current level of the labour share. We also tested whether the inclusion of a linear time trend affects the results. We find that the main effect of the time trend is to make the coefficient on regulatory reform insignificant. We also replace the relative price of imports and exports with the relative price of non-commodity imports and exports. This has no effect on our results.

One potential problem with the baseline model is the possible endogeneity of openness. This endogeneity is likely to depend on country size (IMF (2007)). Harrigan (2000) outlines how consistent estimation of the translog function requires instruments for prices and he suggests using instruments that are correlated with international supply and domestic demand. Changes in the labour share may also spur capital outflows and an increase in the volume of imports as firms shift away from production that is intensive in domestic labour. Firms may increase ICT investment for similar reasons. We therefore re-estimate the model with instrumental variables. The instruments for the potentially endogenous variables include lags of relative import and export prices, lags of outflows and outward stocks of FDI, and the effective consumption tax. Following Harrigan (2000) and IMF (2007), international supply is represented by export-weighted real GDP growth in trading partners and distance-weighted export-adjusted employment in the rest of the world. Domestic demand conditions are approximated by the (log) population and the (lagged) share of government consumption in GDP.

Table 2.10 presents the results of the instrumental variables estimation by Two Stage Least Squares. The results confirm our findings from the other specifications: the relative price of exports and FDI outflows have significant and negative effects on the labour share. There is also evidence that import penetration is associated with a lower labour share. However, the reform of labour (as represented by a decline in the bargaining index) and product markets tends to benefit workers. Finally, we find that technical change does not have a significant effect in the short run but it does benefit labour in the long run as workers adapt to new technology.

2.6.7 Quantitative Impact of Openness on the Labour Share

We now quantify the impact the openness variables have had on the annual change in the labour share in each country by multiplying the coefficients from the instrumental variables regression by the average annual change in the openness variables. Figure 2.9 presents the average annual change in the labour share while Figures 2.10 through 2.12 quantify the proportion of this change that is attributable to the relative price of exports, outflows of FDI and the volume of imports. As would be expected, globalisation has had the largest impact on the labour share in small open economies such as Ireland and Finland, while the impact in medium-size to large economies such as the United Kingdom, Germany and the United States has been relatively small. For example, the decline in relative export prices has boosted the labour share by approximately 0.3 percent per annum in Finland but by only less than half that in the United Kingdom and the United States. However, larger FDI outflows and higher imports more than offset this in the case of Finland. Imports have a substantially larger negative impact on the labour share relative to FDI in the case of the United States, although the net effect of openness has been negligible.

2.7 Conclusions

Our results suggest that globalisation has had a significant impact on the dynamics of the labour share. We find that these effects work in the usual Stolper-Samuelson way, particularly in the case of relative export prices. However, we also find that the changing nature of trade, particularly the trend towards trade in intermediate goods, plays an important role. Our results provide a macroeconomic complement to the sectoral, worker- and firm-level studies of the relation between offshoring and the domestic labour market.

We find that it is total FDI outflows, rather than the destination of those flows, which matters. This suggests that it is the outward mobility of capital, and not solely wage competition from emerging economies, that causes wage restraint among workers. The impact of bargaining institutions on the labour share is somewhat weaker and the strength of the relation is sensitive to the specification of the econometric model. For example, when we group countries with similar labour markets together, we find that bargaining institutions have a positive and significant effect on the labour share. Similarly, when time effects are omitted, the regulatory reform of product markets also has a positive and significant effect on the labour share. It could be argued, however, that the fixed effects absorb an excessive amount of explanatory power to be useful and that they are simply capturing the time-invariant or common changes in certain labour market institutions.

Our results also contribute to the literature in other areas. We find some evidence that technical change, as measured by the share of Information and Communications Technology in the capital stock, adversely affects workers in the short run but strong evidence that technical change benefits workers over time. This suggests that a period of adaptation is required before workers can benefit by increasing productivity. Our findings are also suggestive of the nature of substitution between capital and labour and the existence of factor price insensitivity. The labour-capital ratio is positive and significant in many of our specifications, indicating that the elasticity of substitution between capital and labour may be quite high.

The ultimate aim of this chapter is to highlight the possible relation between the impact of globalisation on domestic labour markets and the changing nature of inflation dynamics over the last two decades. Although we find that globalisation has a significant effect on labour markets, there are considerable cross-country differences in the size of this impact. Unsurprisingly perhaps, it is in small open economies that globalisation has most affected the labour share. These results motivate a closer examination of the relation between the labour share and inflation, which we undertake in chapter 3.

2.8 Appendix A: Transcendental Logarithmic Functions

The advantage of flexible functional forms is that they permit the analysis of second order effects, in this case, the substitutability parameters. The translog functional form is more flexible than a Cobb-Douglas specification which requires unitary elasticity of substitution so that the coefficients on all the second order terms are zero. In this approach, we specify a flexible form of the (cost) function with certain regularity conditions using both Shephard's lemma and duality.[32] The parameters can then be estimated by linear regression. Following Greene (2011), let output, Y, be a function of a vector of inputs, X_i :

$$Y = g(X_1, X_2, ..., X_k) \tag{2.11}$$

Taking a log transformation of this function yields:

$$\ln Y = \ln g(X_1, X_2, ..., X_k) = f(\ln X_1, \ln X_2, ..., \ln X_k) \tag{2.12}$$

The translog production function can be viewed as a Taylor series approximation around the point corresponding to the sample arithmetic mean. For this reason, each variable can be normalised around the sample arithmetic mean.[33] Taking a second-order Taylor series expansion around the point where $x = 1$, so that $\log x = 0$:

$$\ln y = f(0) + \sum_{k=1}^{k} \left[\frac{\partial f(\cdot)}{\partial \ln x_k}\right]_{\ln x=0} \ln x_k + \frac{1}{2}\sum_{k=1}^{k}\sum_{l=1}^{k} \left[\frac{\partial^2 f(\cdot)}{\partial \ln x_k} \partial \ln x_l\right]_{\ln x=0} \ln x_k \ln x_l + \epsilon \tag{2.13}$$

When the derivatives are evaluated at zero, they can be treated as constants:

$$\ln y = \beta_0 + \sum_{k=1}^{k}\sum_{l=1}^{k} \gamma_{kl} \ln x_k \ln x_l + \epsilon \tag{2.14}$$

As the cost function is twice differentiable, the Hessian matrix is twice differentiable. By Young's theorem, this gives a set of symmetry restrictions on the parameters of the cross-

32 Shephard's duality shows that input demand functions are derivatives of the cost function with respect to input prices.

33 Normalisation helps ensure local approximation, regularity conditions, monotonicity and convexity.

partial derivatives.

The dual cost function can be written in translog form:

$$\ln C = \alpha_0 + \sum_{i=1}^{M} \alpha_i \ln w_i + \sum_{k=1}^{K} \beta_k \ln x_k + \frac{1}{2} \sum_{i=1}^{M} \sum_{j=1}^{M} \gamma_{ij} \ln w_i \ln w_j$$
$$+ \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \delta_{kl} \ln x_k \ln x_l + \sum_{i=1}^{M} \sum_{k=1}^{K} \phi_{ik} \ln w_i \ln x_k \qquad (2.15)$$

where w_i is the payment to factor i, and x_k is the endowment of factor k. If product and factor markets are competitive and the latter are paid their marginal product, then taking the first derivative of the above with respect to w_i, yields the cost share of factor i:

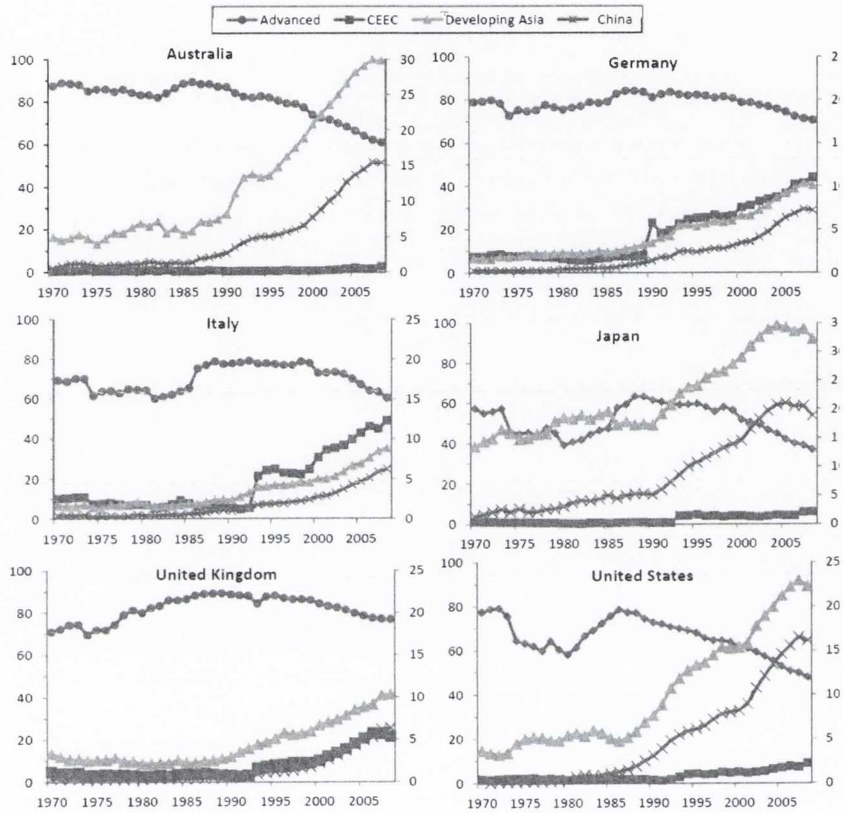
$$s_i = \alpha_i + \sum_{j=1}^{M} \gamma_{ij} \ln w_j + \sum_{k=1}^{K} \phi_{ik} \ln x_k \qquad (2.16)$$

The primary advantage of adopting the translog functional form is therefore in the computation of the first derivative, which yields the share equations.

Figure 2.1: CPI Inflation rates 1970-2008

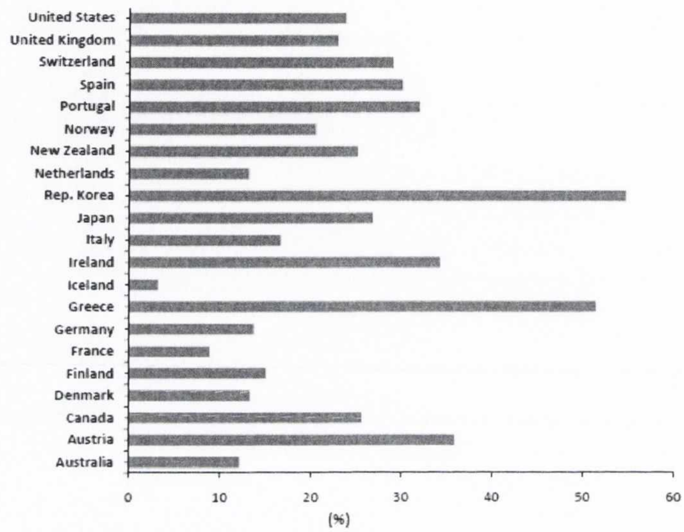
Notes: Vertical axis is CPI inflation in percent. Source: IMF, International Financial Statistics.

Figure 2.2: Origin of Advanced Country Imports, 1970-2008



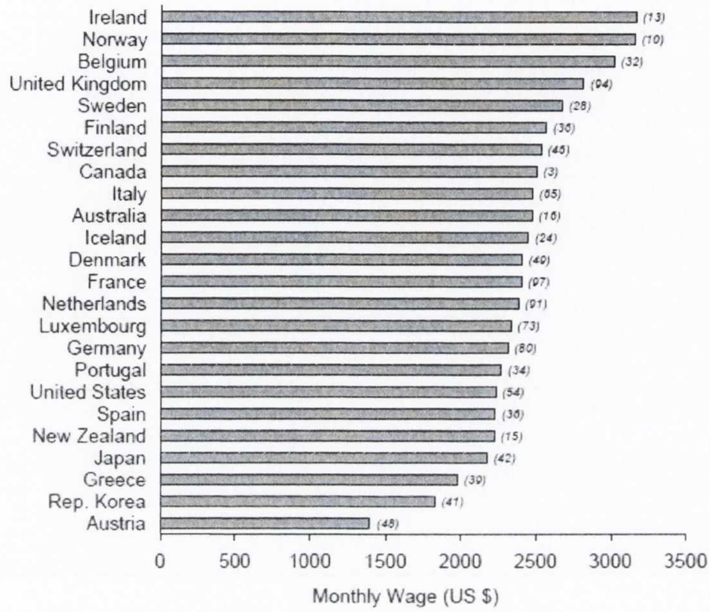
Source: OECD Monthly Statistics of International Trade.

Figure 2.3: Share of FDI Assets in Non-Advanced Countries, 2007



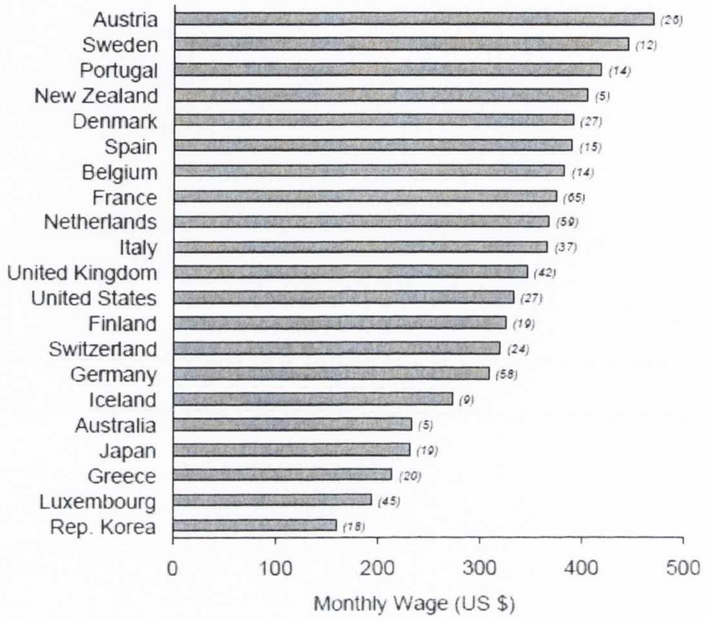
Source: OECD International Direct Investment Statistics.

Figure 2.4: Outflow-weighted Monthly Wage in FDI Partners, 2000-2003



Source: OECD International Direct Investment Statistics, Freeman and Oosterndorp (2000), ILO LABORSTA. The number of destination countries is in parenthesis.

Figure 2.5: Outflow-weighted Monthly Wage in Non-Advanced FDI Partners, 2000-2003

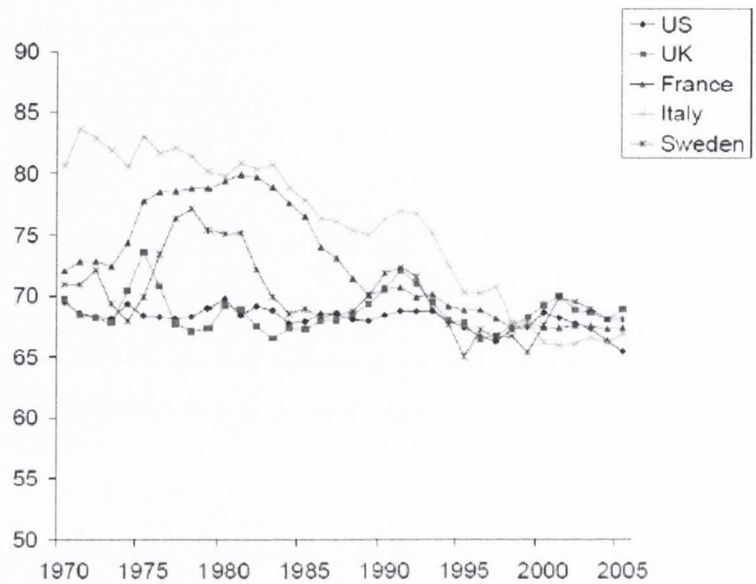


Source: OECD International Direct Investment Statistics, Freeman and Oostendorp (2000), ILO LABORSTA. The number of destination countries is in parenthesis.

Figure 2.6: Adjusted and Unadjusted Labour Shares in Advanced Countries

Notes: Vertical axis begins at 50 percent. Source: OECD Main Economic Indicators.

Figure 2.7: Adjusted Labour Share in selected countries



Notes: Vertical axis begins at 50 percent. Source: OECD Main Economic Indicators.

Figure 2.8: Offshoring: Trade in Tasks

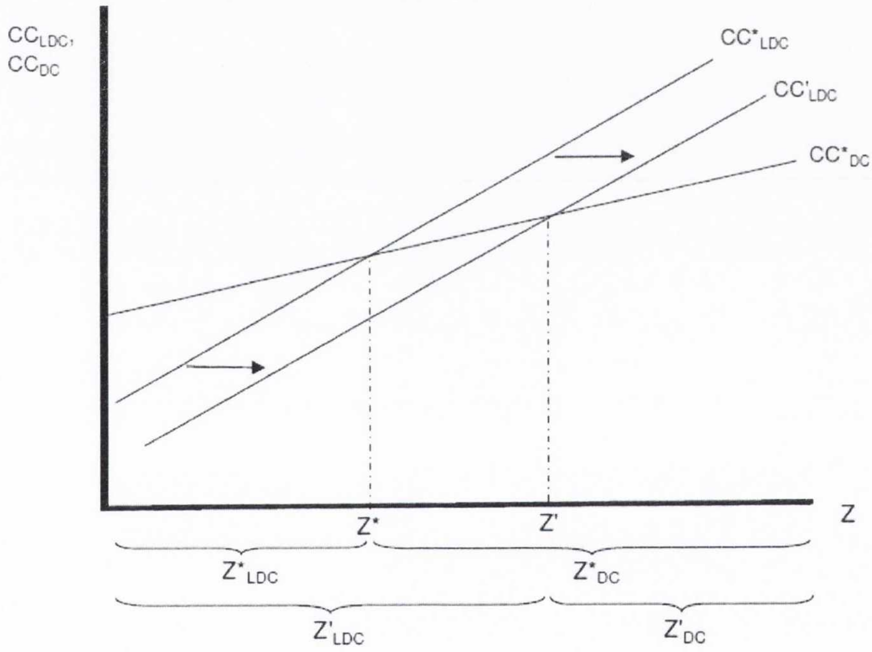
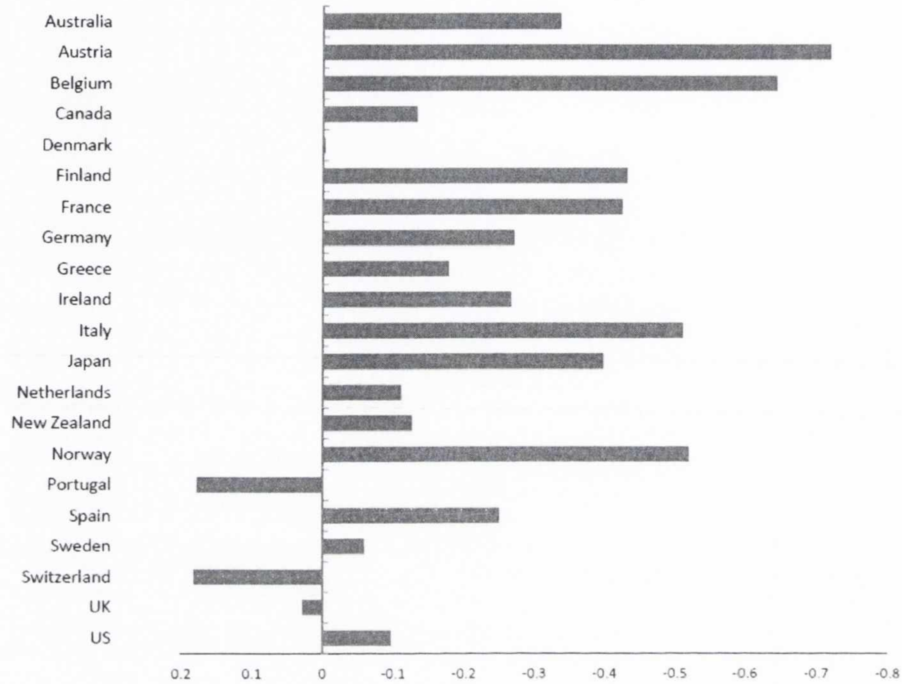
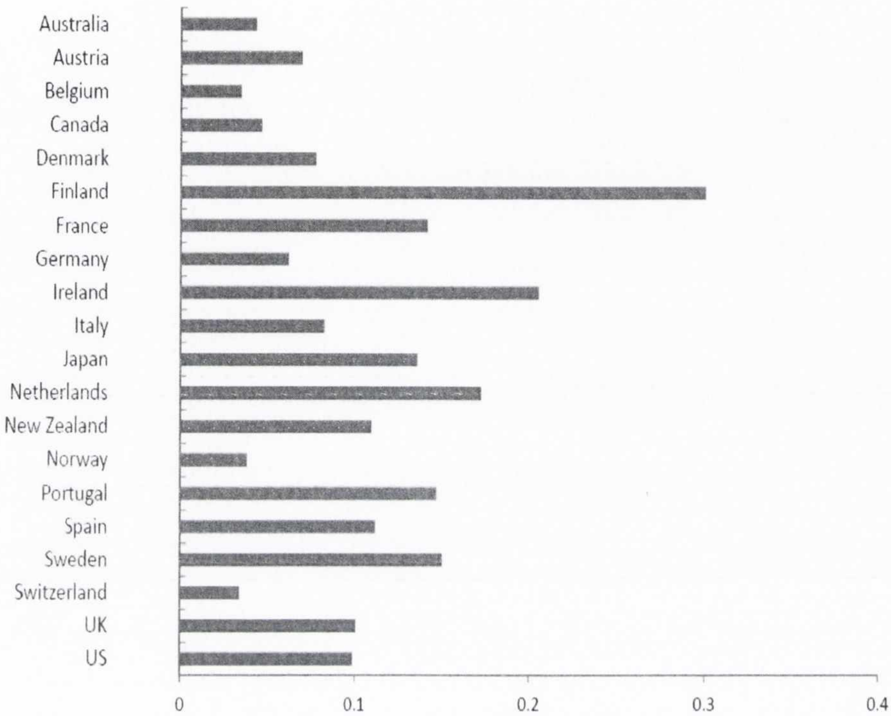


Figure 2.9: Average Annual Change in the Labour Share, 1980-2007



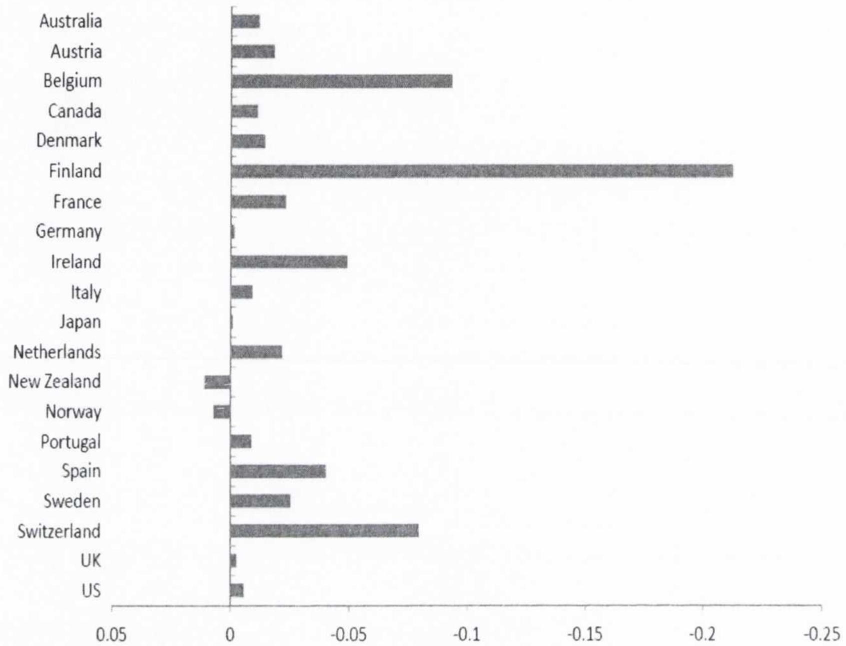
Notes: the horizontal axis is measured in percent and is reversed.

Figure 2.10: Average Annual Impact of Relative Export Prices on the Labour Share



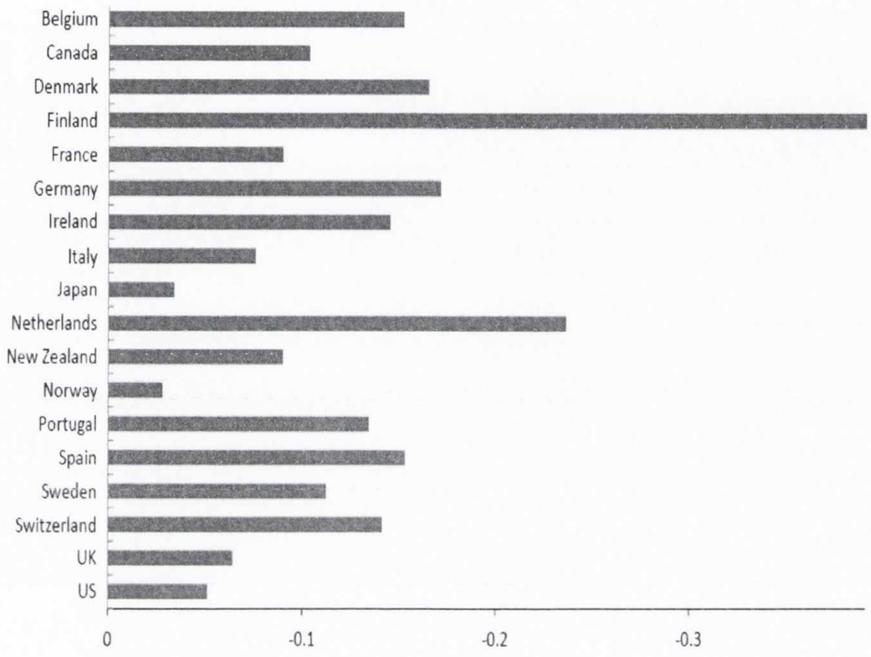
Notes: own calculations based on the coefficients from the instrumental variables regression and the average annual change in relative export prices. Horizontal axis is measured in percent.

Figure 2.11: Average Annual Impact of FDI on the Labour Share



Notes: own calculations based on the coefficients from the instrumental variables regression and the average annual change in outflows of FDI. The horizontal axis is measured in percent and is reversed.

Figure 2.12: Average Annual Impact of Imports on the Labour Share



Notes: own calculations based on the coefficients from the instrumental variables regression and the average annual change in imports. Horizontal axis is in percent and is reversed.

Table 2.1: Correlation between Unit Labour Costs, and Headline and Core Inflation

	$\rho(\pi_H, ulc)$		$\rho(\pi_C, ulc)$	
	1970-1989	1990-2007	1970-1989	1990-2007
Australia	0.6209	0.5944	0.4073	0.4953
Austria	0.744	0.6539	0.672	0.5938
Belgium	0.8271	0.6049*	0.728	0.738
Canada	0.8644	0.7953	0.8838	0.6759*
Denmark	0.7091	0.3643*	0.7366	0.013***
Finland	0.8543	0.613*	0.8175	0.5367*
France	0.8948	0.6966**	0.9172	0.4059***
Germany	0.7258	0.8364	0.7882	0.8403
Greece	0.6425	0.8236	n.a.	0.8239
Iceland	0.814	0.638	n.a.	0.2393
Ireland	0.8453	0.1882***	0.8476	0.1848***
Italy	0.9064	0.5926***	0.904	0.5125***
Japan	0.9582	0.8837*	0.9743	0.8771**
Luxembourg	0.7753	0.5808	0.7974	0.4092**
Mexico	0.9649	0.8432**	0.9427	0.8824
Netherlands	0.8284	0.7476	0.8888	0.603**
New Zealand	0.8163	0.3393**	0.7656	0.266**
Norway	0.7316	-0.0188***	0.8824	-0.1457***
Portugal	0.4361	0.9032***	n.a.	0.8436
Rep. Korea	0.8194	0.7967	n.a.	0.8894
Spain	0.9056	0.8241	0.9249	0.8852
Sweden	0.5574	0.6462	0.5965	0.6158
U.K.	0.8597	0.7875	0.8644	0.8036
U.S.	0.9529	0.7656***	0.8912	0.6539**

Notes: Correlation between nominal unit labour costs (ULC) and annual changes in the headline (π_H) and core (π_C) consumer price index. *, **, *** denotes statistical significance at 10%, 5% and 1% respectively. Source: OECD Main Economic Indicators.

Table 2.2: Union Density, Bargaining Centralisation, Benefit Replacement and Employment Protection in Advanced Countries

Country	Union Density		Central./Coord.		Benefit R.R.		Empl. Protection	
	1970-85	1990-07	1970-85	1990-07	1970-85	1990-07	1970-85	1990-07
Anglo								
Australia	48.0	31.6	0.4	0.5	20.8	24.9	0.3	0.4
Canada	34.1	32.6	0.4	0.4	18.5	16.8	0.3	0.3
U.K.	48.2	34.5	0.4	0.3	23.6	17.5	0.2	0.2
U.S.	22.4	14.1	0.3	0.3	12.9	12.6	0.1	0.1
European								
Austria	57.5	40.7	1.0	0.9	25.3	30.8	0.5	0.7
Belgium	50.8	53.1	0.5	0.5	44.7	40.6	1.1	0.9
France	19.5	9.3	0.3	0.3	27.0	38.1	0.8	1.0
Germany	34.2	28.1	0.5	0.5	29.0	27.4	1.0	0.9
Ireland	61.8	48.4	0.4	0.4	24.4	30.8	0.3	0.3
Italy	45.9	36.8	0.4	0.4	1.2	18.7	1.2	1.0
Japan	32.4	23.3	0.3	0.2	10.7	9.8	0.7	0.7
Netherlands	34.8	23.8	0.6	0.6	48.5	52.4	0.9	0.8
New Zealand	62.9	31.9	0.4	0.3	28.5	29.6	0.3	0.4
Portugal	56.0	24.6	0.4	0.5	6.3	36.4	1.3	1.3
Spain	19.5	14.8	0.4	0.4	21.9	35.6	1.3	1.1
Switzerland	30.4	22.3	0.4	0.4	8.4	29.7	0.3	0.3
Nordic								
Denmark	72.5	74.8	0.5	0.5	45.0	54.3	0.8	0.6
Finland	65.0	75.3	0.4	0.4	24.0	35.6	0.8	0.7
Norway	55.7	56.2	0.6	0.5	18.6	38.6	1.0	0.9
Sweden	75.7	81.8	0.6	0.5	20.0	26.7	0.9	0.9

Source: Nickell (2006), OECD(2007) and Visser (2009).

Table 2.3: Labour Share, Bargaining Index and Openness: Baseline specification

Labour Share	[1]	[2]	[3]	[4]
P_{imp}	0.062***	0.016	0.023	-0.005
	[0.017]	[0.020]	[0.018]	[0.020]
P_{exp}	-0.187***	-0.096***	-0.181***	-0.122***
	[0.022]	[0.024]	[0.022]	[0.024]
L/K	11.353***	0.497	8.278***	-0.557
	[2.636]	[1.569]	[2.894]	[1.599]
Reg. Reform	1.059***	1.565***	0.435	0.545
	[0.234]	[0.289]	[0.271]	[0.342]
Barg	-0.145	5.247***	0.181	4.858***
	[1.188]	[1.177]	[1.156]	[1.126]
ICT	-0.439**	-0.192	-0.274	-0.047
	[0.174]	[0.216]	[0.171]	[0.206]
ICT^2	0.010**	0.007	0.009**	0.005
	[0.004]	[0.006]	[0.004]	[0.005]
FDI	-0.065***	-0.065**	-0.045**	-0.039
	[0.022]	[0.027]	[0.022]	[0.026]
Anglo		3.588**		1.490
		[1.466]		[1.472]
Nordic		-1.642		-2.698**
		[1.248]		[1.271]
Time Effects			Yes	Yes
Country Effects	Yes		Yes	
N.obs	370	370	370	370
Countries	20	20	20	20
R^2	0.80	0.45	0.82	0.49

Notes: the dependent variable is the total economy labour share. The independent variables are the relative price of imports and exports respectively, the (log) Labour-Capital ratio, an index of product market regulation, index of bargaining power, share of Information and Communications Technology in the capital stock, outflows of FDI, and dummy variables for the type of labour market. Standard errors are Newey-West corrections. *, **, *** represent significance at 10%, 5% and 1% respectively.

Table 2.4: Labour Share, Bargaining Institutions and Openness

Labour Share	[1]	[2]	[3]	[4]
P_{imp}	0.057***	0.020	0.019	0.004
	[0.017]	[0.020]	[0.018]	[0.019]
P_{exp}	-0.184***	-0.103***	-0.176***	-0.137***
	[0.022]	[0.024]	[0.022]	[0.024]
L/K	10.465***	-0.424	9.406***	-0.574
	[2.815]	[1.622]	[3.114]	[1.696]
Reg. Reform	0.892***	1.419***	0.437	0.537
	[0.241]	[0.291]	[0.273]	[0.335]
BRR	-0.062**	-0.021	-0.052*	-0.011
	[0.031]	[0.033]	[0.029]	[0.032]
EPL	1.793	5.965***	0.470	4.359***
	[1.435]	[1.510]	[1.410]	[1.462]
Union	0.073*	0.070*	0.009	0.035
	[0.039]	[0.038]	[0.038]	[0.038]
Tax	0.015	0.122***	0.048	0.127***
	[0.038]	[0.037]	[0.037]	[0.036]
Central.	-0.141	2.941	0.293	1.945
	[1.649]	[1.801]	[1.678]	[1.697]
ICT	-0.520***	-0.237	-0.314*	-0.098
	[0.174]	[0.215]	[0.175]	[0.203]
ICT^2	0.012***	0.009	0.009**	0.006
	[0.004]	[0.006]	[0.004]	[0.005]
FDI	-0.073***	-0.073***	-0.057**	-0.049*
	[0.023]	[0.027]	[0.023]	[0.025]
Anglo		5.216***		2.778*
		[1.573]		[1.609]
Nordic		-4.762**		-4.311**
		[2.068]		[2.076]
Country Effects	Yes		Yes	
Time Effects			Yes	Yes
N. Obs	370	370	370	370
Countries	20	20	20	20
R^2	0.81	0.48	0.82	0.50

Notes: Reg. Reform is an index of product market regulation, BRR is the benefit replacement ratio, EPL is employment protection, Union is trade union density, Tax is the labour tax wedge, Central is the degree of bargaining centralisation. Standard errors are corrected for heteroscedasticity and autocorrelation. *, **, *** represent significance at 10%, 5% and 1%, respectively.

Table 2.5: Labour Share, Bargaining Index and FDI Outflows to non-advanced countries

Labour Share	[1]	[2]	[3]	[4]
P_{imp}	0.043***	-0.007	0.022	-0.017
	[0.016]	[0.017]	[0.016]	[0.018]
P_{exp}	-0.144***	-0.036	-0.170***	-0.089***
	[0.021]	[0.024]	[0.021]	[0.026]
L/K	13.854***	1.511	5.402**	0.428
	[2.308]	[1.222]	[2.677]	[1.300]
Reg. Reform	0.840***	1.103***	0.104	0.042
	[0.202]	[0.240]	[0.228]	[0.308]
Barg	-0.305	4.565***	-0.366	4.313***
	[1.147]	[1.004]	[1.070]	[0.971]
ICT	-0.367**	-0.143	-0.361**	-0.041
	[0.150]	[0.181]	[0.149]	[0.180]
ICT^2	0.009***	0.007	0.010***	0.006
	[0.004]	[0.005]	[0.004]	[0.005]
FDI	-0.057***	-0.058**	-0.057***	-0.046*
	[0.021]	[0.026]	[0.020]	[0.026]
FDI^{NA}	-0.050	-0.053	-0.032	-0.007
	[0.071]	[0.089]	[0.065]	[0.088]
Anglo		2.689**		0.561
		[1.118]		[1.145]
Nordic		-0.536		-1.761
		[1.111]		[1.075]
Country Effects	Yes		Yes	
Time Effects			Yes	Yes
N. Obs	370	370	370	370
Countries	20	20	20	20
R^2	0.81	0.46	0.82	0.47

Notes: FDI and FDI^{NA} are total FDI outflows and outflows to non-advanced countries respectively. Standard errors are corrected for autocorrelation and heteroscedasticity. *, **, *** represent significance at 10%, 5% and 1%, respectively.

Table 2.6: Labour Share, Bargaining, FDI and Imports

Labour Share	[1]	[2]	[3]	[4]
P_{imp}	0.040**	0.018	0.040**	0.012
	[0.016]	[0.016]	[0.017]	[0.017]
P_{exp}	-0.148***	-0.171***	-0.152***	-0.167***
	[0.021]	[0.021]	[0.022]	[0.022]
L/K	13.033***	6.896**	13.126***	7.112**
	[2.278]	[2.792]	[2.296]	[2.864]
Reg. Reform	0.343	-0.021	0.368	-0.005
	[0.238]	[0.240]	[0.240]	[0.245]
Barg	-0.342	-0.537	-0.727	-0.726
	[1.126]	[1.070]	[1.161]	[1.104]
ICT	-0.369**	-0.336**	-0.398***	-0.342**
	[0.149]	[0.149]	[0.153]	[0.152]
ICT^2	0.010***	0.009***	0.010***	0.010***
	[0.004]	[0.004]	[0.004]	[0.004]
FDI	-0.038*	-0.052**	-0.038*	-0.054**
	[0.020]	[0.020]	[0.021]	[0.021]
Imports	-0.130***	-0.059	-0.103**	-0.053
	[0.035]	[0.039]	[0.041]	[0.045]
$Imports^{NA}$			-0.012	-0.003
			[0.009]	[0.010]
Country Effects	Yes	Yes	Yes	Yes
Time Effects		Yes		Yes
N. Obs	370	370	368	368
Countries	20	20	20	20
R^2	0.81	0.82	0.81	0.82

Notes: Imports and $Imports^{NA}$ refer to the volume of total imports and imports from non-advanced countries, respectively. Standard errors are corrected for autocorrelation and heteroscedasticity. *, **, *** represent significance at 10%, 5% and 1% respectively.

Table 2.7: Labour Share and Interactions between Bargaining and Openness

Labour share	[1]	[2]	[3]	[4]	[5]
P_{imp}	0.003	-0.097	0.011	0.093***	0.029
	[0.037]	[0.059]	[0.040]	[0.028]	[0.037]
P_{exp}	-0.051	-0.005	-0.063	-0.203***	-0.099**
	[0.054]	[0.081]	[0.051]	[0.032]	[0.050]
K/L	11.207***	11.657***	11.131***	8.263***	11.064***
	[2.745]	[2.746]	[2.804]	[2.958]	[2.787]
Reg. Reform	0.410	0.371	0.516*	0.814***	0.523*
	[0.275]	[0.268]	[0.271]	[0.312]	[0.270]
EPL	0.297	-0.484	5.710**	0.556	0.741
	[1.456]	[1.423]	[2.628]	[1.487]	[1.438]
Union	0.145**	0.045	0.030	0.028	0.043
	[0.057]	[0.037]	[0.038]	[0.039]	[0.038]
Tax	0.031	0.248***	0.010	0.005	0.016
	[0.039]	[0.083]	[0.039]	[0.040]	[0.038]
BRR	-0.087***	-0.101***	-0.072**	-0.097***	-0.076**
	[0.030]	[0.030]	[0.030]	[0.035]	[0.031]
ICT	-0.017	-0.059	-0.050	-0.075	-0.044
	[0.049]	[0.047]	[0.050]	[0.051]	[0.048]
Central.	1.200	0.493	1.296	1.597	5.296
	[1.719]	[1.696]	[1.743]	[1.820]	[3.919]
FDI	-0.061	-0.014	-0.031	0.026	-0.020
	[0.051]	[0.106]	[0.067]	[0.063]	[0.097]
Imports	-0.007	0.138	-0.036	-0.131***	-0.048
	[0.061]	[0.096]	[0.060]	[0.047]	[0.066]
P_{exp}*Union	-0.003**				
	[0.001]				
Imports*Union	-0.004***				
	[0.001]				
P_{imp}*Tax		0.004***			
		[0.002]			
P_{exp}*Tax		-0.005**			
		[0.002]			
Imports*Tax		-0.007***			
		[0.002]			
P_{exp}*EPL			-0.162**		
			[0.063]		
Imports*EPL			-0.168**		
			[0.080]		
Imports*BRR				0.002**	
				[0.001]	
P_{exp}*Central.					-0.167*
Country Effects	Yes	Yes	Yes	Yes	Yes
N.Obs	370	370	370	339	370
Countries	20	20	20	20	20
R^2	0.81	0.82	0.81	0.81	0.81

Notes: Columns show the interaction of the openness variables with union density, the tax wedge, employment protection, benefit replacement rates and bargaining centralisation respectively. Only significant interaction coefficients are reported. Standard errors are corrected for autocorrelation and heteroscedasticity. *, **, *** represent significance at 10%, 5% and 1% respectively.

Table 2.8: Labour Share, Bargaining and Openness in Manufacturing

Labour Share	[1]	[2]	[3]	[4]
P^M_{imp}	11.594**	9.555**	12.065***	14.009***
	[4.536]	[4.532]	[4.627]	[4.443]
P^M_{exp}	-16.251***	-15.294***	-17.856***	-16.434***
	[3.667]	[3.747]	[3.701]	[3.504]
L/K^M	-1.794	11.910*	2.373	11.888**
	[4.334]	[7.017]	[4.533]	[5.491]
ICT^M	-0.867**	-0.961***	-0.773**	-0.768***
	[0.357]	[0.343]	[0.344]	[0.288]
ICT^2	0.008	0.010	0.004	0.004
	[0.008]	[0.008]	[0.008]	[0.006]
Barg	-1.004	-1.779	-2.084	-1.612
	[2.672]	[2.568]	[2.664]	[2.611]
FDI^M	-0.080***	-0.078***	-0.057**	-0.075***
	[0.024]	[0.024]	[0.026]	[0.026]
$Imports^M$			-0.109*	0.186**
			[0.065]	[0.081]
Country Effects	Yes	Yes	Yes	Yes
Time Effects		Yes		Yes
N. Obs	233	233	233	233
Countries	13	13	13	13
R^2	0.52	0.55	0.54	0.57

Notes: Dependent Variable: labour share in manufacturing. Independent variables: relative price of imports; relative price of manufacturing exports, Capital-Labour ratio and ICT share of capital stock in manufacturing, bargaining index, and Outflows of FDI and the import share in manufacturing. Standard errors are corrected for heteroscedasticity and autocorrelation. *, **, *** represent significance at 10%, 5% and 1% respectively.

Table 2.9: Labour Share and lags of Bargaining and Openness

Labour Share	[1]	[2]	[3]	[4]
$P_{imp,t-1}$	0.021	0.026	0.022	0.029
	[0.025]	[0.024]	[0.024]	[0.024]
$P_{exp,t-1}$	-0.049***	-0.047***	-0.060***	-0.051***
	[0.016]	[0.015]	[0.019]	[0.019]
K/L_{t-1}	18.075***	14.652***	15.190***	12.008***
	[2.904]	[2.988]	[3.618]	[3.729]
Reg. $Reform_{t-1}$	0.853***	0.840***	0.295	0.322
	[0.252]	[0.260]	[0.330]	[0.328]
ICT_{t-1}	-0.697***	-0.659***	-0.748***	-0.752***
	[0.195]	[0.190]	[0.190]	[0.188]
ICT^2_{t-1}	0.018***	0.017***	0.020***	0.019***
	[0.005]	[0.005]	[0.005]	[0.005]
$Barg_{t-1}$	-0.862		-0.529	
	[1.415]		[1.358]	
FDI_{t-1}	-0.072***	-0.077***	-0.060**	-0.070**
	[0.027]	[0.027]	[0.029]	[0.029]
EPL_{t-1}		-0.864		-0.644
		[1.488]		[1.440]
$Union_{t-1}$		0.051		0.02
		[0.038]		[0.040]
Tax_{t-1}		-0.099**		-0.082*
		[0.048]		[0.048]
BRR_{t-1}		-0.103***		-0.106***
		[0.036]		[0.035]
$Central._{t-1}$		2.442		2.950*
		[1.840]		[1.774]
Country Effects	Yes	Yes	Yes	Yes
Time Effects			Yes	Yes
N. Obs	350	350	350	350
Countries	20	20	20	20
R^2	0.81	0.82	0.82	0.83

Notes: The dependent variable is the labour share in total economy. Regressors are as defined in previous tables but lagged one period. Standard errors are corrected for autocorrelation and heteroscedasticity. *, **, *** represent significance at 10%, 5% and 1% respectively.

Table 2.10: Labour Share, Bargaining and Openness: Instrumental Variables estimation

Labour Share	[1]	[2]
P_{imp}	0.035	0.037
	[0.029]	[0.030]
P_{exp}	-0.304***	-0.331***
	[0.091]	[0.086]
L/K	19.167***	19.492***
	[4.152]	[3.905]
ICT	-0.297	-0.227
	[0.217]	[0.205]
ICT^2	0.011**	0.009**
	[0.005]	[0.004]
Reg. Reform	1.695***	1.225***
	[0.324]	[0.398]
Barg	-6.585***	-6.573***
	[2.122]	[2.138]
FDI	-0.165***	-0.130**
	[0.061]	[0.066]
Imports		-0.111*
		[0.059]
Hansen J-stat	11.53	12.1
p-value	(0.312)	(0.278)
Anderson	28.81	26.7
p-value	(0.021)	(0.028)
Country Effects	Yes	Yes
N. Obs	302	302
Countries	20	20
R^2	0.83	0.84

Notes: Estimation is by Two Stage Least Squares (2SLS). Instruments include: lags of relative import and export prices, lags of outflows and the outward stock of FDI, population, export-weighted real GDP growth of partner economies, distance-weighted export-adjusted employment growth in rest of the world, share of government consumption in GDP, and effective consumption tax rate. Hansen J-stat is the Sargan-Hansen test of overidentifying restrictions with the null hypothesis that the instruments are valid. Anderson is the Anderson-Rubin test of the joint significance of endogenous regressors with the null hypothesis that the coefficients of the endogenous regressors are jointly equal to zero.

Chapter 3

Globalisation, Inflation and the New Keynesian Phillips Curve

One of the most striking features of the global economy since the early 1990s has been the consistent decline in the average level and volatility of inflation. At the same time, the integration of China, India and the former Soviet bloc into the world economy has increased the share of trade in world GDP by approximately one-fifth.[34] The concurrent decline in inflation rates and increasing levels of openness have naturally prompted many to suggest that these phenomena are related and that lower inflation reflects greater global competition in both product and factor markets (Rogoff (2006)). Indeed, some authors have suggested that inflation has become less responsive to the domestic macroeconomic environment and more sensitive to global supply and demand conditions (Borio and Filardo (2007)). According to this view, if the trend continues and inflation becomes an increasingly global phenomenon, national central banks may lose the ability to control inflation within their borders. The aim of this chapter is to determine the impact of globalisation on domestic inflation and in this way, examine the empirical validity of the "global inflation" hypothesis.

There are several channels through which globalisation can affect domestic inflation. As the level of inflation ultimately depends on the central bank's nominal anchor, in order for globalisation to affect the medium-term level of inflation, it must influence the choice for the level of this anchor. As Romer (1993) and Lane (1997) show, trade openness can reduce the

[34] See the World Bank's *World Development Indicators*.

incentive for central banks to engage in unexpected monetary easing and therefore lowers the economy's time consistent level of inflation.

The focus of this chapter, however, is on the channels through which globalisation can affect the determination of inflation in the short run, a period during which prices are assumed to exhibit some degree of price rigidity. In traditional models of inflation, the impact of globalisation on domestic inflation is usually captured by changes in the nominal exchange rate or relative import prices. However, this does not fully capture the potential effects of greater trade openness. First, greater competition in domestic product markets due to trade integration can affect the pricing decisions of domestic firms, whereby strategic pricing complementarities reduce the pass-through to prices of increases in marginal costs. In this sense, the price of tradable goods may increasingly be determined by global rather than domestic supply and demand factors. In addition, greater financial integration facilitates larger current account imbalances which can further weaken the link between domestic supply and demand (IMF (2006)). A decline in the responsiveness of inflation to domestic factors would suggest that globalisation should lower the slope of the Phillips curve. However, in the limit of fully integrated product and factor markets, the Phillips curve may be vertical as firms in perfectly competitive sectors fully pass through changes in marginal costs (Rogoff (2006)).

Borio and Filardo (2007) argue that traditional models of inflation are misspecified as they do not capture these additional dimensions of the relation between openness and inflation and are therefore too "country-specific". In particular, as goods in these models are treated as heterogenous across countries, domestic inflation is assumed to be primarily determined by excess domestic demand for the domestic good. In addition, each factor of production is assumed to have low substitutability across countries so that inputs have a high degree of good-specificity. Borio and Filardo (2007) argue that greater integration of product markets means that goods are less differentiated by national borders so that a more "globe-centric" approach to inflation determination may be more appropriate. Similarly, the global fragmentation of production implies that movements in factor prices increasingly reflect global rather than domestic capacity constraints and so inflationary pressures originating from factor markets will have a larger global component.

Several studies have augmented traditional Phillips curve models with a measure of global excess demand, such as the trade-weighted output gap, in order to test this "globe-centric" view of inflation. However, the empirical evidence has been mixed. For example, Borio and Filardo (2007) find in a panel of sixteen countries that the trade-weighted output gap is positive and significant and that the coefficient is often larger than that on the domestic output gap. In addition, they find that the former has been increasing over time, whereas the latter has declined. However, Ihrig et al (2007) show that Borio and Filardo's (2007) model may be misspecified and that their results are not robust to additional covariates.

The theoretical framework used in all of these studies is the accelerationist Phillips curve which relates inflation to a measure of excess demand such as the output gap, and lagged inflation. In this chapter, we use an alternative model of inflation, the New Keynesian Phillips Curve (NKPC). The NKPC is derived from the profit-maximising problem of forward-looking firms and incorporates an assumption about price stickiness so that inflationary pressure is derived from firms increasing prices in order to restore a desired markup over marginal cost.[35] However, as marginal costs are not observed at the aggregate level, much of the empirical testing of the NKPC has focused on finding a suitable proxy of aggregate real marginal cost. In this study, we follow much of the empirical literature and use the labour share of income, or real unit labour costs, to approximate real marginal cost.

From a theoretical perspective, Woodford (2009) shows that it is difficult to reconcile the "global slack" hypothesis with inflation dynamics in a standard New Keynesian model. In Woodford's model, the wage demands of domestic workers depend on the marginal disutility of labour and the marginal utility of additional income (in units of domestic currency). The

[35] Thus, the NKPC is a model of *domestic* inflation.

marginal disutility of labour depends only on domestic output due to the assumption that the factors of production are not traded internationally. However, the marginal utility of income depends on foreign output for two reasons. First, an increase in foreign output leads to higher consumption of foreign goods and therefore, a lower marginal utility of consumption of foreign goods. Second, an increase in foreign output leads to terms of trade appreciation and therefore a higher marginal utility of income in terms of domestic goods. The net effect will depend on the intertemporal elasticity of substitution of consumer expenditure and a value greater than unity, which is the empirically relevant case, will mean that the terms of trade effect will dominate. In this case, an increase in foreign output will lead to a fall in domestic marginal costs. This is clearly the opposite of the sign predicted by the "globe-centric" view of inflation as domestic inflation actually becomes more responsive to domestic slack.

Woodford (2009) shows that only with the assumption of international trade in the factors of production will the NKPC need to be augmented to include a measure of global capacity excess demand. In this case, an increase in foreign output will raise foreign marginal cost and, assuming a single global labour market, will also lead to an increase in domestic marginal costs. However, Woodford's model also omits some of the key channels through which globalisation can affect domestic inflation. In particular, he assumes that price and wage markups are constant even though strategic complementarities in wage- and price-setting may become more important as product and factor markets become more integrated. By contrast, these channels are of central interest in this chapter.

Our main contribution is to examine this globe-centric view of inflation in the context of the New Keynesian Phillips Curve. First, we provide evidence on the empirical fit of the baseline and hybrid open-economy NKPC for a sample of twelve countries. The innovation in this part of the chapter is how we allow for a negative relation between the equilibrium or "desired" markup and the intensity of foreign competition, as measured by the interaction between the level of import penetration and the change in relative non-commodity import prices. These results also provide evidence on the importance of real rigidities, such as employment adjustment costs, to inflation dynamics and our relatively large sample facilitates a cross-country comparison of the relative importance of these costs according to a priori assumptions about the flexibility of each country's labour market.

Second, we test the "global slack" hypothesis by including a measure of foreign marginal cost in the open-economy NKPC. We are aware of only one other study that examines the role of global slack in the context of the NKPC (Milani (2010)). However, in that study the variable driving inflation is the output gap, despite there being considerable evidence that output gap versions of the NKPC perform poorly. Instead, we construct a measure of foreign real marginal cost as the trade-weighted labour share in each country's ten largest trading partners. We include this measure of foreign marginal costs in the NKPC in order to capture the importance of movements in marginal costs to the price- and wage-setting decisions of domestic firms and workers. Existing models do not try to capture these strategic complementarities.

Finally, our study decomposes the main driving variable in the NKPC, namely the labour share, into common and idiosyncratic components and includes these components separately in the open-economy NKPC. In this way, we merge the literature on the NKPC with that which uses factor models to decompose macroeconomic variables into their global and country-specific components. The advantage of this empirical strategy is that it allows globalisation to affect domestic inflation indirectly via domestic marginal costs and therefore captures the main channel through which foreign output affects inflation in Woodford's (2009) model. In addition, as the estimated idiosyncratic and common components are orthogonal, any potential multicollinearity problem, arising from the use of measures of domestic and global marginal cost, is reduced.

The remainder of the chapter is structured as follows. Section 3.1 discusses the contribution of our study to the literature. Section 3.2 outlines the baseline and hybrid open-economy New Keynesian Phillips curve which provide the basis for the specification of our econometric model. Section 3.3 outlines our data sources and Section 3.4 presents the econometric results. Section 3.5 discusses the issue of time-variation in the estimated parameters. Section 3.6 presents the results of our sensitivity analysis and section 3.7 concludes.

3.1 Literature

The focus of this study is on the possible relation between globalisation and inflation. In contrast to the earlier work of Romer (1993) and Lane (1997) which examined the effect of openness on a central bank's inflation target, the recent literature has concentrated on how globalisation affects inflation in the short run, a period during which prices exhibit a degree of rigidity. In particular, this literature has questioned whether the workhorse model for analysing short-run inflation dynamics, the Phillips curve, needs to be modified to incorporate the influence of global forces on domestic inflation. We now discuss how this chapter relates to existing studies of the impact of globalisation on inflation dynamics.

Globalisation and the Accelerationist Phillips Curve

Borio and Filardo (2007) argue that the traditional models of inflation are misspecified and that a more "globe-centric" approach to inflation modelling is required. This implies that accelerationist Phillips curve models need to be augmented with a measure of global excess demand such as the trade-weighted output gap. They find, in a panel of sixteen countries, that the sensitivity of domestic inflation to measures of domestic excess demand, such as the output gap, has actually been falling since the mid-1990s while the sensitivity of inflation to global excess demand has increased. Moreover, they find that the coefficient on the global output gap is actually larger than that on the domestic output gap for some countries, thereby suggesting that central banks should pay closer attention to the external factors that affect domestic inflation. Their results have been supported by Razin and Binyamini (2007) who find that foreign rather than domestic output gaps are becoming increasingly important in the determination of domestic inflation.

However, criticisms of this approach center on both the specification of the econometric model of inflation and on the robustness of the results. The dependent variable in Borio and Filardo's econometric model is the deviation of core inflation from a stochastic trend, computed using a Hodrick-Prescott (H-P) filter, rather than simply the level of core inflation. While this adjustment is important if inflation has a time-varying mean, it is a relatively unconventional approach.[36] Ihrig et al (2007) suggest that Borio and Filardo's model is misspecified due to serial correlation in the error term and find that their results are not robust to other detrending procedures or to the estimation of more conventional models of inflation. The coefficients on the foreign output gap are generally insignificant, and often negative, when more conventional models of inflation are estimated. In addition, IMF (2006) find that even when H-P filtered inflation is used as the dependent variable, the coefficients on the domestic and "global" output gaps are not robust to the inclusion of other covariates such as import and commodity prices.

Similarly, Pain et al (2006) find no role for foreign output gaps in the domestic inflation process for a panel of 21 OECD countries from 1980 to 2005, while Ball (2006) finds foreign output gaps have little explanatory power in a Phillips curve model for 14 OECD countries from 1985 to 2005. These studies conclude that the primary explanation for any flattening of the Phillips curve that has occurred is likely to be due to improvements in monetary policy and strongly anchored inflation expectations. Indeed, Ball (2006) questions the theoretical validity of examining the impact of openness on inflation rather than on relative price and argues that, although globalisation may reduce the markup over marginal costs, that this should not change the cyclical relation between output and price.

IMF (2006) also investigate the effect of globalisation/openness on inflation but control

[36] Borio and Filardo (2007) argue that it is necessary to estimate the trend using a Hodrick-Prescott filter on core inflation in order to account for factors that affect the low-frequency inflation trend. They suggest that imposing this statistical structure on the low-frequency component of inflation better facilitates the joint estimation of the autoregressive component of inflation and the output gap.

for other factors that may have contributed to the decline in aggregate inflation, such as a more credible monetary policy.[37] The IMF's findings suggest that approximately half of the decline in the sensitivity of inflation to the domestic output gap can be attributed to openness. However, the impact of openness on inflation does not operate via the relative import price channel, which although strongly pro-cyclical, is cumulatively small and tends to be offset by rising oil prices. Instead, the impact of openness on inflation works mainly through restraining labour compensation and through lower unit labour costs. Importantly, given the focus of this chapter, they find evidence for the "global competition hypothesis" with sectoral differences in import penetration explaining one-third of the difference in sectoral relative prices.

Other studies on the impact of globalisation on inflation have focused on particular countries or particular entities. For example, Calza (2009) examines whether the relation between euro-area inflation and a measure of the global output gap has changed over the period Q2 1972 to Q4 2003. As the eurozone is a largely closed economic area, it is perhaps unsurprising that he finds little evidence that either the trade-weighted output gap of euro-area's twenty five largest trading partners or a PPP adjusted GDP-weighted output gap has significant explanatory or predictive power for headline inflation in the euro-area. However, when he allows for a break in the mean level of inflation in the mid-1980s, the coefficient on the foreign output gap increases and becomes significant. Mody and Ohnsorge (2007) also focus on inflation in euro-area economies and find that the main effect of globalisation is to reduce the country-specific component of inflation and to weaken the link between domestic demand conditions, as measured by the output gap, and price setting via a decline in the market power of domestic producers.

Most of the above studies assume that an economy's exposure to external factors is via the trade channel so that weighting the economy's exposure to economic shocks in another economy by the economy's trade share adequately captures that exposure. A second method

[37] The credibility of monetary policy is approximated using the Laxton and N'Diaye (2002) measure of the inflation premium derived from the behaviour of long-term bond yields.

adopts a statistical approach to estimating the set of economic shocks that are common to a group of countries, and allows for these shocks to have different effects in each country. The advantage of this approach is that a particular transmission channel does not have to be assumed.

Eickmeier and Pijnenburg (2013) use a factor model to estimate the idiosyncratic and common components of the variables, such as the output gap and unit labour costs, that drive inflation in 24 OECD countries over the period 1980 to 2007. The components are then included in a standard accelerationist inflation model. They find that the common component of unit labour costs, rather than the common component of the output gap, can explain a large amount of the variation in inflation across countries. Similar to IMF (2006), openness variables such as import prices, that have traditionally been used to control for external shocks, have only a small effect on inflation.

Our study utilises both the trade-weighted and factor methods to measure an economy's exposure to inflationary pressures resulting from foreign excess demand. Our use of both of these methods is novel in terms of the particular measure of excess demand that we employ and in the particular theoretical and empirical approach we adopt. This approach is based on the New Keynesian model of inflation, which we now discuss in more detail.

The New Keynesian model of Inflation

The studies discussed above use the traditional or "accelerationist" Phillips curve model to analyse inflation dynamics. Although this model has performed well historically, it has tended to over predict inflation since the mid-1990s. In addition, the backward-looking nature of expectations in the model suggests that any changes in the monetary regime would lead to the model being misspecified and therefore it is subject to the Lucas critique. By contrast, the New Keynesian Phillips curve is a model of inflation that incorporates both rational expectations and structural relations, in which inflation evolves from staggered price-setting of optimising monopolistically competitive firms. The model of price-setting usually invoked is that of Calvo (1983).[38] The variable "driving" inflation in this model is the average change in real marginal cost across firms, rather than detrended output or the "output gap" as in the case of the accelerationist model. The NKPC theory implies that it is real marginal cost that provides a measure of capacity utilisation. However, as aggregate marginal cost is not observable it must be approximated and much of the literature is directed at addressing the appropriateness and empirical success of different approximations.

The extent to which this model of price-setting implies a relation between inflation and output depends on the degree to which the empirical measure of the output gap approximates the theoretical concept of marginal costs. As the baseline NKPC is entirely forward-looking, the driving variable in this case is the present discounted value of current and future output gaps. This implies that inflation should lead the output gap, a relation that is not supported empirically.

However, there are theoretical and practical difficulties with the use of the output gap as the driving variable in the NKPC, which may explain its poor empirical performance. First, conventional measures of the output gap are likely to contain significant measurement error given that potential output is an unobservable variable. This measurement error will be compounded if supply shocks are causing high frequency variation in potential output. In the presence of nominal rigidities, supply shocks may push detrended output and the true output gap in opposite directions (Gali and Gertler (1999)). In addition, the use of the output gap as the driving variable in the NKPC is only correct under the assumption of a constant wage markup, which may not be the case if there is structural change in an economy's labour markets (Gali et al (2001)). Second, the relation between the output gap and real marginal

[38] One criticism of the Calvo model of price-setting is that it implies that there is a small proportion of firms whose prices were set at some arbitrary date in the past (Sbordone (2002)). Alternative models of pricing assume that prices of all firms are changed within a fixed time period (see for exampleTaylor (1980)). In Calvo's model, firms have a fixed probability $(1-\theta)$ of changing prices in each period, whereas in Taylor's model, firms set their prices for a fixed number of periods and have a zero probability of changing prices during that time. Sbordone (2002) finds that the alternative assumptions of random or uniform intervals between price changes do not affect the fit of the New Keynesian model but that this is conditional on the average frequency of price adjustments being correct.

cost may itself be weak. For example, the labour share, another proxy for real marginal cost, tends to lag changes in the output gap.[39]

One useful feature of using the labour share (or real unit labour costs) as a measure of real marginal costs is that it reflects the impact of both labour productivity and wages on potential inflationary pressures, which contrasts with other conventional measures of inflationary pressures such as the output gap. For this reason, many empirical studies of the NKPC use the labour share as the driving variable and our study follows the literature in this respect.

Gali and Gertler (1999) estimate the NKPC on US data and find that real marginal costs, as approximated by the labour share, are a significant determinant of inflation. Importantly, in the context of empirical studies of the Phillips curve relation discussed above, they find that the output gap, or detrended output, does not have a statistically significant effect on inflation in the NKPC framework. In contrast to the behaviour predicted by the accelerationist model, they also find that inflation expectations are predominantly forward-looking. Gali et al (2001) find that the coefficient on the output gap is negative and insignificant but also find that the labour share coefficient is positive and significant when it is used as the driving variable. Rudd and Whelan (2007) estimate the NKPC on US data over the period 1960 Q1 to 2004 Q3 and find that detrended output is negative and significant.[40] In addition, Gali, et al (2007) find that, although the price markup, or inverse of the labour share, exhibits relatively weak comovement with detrended output, the negative comovement of the price markup and the output gap increases when they allow alternately for a Constant Elasticity of Substitution (CES) production function, overhead labour, overtime premia and convex employment adjustment costs.

The poor empirical performance of the output-gap as the driving variable in the NKPC therefore suggests that either the NKPC is an inadequate model of inflation dynamics or that the output gap is simply a poor approximation of real marginal cost. There is, as we dis-

39 Woodford (2003) outlines the conditions under which real marginal cost may be approximated by the labour share of income.

40 Rudd and Whelan (2007) also estimate a closed form of the NKPC with forecasted labour shares and find that, although the labour share coefficient is positive and significant, the model has very low explanatory power.

cuss below, considerable evidence in favour of the labour share version of the NKPC and taking account of real rigidities in the measure of real marginal cost could significantly increase its performance. For example, the assumption of a Cobb-Douglas technology implies that average marginal costs can be approximated by average unit labour costs but there are also several reasons why the conventional measure of the labour share or real unit labour costs may not closely approximate real marginal costs. First, if there are significant costs to adjusting employment, firms may instead try to increase the effort margin (Woodford and Rotemberg (1999)). Second, the existence of "overhead labour" drives a wedge between marginal and average cost because of a "productivity bias", whereby the growth rate of the effective labour input is greater than the growth rate of hours (Sbordone (2002)).[41]

There is mixed evidence on the importance of the adjustment costs to the empirical fit of the NKPC. Sbordone (2002) finds that the difference between marginal and average labour cost due to employment adjustment costs does not significantly affect the fit of the NKPC and shows that modifying the production function to include overhead labour does not improve the measure of marginal cost or change the fit of the NKPC. However, this study relates to the US where labour markets are relatively flexible. By contrast, Tillman (2006) shows that augmenting the NKPC with quadratic employment adjustment costs significantly improves the ability of the model to fit aggregate euro area inflation. Similarly, Batini et al (2000, 2005) find that employment adjustment costs significantly increase the procyclicality of real marginal cost in the United Kingdom. Our study contributes to this literature on the importance of real rigidities to inflation dynamics and, in contrast to these single-country studies, we provide evidence for a sample of 12 countries, which are diverse in terms of the structure of their labour markets.

Although not the primary focus of our study, we also contribute to the debate between proponents of the accelerationist model and New Keynesians about whether inflation expec-

41 "Overhead labour" are hours that firms need to employ regardless of the level of production.

tations are predominantly backward- or forward-looking. Specifically, the second specification of the NKPC that we consider is a "hybrid" model that includes lagged inflation as an independent variable. In general, the theoretical motivation for the inclusion of the lagged inflation term in the new Keynesian model is that a fraction of firms resetting their prices in any period follow a rule-of-thumb pricing rule, whereby they index the firm's price to the previous period's optimal reset price with a correction for lagged inflation.

Other studies have attempted to model inflation persistence in a more micro-founded framework. In the standard wage contracting model (for example, Taylor (1980)), agents negotiate the nominal wage in terms of their expectation of the real wage over the contracting period. In Fuhrer and Moore (1995), however, agents negotiate the nominal wage in terms of the relative real wage over the contracting period and therefore compare the current nominal contracted wage with an average of nominal contract wages that were negotiated in the recent past and those that are expected to be negotiated in the future. In our model, the inclusion of lagged inflation results from our particular specification of price adjustment costs, which are assumed to increase with the deviation of a firm's price changes from the general level of inflation. This assumption generates long run neutrality between real and nominal variables.

The lagged inflation term tends to be highly significant in empirical tests of the hybrid NKPC. Gali, Gertler and Lopez-Salido (2001) find that the hybrid NKPC fits euro area inflation well over the period 1970 to 1998 and that inflation tends to be more forward-looking in the euro area than in the United States over this period. Gali et al (2005) also estimate a hybrid model using US data over the period 1960 Q1 to 1997 Q4 and find that lagged inflation, although statistically significant, is quantitatively unimportant. However, Rudd and Whelan (2005, 2007) argue that Generalised Method of Moments (GMM) estimation of such models may be misspecified due to omitted variables. The instrument set for expected inflation will include variables that are correlated with current inflation but which are not included directly in the estimating equation. Specifically, the instrument set in empirical studies of the NKPC typically includes lags of inflation, detrended output and commodity prices but these variables are then omitted from the inflation equation. Therefore, the finding of a large coefficient on expected inflation may simply reflect the effect of these variables on current inflation and so forward-looking behaviour is actually unimportant.

Similarly, the direct effect of lagged inflation in the hybrid model will be biased downwards if lags of inflation are included in the instrument set.[42] Gali et al (2005) show that this will be the case only if forward-looking behaviour in price-setting is entirely absent. In order to reduce the omitted variable bias, they include additional lags of inflation as both explanatory variables and instruments. They find that these additional lags are insignificant and conclude that they have no independent role in affecting current inflation, outside of their role as instruments for expected future inflation. By contrast, Rudd and Whelan (2007) estimate the hybrid model in its closed form on US data over the period 1960 Q1 to 2004 Q3 and use a VAR with two lags of the labour share and detrended output to construct a measure of expected future values of the driving variable. They find that nearly all of the variation in inflation explained by the model is due to the inflation lag.

Therefore, estimation of the closed form and structural forms of the hybrid model appears to yield significantly different results, although Gali et al (2005) argue that the results are identical when the implied restrictions of the structural form are incorporated in the estimation of the closed form NKPC. As the precise estimation of the backward- and forward-looking components of inflation requires either forecasting future values of the labour share or incorporating these structural restrictions, our results can only be suggestive of the relative importance of each component.

[42] Rudd and Whelan (2007) argue that using overidentification tests to detect this potential misspecification would have no power in this context. They also argue that using survey measures of inflation expectations would not mitigate the bias. Intuitively, if economic agents use variables to forecast inflation that are not included in the inflation equation, then these survey measures will tend to receive a large weight even if they play no direct role in determining current inflation.

Globalisation and the New Keynesian Phillips Curve

There has been relatively little empirical research on the impact of globalisation on inflation dynamics in the New Keynesian model. Sbordone (2009) and Guerrieri et al (2010) investigate the impact of international competition on inflation in the United States. The primary channel through which globalisation affects domestic inflation in these models is through its impact on the elasticity of demand for each firm's good. In these models, the price elasticity of demand varies with both the firm's relative price and the level of competition. Sbordone (2009) assumes that higher market shares are associated with lower elasticities of demand. A higher elasticity of demand implies lower steady-state or "desired" markups. Therefore, greater import penetration is likely to lead to lower markups via its impact on demand elasticities and thus greater real rigidities due to the strategic-complementarity in price-setting. Sbordone (2009) assumes that competition is approximated by an increase in the variety of goods in the domestic market but finds that the resulting increase in competition is too small to have affected the slope of the NKPC.

Guerrieri et al (2010) find that foreign competition lowered goods inflation in the US by 1 percentage point during the period 2000 to 2006. We incorporate the findings of Sbordone (2009) and Gurrieri et al (2010) by allowing the strategic complementarity arising from greater import penetration to increase the sensitivity of domestic inflation to relative import prices.

Rumler (2007) estimates a closed- and open-economy NKPC for nine euro economies and the euro area aggregate, and finds that the degree of price rigidity is lower in the open-economy case. He argues that this may due to firms facing more variable input costs as they import from international markets. However, he also finds that greater openness allows firms to substitute foreign for domestic intermediate inputs, thus mitigating the need of firms to change prices in order to restore their desired markup. In our model, the coefficient on real marginal cost, or the labour share, depends on the degree of price rigidity. Rumler's (2007) study, therefore, provides some intuition on how globalisation affects the slope of the NKPC.

As far as we are aware, we are the first study to examine the impact of foreign marginal cost on domestic inflation using the labour share version of the NKPC and also the first to explore the global slack hypothesis in the context of the baseline open-economy NKPC, as outlined by Batini et al (2000). As mentioned, one of the innovations contained in this chapter is the statistical decomposition of domestic marginal cost into a purely idiosyncratic (country-specific) component and a common (global) component. This allows us to further isolate the impact of globalisation on inflation by also allowing openness to affect domestic marginal cost.

Our baseline econometric model is based on the theoretical and empirical framework outlined in Batini et al (2000, 2005). They extend the canonical NKPC to an open economy setting by allowing competition from foreign firms to affect the equilibrium markup of domestic firms and incorporating imported intermediate inputs in the production function so that changes in material input prices will affect domestic inflation. They estimate the open-economy NKPC for the United Kingdom over the period 1972 Q3 to 1999 Q2 using the labour share of income as the measure of real marginal cost. They find that the labour share is a highly significant determinant of inflation, with relative import prices, changes in real oil prices and employment adjustment costs also being important. However, their measure of the intensity of foreign competition, calculated as the world price of domestic GDP, and the desired markup, approximated by the output gap, are both insignificant. Balakrishnan and Lopez-Salido (2002) also investigate the impact of openness on domestically generated inflation in the United Kingdom using a similar framework to that outlined in Batini et al (2000) and find a significant impact of changes in the terms of trade and the ratio of domestic wages to import prices.

There are several key differences between our study and those of Batini et al (2000, 2005). First, we capture the impact of foreign competition on the equilibrium markup via the interaction between the level of import penetration in domestic spending and the change in relative non-commodity import prices, rather than through changes in the world price of domestic GDP. The inclusion of this variable is primarily motivated by findings of Sbordone (2009) and Guerierri et al (2010). However, there is also substantial sectoral evidence that greater import penetration is associated with lower markups and lower inflation. For example, Chen et al (2004, 2009) find that import penetration is associated with lower markups in the European Union's manufacturing sectors, while Auer and Fischer (2010) find that a greater import share from low wage countries has also significantly reduced producer-price inflation in the European manufacturing sector.

Second, we augment the baseline open-economy NKPC with a measure of foreign marginal cost in order to capture strategic complementarities in price- and wage-setting, which may not be fully captured by the competitive pressures reflected in the degree of import penetration. Third, we use statistical methods to decompose changes in the domestic labour share into changes that are country-specific and those that have a global origin. In this way, we allow globalisation to affect the main driver of domestic inflation in New Keynesian models. Finally, our sample contains twelve countries whereas the focus of the Batini et al (2000, 2005) studies is on the United Kingdom alone.

One empirical study that has examined the role of global excess demand in the context of the New Keynesian model is Milani (2010). Following Woodford (2009), Milani identifies a direct and indirect channel through which foreign output can directly and indirectly affect inflation: the former operates via an additional component in the aggregate supply (Phillips curve) relation, while the latter allows foreign output to affect domestic demand via the Investment-Savings (IS) equation and therefore the domestic output gap in the aggregate supply relation. He finds that global output has important effects on domestic output via the second channel, but not as a separate variable in the Phillips curve. However, the empirical performance of New Keynesian models with the output gap as the driving variable is, as discussed, known to be poor and Milani does not consider alternative measures of real marginal cost, such as the labour share, which have been more successful empirically. In addition, Milani's model assumes that the wage and price markup are constant even though greater international competition should increase the price elasticity of demand for goods and labour. By contrast, we follow Batini et al (2000) in allowing import competition to affect firms' desired markup and we assume that our measure of foreign marginal cost will capture the effect of globalisation on the wage markup.

In the next section, we outline the baseline open-economy New Keynesian Phillips curve and show how it is possible to specify price adjustment costs so that we can derive a "hybrid" model, in which inflation depends on its own lag. These models then provide the theoretical motivation behind our estimating equations in the empirical section of the chapter.

3.2 The Open-Economy New Keynesian Phillips Curve

The model underlying our baseline econometric specification is based on the labour-share version of the open-economy NKPC outlined in Batini et al (2000, 2005).[43] The economy comprises F identical firms that produce using a Cobb-Douglas technology. The value added of each firm i has the following form:

$$Y_{it} = A_{it} N_{it}^{\alpha} \tag{3.1}$$

where $\alpha > 0$, Y_{it} is valued added of firm i, N_{it} is employment, and A_{it} is an index of productivity.[44] The production costs of each firm are given by:

$$C_{it} = W_{it} N_{it} + cK_i \tag{3.2}$$

where W_{it} is the labour compensation per employee and cK_i is the pre-determined cost of capital. Using (1), we can write the total cost of production for each firm, C_{it}, as:

[43] The model outlined in Batini et al (2005) is a condensed version of Batini et al (2000).

[44] Following Batini et al (2000, 2005) we assume that capital is fixed with regard to short-run variation in output.

$$C_{it} = W_{it} Y_{it}^{\frac{1}{\alpha}} A_{it}^{\frac{-1}{\alpha}} + cK_i \tag{3.3}$$

We can now derive an expression for marginal cost, MC_{it}, by differentiating (3.3) with respect to value added:

$$MC_{it} = (1/\alpha)(W_{it} Y_{it}^{(1/\alpha - 1)} A_{it}^{-1/\alpha}) = (1/\alpha)(W_{it} N_{it}/Y_{it}) \tag{3.4}$$

and real marginal cost, RMC_{it}, can be written as:

$$RMC_{it} = (1/\alpha)(W_{it} N_{it}/P_{it} Y_{it}) \tag{3.5}$$

In the absence of adjustment costs, the optimal, or frictionless price, P^*, is a constant markup, μ^*, over marginal cost:

$$P_{it}^* = \mu_{it}^* MC_{it}$$

or in log form,

$$p_{it}^* = \ln \mu_{it}^* + mc_{it} \tag{3.6}$$

The equilibrium markup is inversely related to the elasticity of demand for the firm's good, $\mu_{it}^* = (1 - \frac{1}{\eta_{it}})^{-1}$, where η_{it} is the elasticity of demand. We assume there are quadratic adjustment costs to changing prices and employment. The firm's real profit $\varphi(p_i)$, can be approximated by a Taylor expansion around the log of the firm's optimal price, p_i^* (see Batini et al (2005)):

$$\varphi(p_i) \simeq \varphi(p_i^*) - (\frac{\theta}{2})(p_i - p_i^*)^2 \tag{3.7}$$

where p_i is the log of the firm's price, P_i. As p_i^* is the equilibrium price, then $\varphi'(p_i^*) = 0$ and $\theta = -\varphi''(p_i^*) > 0$. Firms maximise the objective function above subject to additional adjustment costs. At the beginning of period t, firms must choose the path of p_i and n_i that solves:

$$\min E_{t-1}\sum_{s=0}^{\infty}\beta^s\left[\left(p_{it+s}-p^*_{it+s}\right)^2+b_p(p_{it+s}-p_{it+s-1})^2+b_n(n_{it+s}-n_{it+s-1})^2\right] \quad (3.8)$$

$\forall s \geqq 0$, where β is a discount factor and E_{t-1} is the expectations operator where firms form expectations of the variables based on the information set available at the end of period $t-1$. The costs of adjusting prices and employment are assumed to have a quadratic form. In this way, the model incorporates both nominal inertia and real rigidity, so that firms will prefer to smooth prices and employment. Therefore, each firm wants to minimize the expected discounted value of (squared) deviations of the firm's price from the price it would set in each period in the absence of adjustment costs, or its frictionless price. However, the presence of price and employment adjustment costs also means that firms wish to minimise the expected discounted value of these costs.

This objective function is subject to the constraint that demand is satisfied in each period:

$$a_{it+s}+\alpha n_{it+s}=-\eta(p_{it+s}-p_{t+s})+y_{dit+s} \quad (3.9)$$

where $(p_{it+s}-p_{t+s})$ is the firm's price relative to the aggregate price of value added, y_{dit+s} is (log) demand for the firm's good and η is the elasticity of demand.

The first-order condition is obtained by differentiating (3.8) with respect to the firm's price, p_{it+s}, subject to the constraint given by (3.9). Substituting the expression for the frictionless price given by (3.6) and recalling our assumption that firms are identical, we can obtain the following expression for aggregate inflation, π_t (see Batini et al (2005)):

$$\begin{aligned}\pi_t &= \beta E_{t-1}\pi_{t+1}+\alpha_1 E_{t-1}\ln\mu^*_t+\alpha_1 E_{t-1}rmc_t-\beta\alpha_2 E_{t-1}\Delta n_{t+1}\\ &+\alpha_2 E_{t-1}\Delta n_t+v_t \end{aligned} \quad (3.10)$$

where $\alpha_1 = 1/b_p > 0, \alpha_2 = b_n\eta/b_p\alpha > 0$, $\pi_t = p_t - p_{t-1}$, $rmc_t = mc_t - p_t$ is the log of real marginal cost, $v_t = k(\pi_t - E_{t-1}\pi_t)$ and k is a constant.[45] We can also write this

[45] This specification of employment adjustment costs follows that outlined in Rotemberg and Woodford (1999) and predicts that marginal

expression using the actual markup by noting that real marginal cost is the inverse of the markup , $-rmc_t = p_t - mc_t = \ln \mu_t$ and substituting into (3.10):

$$\pi_t = \beta E_{t-1}\pi_{t+1} + \alpha_1 E_{t-1}(\ln \mu_t^* - \ln \mu_t) - \alpha_2 E_{t-1}(\beta \Delta n_{t+1} - \Delta n_t) + v_t \tag{3.11}$$

Therefore, inflation increases when the markup is below its equilibrium value or real marginal cost is above its equilibrium value. The inflationary pressure derives from firms wanting to increase price in order to restore their desired markup.

However, the above model implies that inflation is not neutral with respect to real variables in the long-run as the process generating the price rigidity in unaffected by the general level of inflation. As Batini et al (2005) show, inflation will be long-run neutral if it is assumed that the adjustment costs depend on each firm's price changes relative to the general level of inflation:

$$\textit{Price adjustment costs} = b_p\left[(p_{it} - p_{it-1}) - (p_{t-1} - p_{t-2})\right]^2 \tag{3.12}$$

It is this assumption that generates inflation inertia in our econometric model. We can now modify the inflation equation to incorporate these adjustment costs :

$$\begin{aligned} \Delta\pi_t = {} & \beta E_{t-1}\pi_{t+1} + \alpha_1 E_{t-1} \ln \mu_t^* + \alpha_1 E_{t-1} rmc - \alpha_2 \beta E_{t-1} \Delta n_{t+1} \\ & + \alpha E_{t-1} \Delta n_t + v_t \end{aligned} \tag{3.13}$$

The dependent variable now includes lagged inflation so that the change in inflation is long-run neutral with respect to real factors.

These inflation equations can now be modified to include open-economy factors. Batini et al (2005) allow openness to affect inflation through two channels. First, if the production function is not Cobb-Douglas, real marginal cost will also depend on the relative price of

costs will increase when employment is temporarily high, so that $\Delta n_t > \beta \Delta n_{t+1}$. The presence of employment adjustment costs implies that short-run marginal costs will increase more rapidly than long-run marginal costs. Therefore, a measure of real marginal cost that incorporates employment adjustment costs will be more procyclical than a measure based on the labour share alone.

materials, which are assumed to be imported. They assume that the demand for materials, M, depends on gross output, Y_G, and is increasing at the margin so that: $M = m(Y_G)Y_G$ and $m' > 0$. The cost of producing gross output will now depend on both the cost of labour and the cost of imported material inputs. Marginal costs will therefore be a function of the labour share, s_L, the price, p_{mt}, and quantity, M, of material inputs, and on the elasticity of the demand for materials with respect to output. The expression of inflation above is in terms of the price of value added and the driving variable is real marginal cost.

The real marginal cost of producing value added, rmc_t, therefore, will depend on the labour share and the price of materials relative to the price of value added: and can be written in log-linear form as:

$$rmc_t = -\ln \alpha + s_{Lt} + \mu_3(p_{mt} - p_t) \tag{3.14}$$

Therefore, allowing for imported material inputs in the production function means that inflation in an open economy will partly be determined by the real price of imports.

The other channel through which openness can affect inflation in Batini et al (2005) is via the equilibrium markup, μ^*. As mentioned above, the markup depends on the elasticity of demand for each firm's good, which will be influenced by the intensity of foreign competition. We assume the latter is proportional to the interaction between the level of import penetration, given by the share of imports in domestic spending , Imp_t (or imp_t in logs) and the change in real import prices, $\Delta(p_t^{imp} - p_t)$.

Finally, we follow Batini et al (2005) in allowing the equilibrium markup to vary with the business cycle, as measured by changes in the output gap $(y_t - y_t^*)$.[46] [47] The equilibrium

[46] Batini et al (2005) also allow deregulation of product markets to affect the desired markup. We omit this term as the impact of deregulation is not the central focus of this chapter. In any case, data on product market deregulation is only available at an annual frequency.

[47] Economic theory does not unambiguously predict the direction in which equilibrium markups will move during business cycle expansions and contractions. For example, the "customer-market" model of Phelps and Winter (1970) implies that firms will raise markups if current excess demand is higher than future expected excess demand as the fall in future profits from a lower market share is less than the rise in current profits from setting a higher markup. Therefore, markups will increase with excess demand. In contrast, the "implicit collusion" model of Rotemberg and Woodford (1992) predicts that the collusive (desired) markup will fall when excess demand is expected to fall relative to the current level. In this case, markups will be negatively correlated with excess demand. Note that the effect of the business cycle on the desired markup is in addition to its effect on the actual markup, which is a consequence of price-stickiness.

markup can now be written as:

$$\ln \mu_t^* = \mu_0 + \mu_1(y_t - y_t^*) + \mu_2(imp_t + \Delta(p_t^{imp} - p_t)) \tag{3.15}$$

where μ_0 is a constant. Substituting the above expressions for real marginal cost and the equilibrium markup in to (3.11) yields an expression for inflation in an open economy:

$$\pi_t = \alpha_0 + \beta E_{t-1}\pi_{t+1} + \alpha_{11}E_{t-1}(y_t - y_t^*) + \alpha_{12}E_{t-1}(imp_t + \Delta(p_t^{imp} - p_t))$$
$$+\alpha_1 E_{t-1}s_{Lt} + \alpha_{13}E_{t-1}(p_{mt} - p_t) - \alpha_2\beta E_{t-1}\beta\Delta n_{t+1} + \alpha_2 E_{t-1}\Delta n_t + v_t \tag{3.16}$$

where v_t is an innovation in inflation. This equation provides the specification for our baseline econometric model. Similarly, the equation in the first-difference of inflation can be written as:

$$\begin{aligned}\Delta\pi_t &= \alpha_0' + \beta' E_{t-1}\Delta\pi_{t+1} + \alpha_{11}E_{t-1}(y_t - y_t^*) + \alpha_{12}E_{t-1}(imp_t + \Delta(p_t^{imp} - p_t)) \\ &\quad +\alpha_1 E_{t-1}s_{Lt} + \alpha_{13}E_{t-1}(p_{mt} - p_t) - \alpha_2\beta E_{t-1}\beta\Delta n_{t+1} \\ &\quad +\alpha_2 E_{t-1}\Delta n_t + v_t\end{aligned} \tag{3.17}$$

Rewriting in terms of the level of current inflation provides the specification for our "hybrid" econometric model:

$$\begin{aligned}\pi_t &= \alpha_0' + \beta' E_{t-1}\pi_{t+1} + (1-\beta')\pi_{t-1} + \alpha_1' E_{t-1}r_t + \alpha_{11}' E_{t-1}(y_t - y_t^*) \\ &\quad +\alpha_{12}' E_{t-1}(imp_t + \Delta(p_t^{imp} - p_t) \ + \alpha_1' E_{t-1}s_{Lt} + \alpha_{13}' E_{t-1}(p_{mt} - p_t) \\ &\quad -\alpha_2'\beta E_{t-1}\beta\Delta n_{t+1} + \alpha_2' E_{t-1}\Delta n_t + \widehat{v}_t\end{aligned} \tag{3.18}$$

where $\alpha' = \alpha/(1+\beta), \beta' = \beta/(1+\beta)$ and $\widehat{v}_t = v_t + \beta(\pi_t - E_{t-1}\pi_t)$.

3.3 Data

Our baseline and hybrid specifications of the open-economy NKPC require the estimation of a large number of parameters in comparison to the closed-economy models used in much of the literature. Fuhrer et al (1995) show that General Method of Moments (GMM) estimators can be subject to small-sample bias and Rudd and Whelan (2005) argue that it is this bias that generates the finding of dominant forward-looking behaviour in some empirical studies of the NKPC. The sample size will therefore be important in reducing any potential bias. The longest period for which quarterly data are available for all of the variables in our econometric model is 1980 Q1 to 2010 Q4 and we obtain this data for twelve countries: Australia, Canada, Finland, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, United Kingdom and United States.[48]

Our baseline and hybrid models of the open-economy New Keynesian Phillips curve closely follow those estimated by Batini et al (2000, 2005) for the United Kingdom. However, data availability dictates that we use the first-difference in the (log) quarterly GDP deflator as our measure of inflation, rather than the deflator for Gross Value Added. The GDP deflator for each country is taken from the OECD's Economic Outlook database.

First, our measure of real marginal cost is the labour share, s_t, which is adjusted to include the labour income of the self-employed in the total labour compensation (see Gollin (2002)).[49] The variable driving inflation therefore is the deviation of the labour share from its steady-state value. Data on the compensation of employees are taken from Economic Outlook. Pre-unification data for Germany are sourced from the Statistisches Bundesamt's Fachseries 18. From Figures 3.1 and 3.2, it appears that this measure of the labour share has fluctuated around a constant mean in some countries, but has exhibited a downward trend

[48] The sample period for Spain actually ends in 2009 Q3 but we assume that the slightly smaller sample size will have a negligible effect on parameter estimates relative to the other countries. The next largest sample period begins in 1990 Q1 and this data is available for a further six countries. We did estimate the baseline and hybrid models for these countries but found that the parameter estimates were very sensitive to changes in the instrument set. This is also the case if we estimate the models for our sample of twelve countries over this shorter period, but not when they are estimated using the longer period. Therefore, we confine our study to those countries for which data for the longer sample period is available.

[49] The adjustment of the labour share to take account of self-employment can be made either in the numerator by including the labour income of the self-employed or in the denominator by subtracting the amount of value added contributed by the self-employed. In addition, Batini et al (2000) argue that it is the labour share in the market sector of the economy that is the appropriate measure of inflationary pressure. Therefore, we use the labour share in the non-farm business sector from the Bureau of Labour Statistics for the United States and we follow the methodology of Batini et al (2000) for the United Kingdom and calculate the adjusted labour share of the market sector of the economy. Due to the lack of data on the government's capital income, this adjustment could not be made for the other countries.

in others. These labour shares are detrended to allow for time-variation in the mean of the series.[50]

We make several adjustments to the real marginal cost variable driving inflation. First, we capture the particular importance of oil prices and their associated volatility by including the change in the real price of oil, Δoil_t as a variable in the econometric model. The dollar price of crude oil is obtained from the IMF's International Financial Statistics and is deflated by the US GDP deflator to obtain the real price of oil. Second, the relative price of material imports, $p_m - p_t$, is measured by the relative price of commodity imports. However, the latter was dropped from our econometric model as it was statistically insignificant when included with the change in the real price of oil. Finally, we allow for employment adjustment costs due to labour market rigidities via the term $(\Delta n_t - \Delta n_{t+1})$, where Δn_t is the change in log of total employment. Data on total employment, which includes both employees and those in self-employment, are also taken from the Economic Outlook database.

Our model allows for variations in the equilibrium or "desired" markup due to foreign competition, the business cycle and deregulation. We measure the extent of foreign competition, Com_t, as the interaction between the share of imports in domestic spending and the change in the real price of imports, $Rpm_t = \Delta(p_t^{imp} - p_t)$. The downward pressure on the desired markup of domestic firms arising from a fall in the relative price of imports, will be greater the higher the level of import penetration. We use the output gap, $gap_t = y_t - y^*$, to capture the business cycle, which reflects the deviation of real GDP from its potential level. The level of import penetration, the relative price of non-commodity imports and the output gap are sourced from the Economic Outlook database. As the quarterly output gap series is not available for Spain, we construct a measure of the gap as the deviation of real GDP from a quadratic trend.

50 Clearly, one way of dealing with the time-varying mean is to use a Hodrick-Prescott filter to estimate the underlying trend. However, there are potentially serious econometric problems associated with using H-P filtered variables when the model is estimated by GMM due to the filter incorporating future information when estimating the trend (see Rudd and Whelan (2007)). In any case, the labour share in each of these countries is stationary after linear detrending, as indicated by the results from Dickey-Fuller tests.

Finally, we augment the baseline and hybrid models with a "global" driving variable. Our measure of global real marginal cost, s_t^{trade} is the adjusted labour share in each country's ten largest trading partners in any year, weighted by their share of the economy's total trade. The bilateral trade data are taken from the OECD's Monthly Statistics of International Trade and data on the total compensation of employees, number of employees and total employment are from, where available, the Economic Outlook database, or otherwise, from national sources.

3.4 Econometric Results

Our estimating equations (3.16) and (3.18), contain expectation terms which are likely to be correlated with the error term. Let Z_t be a vector of variables at time t. If we assume that agents have rational expectations, then the error in the forecast of π_{t+1}, or the inflation "surprise" in period t+1, will be uncorrelated with information dated time t. This implies a set of orthogonality conditions for both of our estimating equations such that:

$$E_t[\pi_t - \alpha_0 - \beta\pi_{t+1} - \alpha_{11}(y_t - y_t^*) - \alpha_{12}(imp_t + \Delta(p_t^{imp} - p_t)) - \alpha_1 s_{Lt} \\ - \alpha_{13}(p_{mt} - p_t) + \alpha_2\beta\Delta n_{t+1} - \alpha_2\Delta n_t]Z_t = 0 \tag{3.19}$$

$$E_t[\pi_t - \alpha_0' - \beta'\pi_{t+1} - (1-\beta')\pi_{t-1} - \alpha_{11}'(y_t - y_t^*) - \alpha_{12}'(imp_t + \Delta(p_t^{imp} - p_t)) \\ -\alpha_1' s_{Lt} - \alpha_{13}'(p_{mt} - p_t) + \alpha_2'\beta\Delta n_{t+1} - \alpha_2'\Delta n_t]Z_t = 0 \tag{3.20}$$

where Z_t is a vector of instruments dated $t-1$ or earlier. We use the Generalised Method of Moments (GMM) estimator to estimate these equations and use lags of the variables as instruments.[51] The instrument set for each country is listed in Table 3.1. In addition to

[51] As mentioned in the previous section, the inclusion of too many instruments can result in estimation bias in small samples. We follow Gali et al (2001) and try to minimise the number of instrument lags chosen. Kleibergen and Mavroeidis (2009) suggest that this is necessary in order to avoid the "many instruments" problem which biases GMM estimates in the direction of Ordinary Least Squares. We use the Kleibergen-Papp (2006) test for weak instruments to select the appropriate number of instruments. However, the number of lags chosen for the domestic labour share, trade-weighted labour share, and the idiosyncratic and common components are the same within each country. It should also be noted that it is possible that some of the independent variables are subject to measurement error. We assume that this error is uncorrelated with past information so that lagged variables are still valid instruments.

lags of the independent variables, we also include lags of per capita wages, calculated as the log of total compensation minus the log of employment. We use the Newey-West (1987) heteroskedasticity and autocorrelation consistent (HAC) covariance matrix, weighted using the Bartlett kernel, and a fixed bandwidth of four.[52]

3.4.1 Baseline and Hybrid Models

Figures 3.1 and 3.2 plot the domestic labour share (left axis) and inflation (right axis) in our sample of countries since 1980. It appears that the labour share tends to lead inflation in Australia, Canada and Finland and to some extent in Italy, whereas inflation appears to lead the labour share in France and Germany. The two series exhibit less obvious comovement in the other countries, although there are periods when the relation does strengthen.

Table 3.2 presents the results from the estimation of the baseline open-economy NKPC, as specified by equation (3.16). The coefficients are broadly consistent with our theoretical framework. Expected inflation is significant in all countries and inflation appears to be predominantly forward-looking in all countries. It also appears that the labour share is an important driver of inflation with a strongly significant coefficient and the expected sign in all but two countries, Canada and Finland.[53] The coefficients on the labour share are small, a finding consistent with much of the NKPC literature. They suggest that a 1 percent increase in gap between the labour share and its steady state value in the United States will lead to an approximate 0.01 percentage point increase in inflation.

There is considerable heterogeneity in the impact of international competition on domestic price-setting. An increase in relative non-commodity import prices is associated with higher inflation in Australia, Canada, Finland, Italy, Japan and Sweden but with lower inflation in Germany and Spain. The latter finding may reflect the importance of imported

[52] The kernel weights the covariances so that the weighting matrix is positive semi-definite. The bandwidth q, determines how the weights from the kernel change with the lags in the estimation of the weighting matrix and is given by q =integer[$4(T/100)^{2/9}$], where T is the number of observations.

[53] The labour share version of the NKPC is a poor fit for Canadian inflation with the coefficient on the labour share generally being insignificant in these models (see Nason and Smith (2008)).

intermediate goods in domestic production. A larger share of imports in domestic spending is also associated with lower inflation in Finland, France, Germany, Italy, Japan, Spain, Sweden and the UK, which suggests that import competition is affecting desired markups in these countries. The interaction term between relative non-commodity import prices and import penetration is negative and significant in half of the countries but positive and significant in the US. This implies that the impact of higher relative import prices on domestic inflation tends to be lower the greater the level of import competition in the economy and thus suggests that the pass-through of higher relative prices of imported intermediate goods will also be lower in these economies.

The output gap, gap_t, is statistically significant in most countries and suggests that desired markups do vary with the business cycle. The sign of the coefficient may reflect the nature of competition in these countries. The coefficient is negative in six countries and suggests that "price wars" may break out in periods of rising excess demand. The positive coefficient for France, Germany, the Netherlands and Spain indicates that the "customer market" model may be a better description of the cyclical behaviour of the desired markup in these countries.

Changes in real oil prices appear to be important determinants of inflation in half of the countries. We find that the coefficient is positive and significant for Germany, Spain and the US but negative and significant in France, Netherlands and Sweden. Clearly, a country's net oil balance will be important in determining the sign of the coefficient. However, as the role of oil price shocks is not the primary focus of this chapter, and given the problem of the small sample bias of the GMM estimator, we do not include the oil balance in our econometric model.

Finally, we find evidence that employment adjustment costs are important sources of rigidity in some countries. The employment terms Δn_{t+1} and Δn_t have the expected sign and are statistically significant in Australia, and France. There is some evidence that they may also be important in Spain, although only one of the coefficients is strongly significant. The evidence for the United States is weak and is consistent with the view that labour markets there are relatively flexible. The coefficients for the other countries are either insignificant or negatively signed, suggesting that either employment costs do not matter for pricing decisions, or they are not being properly captured by our particular specification.

Table 3.2 also contains information related to the suitability of the instruments used in the GMM estimation and to the overall fit of the model. The Kleibergen-Paap statistic corresponds to the Cragg-Donald test for weak instruments when errors are not Gaussian.[54] In all cases, the value of the F statistic exceeded the 10 percent Stock-Yogo critical value (see Stock and Yogo (2002)).[55] The NKPC has been criticised for not closely fitting inflation dynamics relative to the accelerationist model or a simple univariate model in inflation (Rudd and Whelan (2007)). However, the baseline open-economy NKPC fits inflation quite well in a number of countries, as reflected in the value of the adjusted R-squared. It is only in Finland and the UK that its performance is relatively poor.

Table 3.3 presents the results of the "hybrid" inflation specification given by equation (3.18), in which we model the costs of price adjustment so that there is long-run neutrality between real and nominal variables. Inflation has a significant backward-looking component in all countries except Germany and Spain but the size of the coefficients suggests that it is quantitatively modest.[56] However, lagged inflation does significantly improve the statistical fit of the open-economy NKPC in most countries, as measured by the adjusted R-squared. The inclusion of the lagged inflation term appears to have heterogenous effects on the other variables and across countries. The most obvious effect is the decline in the expected inflation coefficient. This suggests that inflation expectations are partly backward-looking. This finding could also be a result of instrumenting expected inflation with lagged inflation and

[54] The null hypothesis of the Kleibergen-Paap test for weak identification is that the model is weakly identified. A rule of thumb recommended by Stock and Staiger (1997) is that a value of F greater than 10 would indicate that the null hypothesis can be rejected.

[55] We do not present the results of the Hansen J of overidentifying restrictions as the lowest p-value was 0.4 and so instrument validity was never close to being rejected.

[56] A Wald test of the restriction that the expected inflation and lagged inflation coefficients sum to unity was rejected for all countries except Canada.

therefore including the latter as an explanatory variable directly in the hybrid model will absorb some of the variance that had been attributed to expected inflation.

The lagged inflation variable also captures some of the persistence of the openness variables. Relative import prices are now insignificant in Finland and Germany and import penetration is insignificant in France. However, the latter is now significant in Australia while the interaction variable is significant in Sweden. The coefficients on the labour share and the output are broadly robust to the inclusion of lagged inflation. There is also stronger evidence that employment adjustment costs are important sources of rigidity in Spain and the United Kingdom, but weaker evidence of their importance in Australia.

Our results also suggest that there is considerable heterogeneity in the impact of openness on inflation across countries, as measured by changes in relative import prices, import penetration and the interaction of these variables. However, the strength of this impact depends on whether we adopt the purely forward-looking specification of the NKPC for modelling inflation dynamics or whether we allow for a backward-looking component in price-setting. In the next subsection, we augment both specifications of the open-economy NKPC to incorporate another potential dimension of openness identified by Borio and Filardo (2007).

3.4.2 Foreign Real Marginal Cost and the NKPC

We now examine whether a measure of foreign real marginal cost provides additional explanatory power in the context of the open-economy NKPC. In this sense, we are testing Borio and Filardo's "globe-centric" or "global slack" view of inflation determination, in which foreign capacity constraints need to be modelled directly as the conventional method of modelling openness does not fully capture the influence of foreign excess demand on domestic inflation. Our model allows openness to affect inflation directly via changes in import and oil prices, and indirectly via the impact of import penetration on the desired markup. However, Borio and Filardo (2007) argue that such models are too country-specific and do not adequately reflect the global fragmentation of production. Moreover, they argue that these models are misspecified, as product and factor prices are increasingly determined by global, rather than domestic supply constraints.

However, Woodford (2009) shows that it is difficult to reconcile the canonical New Keynesian model with the global slack hypothesis. In that model, foreign marginal cost will only affect inflation via domestic marginal cost and only then under certain assumptions about international factor mobility. It could be argued that Woodford's model does not fully incorporate all aspects of this hypothesis. As we have discussed, one of the most important elements of the globe-centric view of inflation is that global competition will affect wage and price markups. Both of these are assumed to be constant in Woodford's model. Therefore, an empirical investigation of this view might point to other important channels through which openness could affect domestic inflation in the New Keynesian model.

We test the global-slack hypothesis by augmenting our baseline and hybrid models with a measure of "foreign" marginal cost:

$$\begin{aligned}\pi_t &= \alpha_0 + \beta E_{t-1}\pi_{t+1} + \alpha_{11}E_{t-1}(y_t - y_t^*) + \alpha_{12}E_{t-1}(imp_t + \Delta(p_t^{imp} - p_t)) \\ &\quad + \alpha_1 E_{t-1}s_{Lt} + \alpha_{13}E_{t-1}(p_{mt} - p_t) - \alpha_2\beta E_{t-1}\beta\Delta n_{t+1} \\ &\quad + \alpha_2 E_{t-1}\Delta n_t + \alpha_3 s_{Lt}^* + v_t \qquad (3.21)\end{aligned}$$

where s_{Lt}^* is foreign marginal cost. We make a similar modification to the hybrid model. Here, we assume that an economy's exposure to foreign inflationary pressures is via the trade channel and therefore we construct a measure of foreign marginal cost as the trade-weighted average of adjusted labour shares in each of our sample country's ten largest trading partners.[57] As discussed in Borio and Filardo (2007), the structure of the weight is intended

[57] The trade weights are updated quarterly. We have also estimated the models using the import share as the weighting variable and also using the fifteen largest trading partners to calculate foreign marginal cost. However, in some cases, it was not possible to calculate labour shares for all of the fifteen trading partners due to a lack of data, particularly for the early part of the sample period. In any case, neither of these adjustments led to significantly different results. Of course, one clear limitation of the weighting scheme we employ is that it does not capture potential third market effects.

to capture the effect of foreign excess demand on the pricing of tradable goods, the possible strategic complementarity in the pricing decisions of firms and wage demands of workers in domestic import-competing industries.

Figures 3.3 and 3.4 plot the evolution of the trade-weighted labour share and inflation since 1980. The trade-weighted labour share does appear to lead inflation in Australia and possibly, the United States, but the converse is the case in Canada, Finland, and Germany. The relation appears to be weak in the other countries as one of the series is more volatile than the other, although there are periods in which there is considerable comovement.

Table 3.4 presents the results of the baseline model augmented with the trade-weighted labour share, s_t^{trade}. We find that this measure of foreign marginal cost is positive and significant in ten of the twelve countries in our sample. We should also note that the trade-weighted labour share is positive and significant for both Canada and Finland, the two countries for which the domestic labour share coefficient is negative. Although the labour share version of the NKPC appears to provide a poor framework for analysing the domestic driver of domestic inflation in those countries, these results do suggest that the labour shares in the country's trading partners provide a channel for international factors to drive domestic inflation.

In addition, this measure of foreign marginal cost is not simply absorbing the explanatory power of the other openness variables, particularly that of relative import prices. The interaction variable is significant in nine countries. These findings suggest that our measure of foreign marginal cost affects domestic inflation via a different channel than the traditional channel of import competition and that this additional openness variable represents an independent source of variation in inflation.

The concept of a "global output gap", as outlined in Borio and Filardo (2007), is intended to capture strategic complementarities in wage- and price-setting. Our model tries to capture the latter via the inclusion of the interaction between relative import prices and import penetration. The trade-weighted labour share may therefore capture the impact of globalisation on domestic wage-setting and particularly its effect on the elasticity of a firm's marginal cost with respect to its output. This wage-setting complementarity may result in lower wage-markups and to greater moderation in wage demands.

Table 3.5 reports the results from the hybrid specification, which is now augmented to include the trade-weighted labour share. The main effect of introducing lagged inflation as an additional explanatory variable is to make the weakly significant trade-weighted labour share in France, the relative import price coefficient in Finland, and the interaction variable in Canada insignificant. However, the import penetration coefficient in Australia is now statistically significant. The effect on the other variables of including lagged inflation is broadly similar to that found in the last subsection.

In conclusion, our results provide some evidence for the Borio and Filardo (2007) hypothesis that inflation models should include measures of global, rather than purely domestic, excess demand. They also provide motivation for building a structural model that incorporates a role for foreign marginal cost so that we can be more specific about the channel through which it affects domestic inflation. However, it is important to note, that the additional explanatory power resulting from the inclusion of the trade-weighted labour share in the NKPC, is very small. The median increase in the adjusted R-squared is approximately three percent. In summary, although our measure of global marginal cost is a statistically significant determinant of inflation in most of the countries in our sample, its impact on inflation is quantitatively small.

3.4.3 Idiosyncratic and Common Components of the Labour Share

We now consider a statistical alternative to our measure of "global" real marginal cost that decomposes the labour share into idiosyncratic (domestic) and common (global) components. The advantage of this approach is that it allows global shocks to affect inflation indirectly through domestic supply and demand conditions and thereby allows global forces to affect domestic real marginal costs.

Woodford (2009) shows that it is possible to extend the canonical New Keynesian model to allow domestic marginal costs to be influenced directly by changes in foreign marginal costs only if there is global trade in the factors of production. For example, if we assume a global homogenous labour market, then the marginal cost of production (in units of a global consumption good) will depend on the wage level in the global labour market. Therefore, domestic marginal costs will respond to changes in global marginal cost that result from higher global output, although productivity differentials and the terms of trade will drive a wedge between the two in terms of units of the domestic good. However, given that labour is not fully internationally mobile, domestic marginal costs will be driven by a combination of domestic and global factors. Our statistical decomposition allows us to distinguish between movements in domestic marginal costs that are purely due to domestic factors and those that have a global origin.

It should be noted that one important feature of factor models is that the estimated common and idiosyncratic components of marginal costs are orthogonal so that any multicollinearity problem associated with using measures of domestic and foreign supply constraints is reduced. We obtain the common and idiosyncratic components of the labour share by a factor analysis of the form:[58]

$$s_{it} = s_t^{cc} + s_{it}^{ic} = \lambda_i' \mathrm{f}_t + s_{it}^{ic}$$

where s_{it} is the labour share in country i at time t, f_t is an $r \times 1$ vector of common factors, λ_i is an $r \times 1$ vector of factor loadings, and s_t^{cc} and s_{it}^{ic} are the common and idiosyncratic components of the labour share, respectively. The common factors of $s_t = [s_{1t}......s_{Nt}]$ are the first r principal components of SS', where $S = [s_t....s_T]'$. The matrix of estimated

58 Eickmeier and Pijnenburg (2013) perform a similar decomposition of the output gap in 24 OECD countries into idiosyncratic and common components.

factors is therefore $\widehat{\mathrm{f}} = \sqrt{T}v$, where T is the number of observations, v is the $T \times r$ matrix of eigenvectors corresponding to the first r eigenvalues of SS'. The estimated $r \times N$ matrix of factor loadings $\widehat{\lambda}_i = [\widehat{\lambda}_{1i}....\widehat{\lambda}_{ri}]$ is given by $\widehat{\mathrm{f}}'S/T$. Therefore, the estimated common component of the labour share is the product of the estimated matrix of factors multiplied by the corresponding factor loadings, $\widehat{s^{cc}} = \widehat{\lambda}_i'\widehat{\mathrm{f}}_i$. We obtain estimates of the idiosyncratic components from $\widehat{s_i^{ic}} = s_{it} - \widehat{s^{cc}}$ and then replace s_t^{cc} and s_{it}^{ic} with these estimates.

Bai and Ng (2002) suggest formal information criteria for determining r, the number of common factors. However, these criteria require a large panel (N>40) in order for the factors to be estimated consistently. As there are only twelve countries in our sample, we use a more informal criterion to determine the number of factors (see Eickmeier and Pijnenburg (2013)). We therefore focus on the share of variance explained by the first r factors. Table 3.6 reports the share of the variance of the domestic labour share explained by each of the first five factors. It is clear that the first three factors explain most of the common variation in the labour share while the fourth and fifth factors are only of very marginal importance. We therefore focus on the first three factors and obtain the idiosyncratic components as the residuals from a regression of the labour shares on the first three factors. It is also clear that the importance of each factor varies considerably across countries and that no factor is dominant across countries. This suggests quite considerable heterogeneity in the dynamics of the labour share in our sample of countries and therefore that the effect of the common labour share component on inflation will also be heterogenous.

The baseline specification of the open-economy NKPC now has the following form:

$$\begin{aligned}\pi_t &= \alpha_0 + \beta E_{t-1}\pi_{t+1} + \alpha_{11}E_{t-1}(y_t - y_t^*) + \alpha_{12}E_{t-1}(imp + \Delta(p_t^{imp} - p_t)) \\ &\quad + \alpha_{13}E_{t-1}(p_{mt} - p_t) + \alpha_{14}E_{t-1}s_t^{ic} + \alpha_{15}E_{t-1}s_t^{cc} \\ &\quad + \alpha_2 E_{t-1}\Delta n_t - \alpha_2\beta E_{t-1}\beta\Delta n_{t+1} + v_t \qquad (3.22)\end{aligned}$$

where s_t^{ic} and s_t^{cc} are, respectively, the idiosyncratic and common components defined above.

We also estimate the hybrid model with these labour share components.

Table 3.7 presents the results of the baseline open-economy NKPC where the labour share, s_{it}, is replaced by the estimates of the common and idiosyncratic labour share components, $\widehat{s_i^{ic}}$ and $\widehat{s^{cc}}$, respectively. The idiosyncratic component of the labour share is significant for all of the countries in the sample but the coefficient is still negative for Canada and Finland. The common component is significant in all countries except Spain, although again it is negative for Finland. This contrasts with our finding of a positive coefficient for the trade-weighted labour share in the last section, even though the trade-weighted labour share and the common component of the labour share are both approximate measures of inflationary pressures from global excess demand. The main difference between the measures is that we use the negatively signed domestic labour share to estimate the global component but this is obviously not included in the construction of the trade-weighted labour share. However, the idiosyncratic components coefficient is also negative for Canada while the common component coefficient is positive. Therefore, it appears that the labour share is an inappropriate proxy for marginal cost in Finland as the coefficients on both of the components are negative.

It is clear that the common component of the labour share has a positive and significant effect on inflation in the other countries in our sample. In general, the factoring of the labour share does not change the significance of the other openness variables. For Germany the weakly significant coefficients on relative import prices and import penetration are now insignificant, as is the import penetration coefficient in the UK. However, the effect of import penetration is now significant for Australia and Sweden, while the coefficient on the interaction variable is now also significant in Australia.

Finally, Table 3.8 presents the results of the hybrid model with the idiosyncratic and common components of the labour share. When we include lagged inflation, we find that the coefficients on import penetration in Spain and relative import prices in France are now significant. In addition, relative import prices are now insignificant in Finland, as is the interaction variable in Japan. In general however, our results are robust to the inclusion of lagged inflation.

As the variance of the domestic labour share does not change with factoring, we would expect to see little change in the overall statistical fit of the model. This is broadly confirmed by comparing the adjusted R-squared in Table 3.2 and Table 3.7. However, our contribution in this section is not to isolate another independent source of variation in inflation, but rather to show that an existing source of variation has both global and domestic components. Moreover, the impact of the global component is independent of that of the other variables that have traditionally been used to capture the effect of openness on domestic inflation such as import penetration and changes in relative import and oil prices. Our findings contrast with those of Milani (2010) who finds that the trade-weighted output gap, which is intended to capture the increase in domestic marginal costs due to higher foreign marginal costs, is statistically insignificant when included in the NKPC for G7 countries. We would argue that this is because empirical estimates of the output gap are, relative to the labour share, poor approximations of real marginal cost.

Finally, our findings suggest that the driving variable used in the empirical testing of both the output gap and labour share versions of the NKPC may need to be further refined. This is particularly well illustrated by the case of Canada, where the negative coefficient on the domestic labour share can be decomposed into a common component with a positive coefficient and an idiosyncratic component with a negative coefficient.

3.5 Time Variation in the Labour Share Coefficients

We now investigate whether the importance of global real marginal cost has been increasing over time and whether the importance of domestic marginal cost has declined. One of the key findings of Borio and Filardo (2007) is that the coefficient on domestic slack (the domestic output gap) in the accelerationist Phillips curve model appears to have fallen over time, whereas the coefficient on foreign slack (the trade-weighted output gap) appears to have been increasing since the late 1990s.[59] However, it is unclear a priori, how the domestic output gap coefficient in the accelerationist model should change due to globalisation. For example, greater competition could reduce the pass-through of changes in marginal cost and therefore lead to a flatter Phillips curve. However, greater competition could also make prices more flexible and, in the limit, lead to a vertical Phillips curve.[60]

In the context of the open-economy NKPC, Rumler (2007) suggests that openness reduces the degree of price rigidity as firms import intermediate goods from volatile international markets. However, to the extent that there is substitutability between domestically and foreign produced intermediate goods, openness may similarly mitigate the need for firms to raise prices in response to an increase in the price of the domestic goods.

In our model, the sensitivity of inflation to real marginal cost is decreasing in the degree of price rigidity, given by the price adjustment costs parameter, b_p. If globalisation increases the contestability of product markets, then any deviation of a firm's price from that of its competitors will become increasingly costly in terms of lost market share. This would correspond to a decrease in b_p and an increase in the sensitivity of inflation to domestic marginal cost. It is also possible that globalisation could have the opposite effect on the frequency of price adjustment. For example, if greater openness reduces both the level and volatility of inflation, firms might choose to reset prices less frequently and this would lead to a reduction in the sensitivity of inflation to domestic marginal cost. Conversely, the sensitivity of inflation to foreign marginal cost would be expected to increase as the share of tradable output increases, product and factor markets become more contestable and strategic pricing complementarities become more important.

Figures 3.5 and 3.6 plot the evolution of the domestic labour share and trade-weighted

59 The hypothesis that globalisation is responsible for the falling coefficient on the domestic output gap is supported by Ball (2006) and IMF (2006) but no such evidence is found by Ihrig et al (2007) and Mody and Ohnsorge (2007). The results from these studies are obtained from a panel regression using the accelerationist Phillips curve specification and the output gap as the measure of excess demand and so a direct comparison with our results is not possible.

60 There is considerable sectoral evidence linking import penetration with a higher frequency of price adjustment. See, for example, Alvarez et al (2006) and Alvarez and Hernando (2006).

labour share coefficients using a 17-year rolling window.[61] Clearly, estimating these models with such a small sample size is potentially subject to econometric bias and therefore these results are merely illustrative. In any case, we do find significant cross-country heterogeneity in the behaviour of both the domestic and foreign labour share coefficients over time. The domestic labour share coefficient has exhibited the largest decline in Australia, Germany and the United States and there is evidence that the coefficient has also fallen in Italy and the United Kingdom in recent years.

Clearly, globalisation is not the only factor that might explain this decline. The implementation of a more credible monetary policy may lead firms to perceive any increase in inflation as temporary and therefore, they may choose to reset prices less often. In addition, the introduction of the single currency would have increased price transparency in euro area countries, and therefore, by increasing competition, could be expected to have restricted firms' ability to increase prices in response to increases in marginal cost. Although our model tries to capture the effect of foreign competition on the elasticity of demand by including the change in import penetration, this would represent an additional competition channel that would affect euro area countries only.

The domestic labour share coefficient does not display an obvious pattern in the other countries in the sample, although it does appear to be fluctuating around a slight upward trend in Sweden. In general, there is mixed evidence that inflation has become less responsive to changes in domestic marginal cost, as measured by changes in the labour share. The other question is whether the coefficient on the trade-weighted labour share has increased and therefore whether domestic inflation has become more sensitive to changes in foreign marginal cost. There is strong evidence that the coefficient is increasing in Australia, United Kingdom and United States and some evidence that it is increasing in Italy. However, for

[61] The choice of 17 years as the size of the rolling window is based on Borio and Filardo's (2008) finding that the coefficient on the foreign output gap began to change significantly in the late 1990s. There is a tradeoff between increasing the size of the window to reduce the size of the econometric bias and detecting the period in which the importance of foreign marginal cost may potentially have significantly changed.

the other countries, the coefficient has either exhibited remarkable stability as in Spain or Sweden, or has fluctuated quite considerably so that no trend is discernible.

In summary, we find considerable cross-country heterogeneity in the evolution of the coefficient on both the domestic labour share and the trade-weighted labour share. Certainly, our findings are not as striking as those of Borio and Filardo (2007), although the latter were obtained from a panel of countries and using a different econometric framework. Nonetheless, we do confirm that there is a clear trend in the coefficients in some countries. Although, there are several reasons why the coefficient on the domestic labour share might have fallen, it is possible that foreign competition is affecting the price-setting decisions of domestic firms. The upward trend in the trade-weighted labour share coefficient does indicate that labour cost pressures in trading partners are becoming more important to domestic inflation dynamics in some countries. However, as discussed in the previous section, the economic impact of foreign marginal cost on domestic inflation is still relatively small.

3.6 Sensitivity Analysis

In this section we assess the empirical performance of our augmented open-economy NKPC using inflation in consumer prices as the dependent variable. We then consider the "many instruments" problem of GMM estimators in small samples which biases the estimates towards Ordinary Least Squares.

3.6.1 CPI Inflation

The canonical NKPC can be extended to model inflation in consumer prices through the inclusion of the terms of trade (see Gali and Monacelli (2005), Woodford (2009), Mihailov (2011)). In this case, the gap between consumer- and domestic-price inflation is proportional to the change in the terms of trade, with this proportionality depending on the degree of openness. However, the open-economy NKPC that has been used in this chapter already incorporates a role for the price of imports relative to domestic prices through its impact on the price-setting behaviour of domestic firms.[62] Therefore, the impact of globalisation should be even stronger when we consider inflation in consumer prices due to associated terms of trade effects.

Table 3.9 presents the results of the estimation of equation (3.21) with consumer price inflation as the dependent variable.[63] First, the evidence in favour of foreign marginal cost as a driver of consumer price inflation is weaker. As the coefficient on lagged CPI inflation is larger than for domestic price inflation it may be that the former is capturing some persistence in the trade-weighted labour share variable. In general, globalisation does have a significant effect on consumer prices via the terms of trade channel, with relative non-commodity import prices and the interaction with import penetration significant in most countries. The negative coefficient on the interaction variable appears to reflect the impact of import competition on domestic inflation as the coefficient has this sign only in countries in which the coefficient on the import penetration variable is insignificant.

Our results suggest that forward-looking expectations are less dominant for CPI inflation, with the persistence likely arising from the terms of trade channel. However, we do find that the domestic labour share and employment adjustment costs are significant drivers of inflation in most countries. A particularly interesting result is that the coefficients on the domestic labour share are now positive and significant in Canada and Finland. This again suggests that the negative coefficient in the model of domestic inflation has a purely domestic origin, possibly related to the impact of the non-market labour share on the behaviour of the total economy labour share. Finally, it appears that globalisation does not have a differential impact on consumer price inflation dynamics in small open economies relative to those that have larger non-traded sectors.

62 Mihailov (2011) also considers this channel in his empirical analysis of the model outlined in Gali and Monacelli (2005). He suggests that the coefficient on the terms of trade also reflects the pricing behaviour of domestic firms. In addition, if some prices are set according to local currency pricing (rather than producer currency pricing), then the terms of trade coefficient will not simply reflect the importance of imports in domestic spending.

63 We obtain data on CPI inflation rates from the OECD's Main Economic Indicators database.

3.6.2 Ordinary Least Squares

For completeness and to indicate both the possible endogeneity bias from not instrumenting for expected future inflation and the possible small sample bias of the GMM estimator, we use OLS to estimate the baseline models that include the trade-weighted labour share and the idiosyncratic and common components of the labour share. Kleibergen and Mavroeidis (2009) and Newey and Windmeijer (2009) discuss the "many instruments" problem of GMM estimation in small samples, whereby the GMM parameter estimates are biased towards least squares. Kleibergen and Mavroeidis (2009) also discuss how significant size distortion can be present in small samples through the use of the HAC estimator for the optimal weighting matrix.

Tables 3.10 presents the results from the estimation of the baseline model with the trade-weighted labour share. It is clear that OLS tends to underestimate the coefficient on expected future inflation, whereas the size and statistical significance of lagged inflation is consistent with the GMM estimates. Thus our conclusion that inflation expectations are predominantly forward-looking is contingent on the instrumentation of expected future inflation. In addition, the statistical evidence in favour of including the trade-weighted labour share in the open-economy NKPC is weakened by the use of OLS. This is also the case for the other globalisation variables, namely the level of import penetration, the relative price of imports and the interaction of these variables. However, we do find that the domestic labour share is still a significant driver of inflation, suggesting that this serves as a good empirical proxy of domestic real marginal cost.

Table 3.11 shows that the estimates of the importance of expected future inflation are also lower when the baseline model with the labour share components is estimated by OLS. The difference in the estimates is similar to that for the model with the trade-weighted labour share. In addition, the evidence in favour of the idiosyncratic component of the labour share as a significant driver of domestic inflation is weaker. However, the common component continues to be significant in the majority of countries.

In conclusion, the estimation of our baseline models by OLS tends to reduce the importance of forward-looking inflation expectations and globalisation in domestic inflation. An interesting extension of this analysis would be to use survey-based measures of inflation expectations to gauge the extent of the endogeneity bias from not instrumenting for expected inflation or the extent of the small sample bias from using the GMM estimator.

3.7 Conclusion

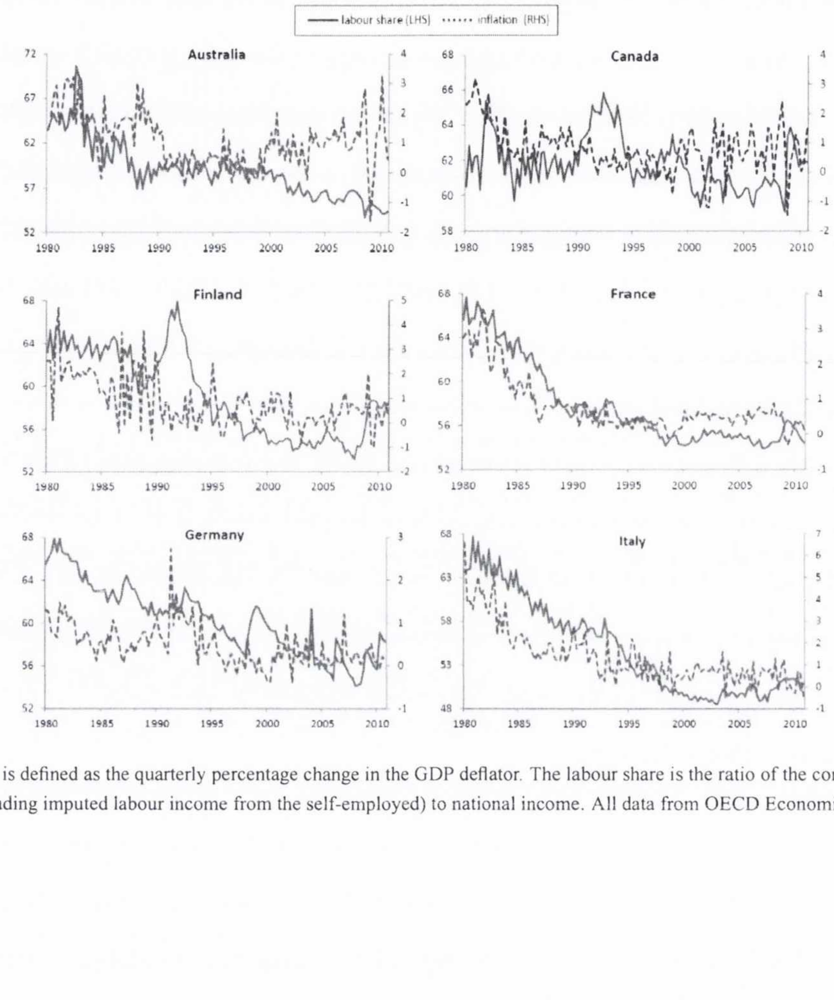
Borio and Filardo (2007) have argued that traditional models of inflation are misspecified as they do not incorporate the influence of global excess demand on domestic inflation. We do not find any evidence that the open-economy NKPC is misspecified, or more specifically, that empirical testing of this model suffers from omitted variable bias. The inclusion of the trade-weighted labour share, our measure of foreign marginal cost, does not generally affect the coefficients on the other variables. In addition, although the trade-weighted labour share has a positive and statistically significant effect on inflation, this effect is economically insignificant. However, we conclude that the trade-weighted labour share represents an independent source of inflation variation and therefore should be incorporated in NKPC models to give a more complete representation of the open-economy dimension of inflation.

Our results complement those from the studies of Monacelli and Sala (2009) and Ciccarelli and Mojon (2010), which find that inflation has a significant global component. We show that the domestic labour share also has a significant global component. To our knowledge, this is an aspect of the driving variable in labour share versions of the NKPC that has not been considered previously. Our results suggest that decomposing the domestic labour share into common and idiosyncratic components may yield greater insight into the "incorrectly" signed labour share coefficient in NKPC models for some countries. In the case of Canada, for example, we found that the negative coefficient on the domestic labour share comprises a negatively signed idiosyncratic component but a positively signed common component.

From a policy perspective, although the trade-weighted labour share coefficient has been increasing in some countries, our findings do not suggest the central bank's reaction function needs to be modified to include a measure of foreign marginal cost. It may instead be more instructive for central banks to monitor fluctuations in the labour share at the global level because of the effect they have on the domestic labour share and therefore, domestic marginal cost. For example, if the integration of product and factor markets continues to accelerate, the global component of domestic marginal cost will become an increasingly important determinant of domestic inflation.

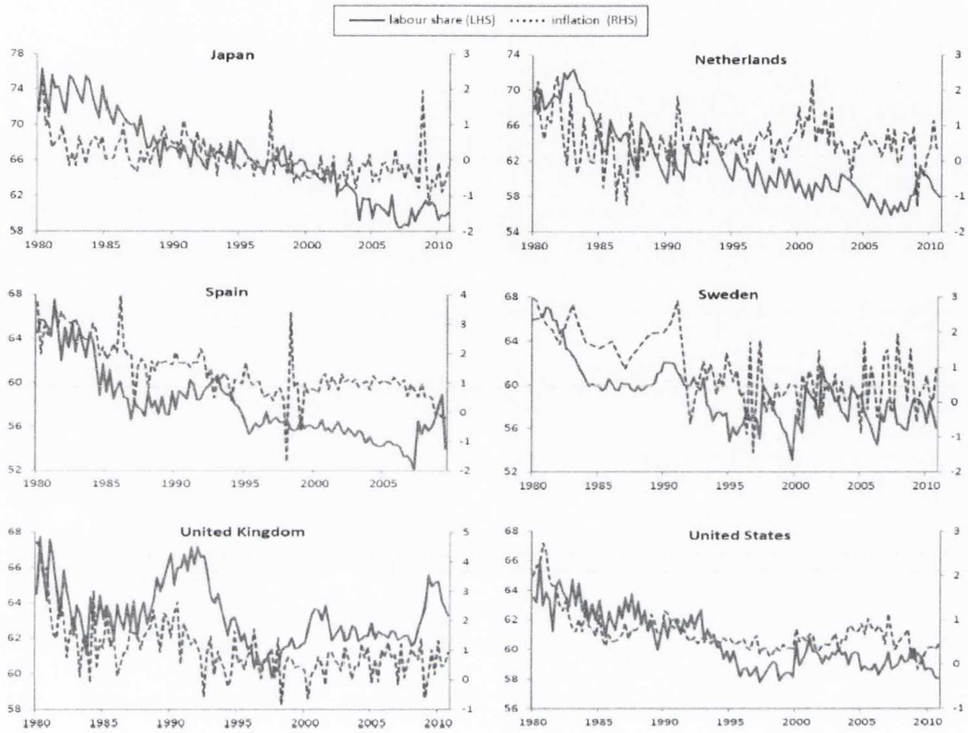
Finally, although not the central focus of our study, our findings also relate to the importance of backward-looking expectations in New Keynesian models. Our results show that a backward-looking component in inflation is statistically significant in all countries except Germany. However, as the coefficient is small relative to that on future expected inflation, these results lend support to the New Keynesian hypothesis that inflation expectations are predominantly forward-looking.

Figure 3.1: Inflation and the Labour Share, selected countries



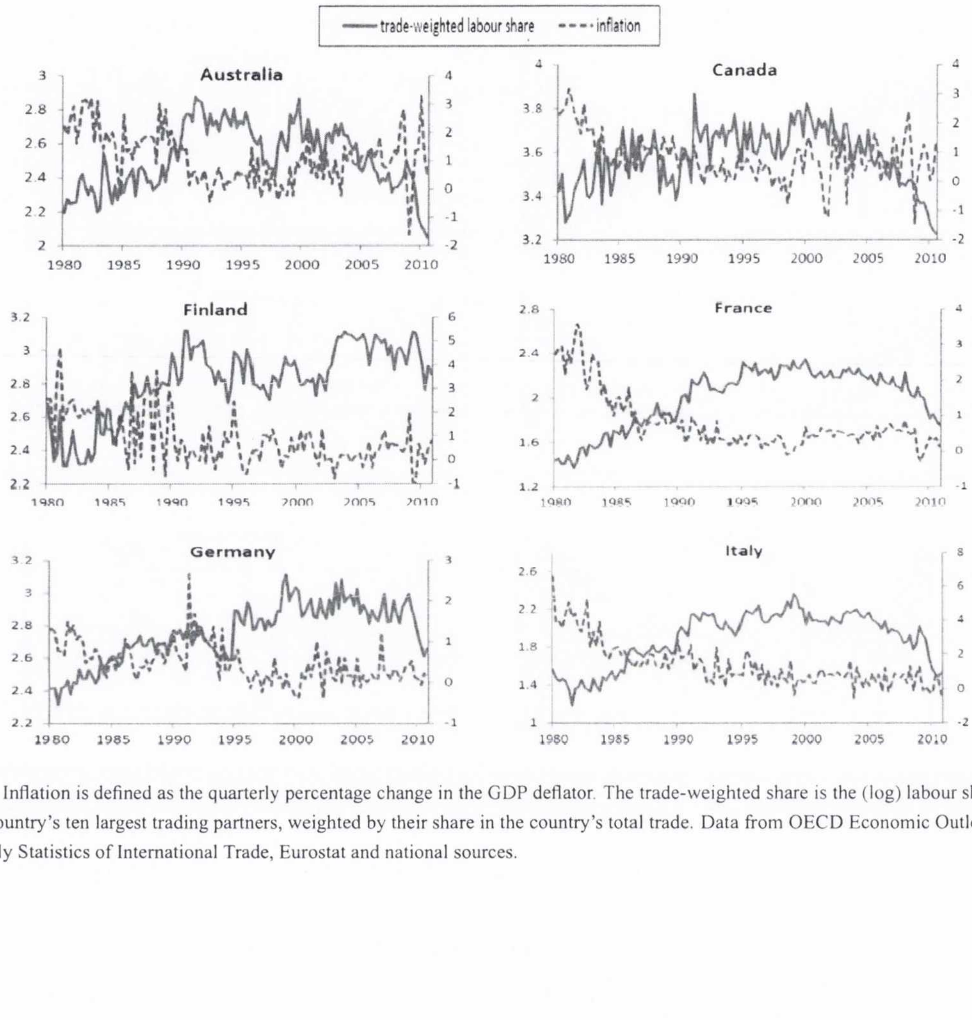
Notes: Inflation is defined as the quarterly percentage change in the GDP deflator. The labour share is the ratio of the compensation of employees (including imputed labour income from the self-employed) to national income. All data from OECD Economic Outlook.

Figure 3.2: Inflation and the Labour Share, selected countries



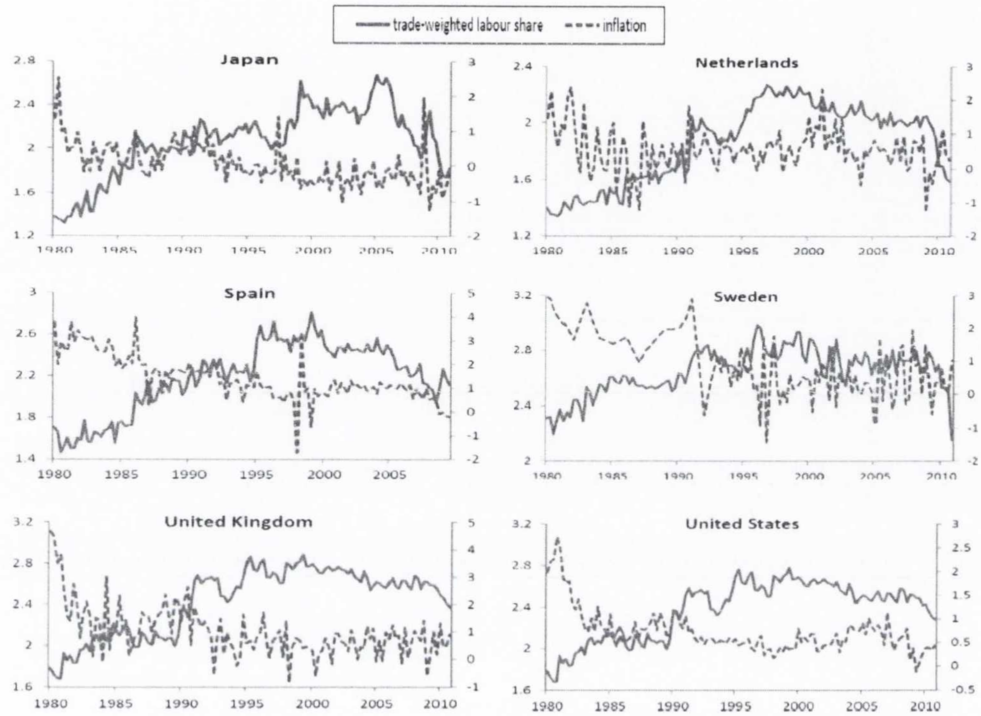
Notes: Inflation is defined as the quarterly percentage change in the GDP deflator. The labour share is the ratio of the compensation of employees (including imputed labour income from the self-employed) to national income. All data from OECD Economic Outlook.

Figure 3.3: Inflation and the trade-weighted Labour Share, selected countries



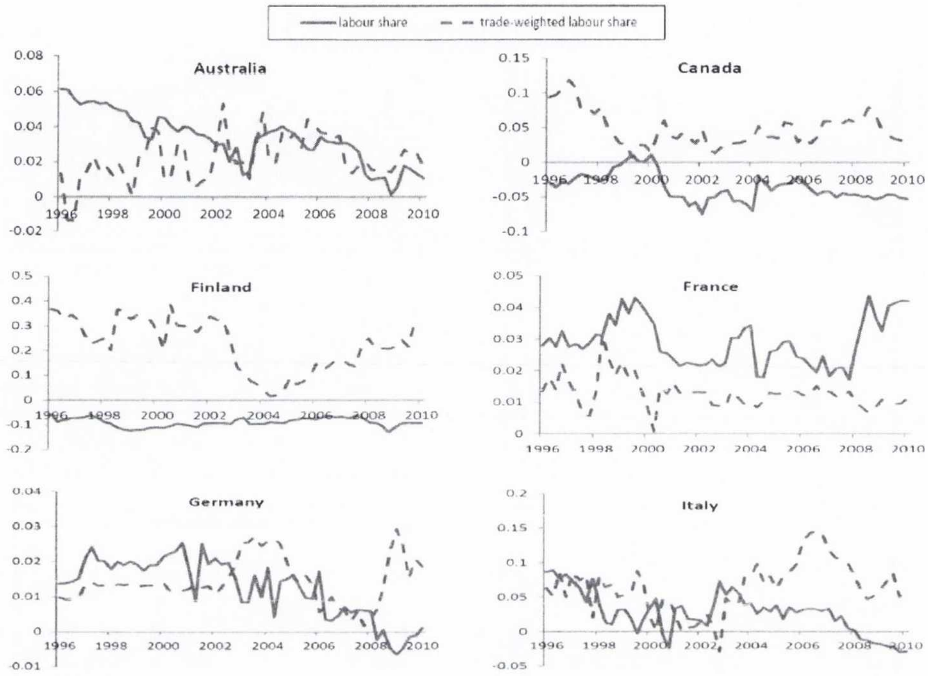
Notes: Inflation is defined as the quarterly percentage change in the GDP deflator. The trade-weighted share is the (log) labour share in each country's ten largest trading partners, weighted by their share in the country's total trade. Data from OECD Economic Outlook and Monthly Statistics of International Trade, Eurostat and national sources.

Figure 3.4: Inflation and the trade-weighted Labour Share, selected countries



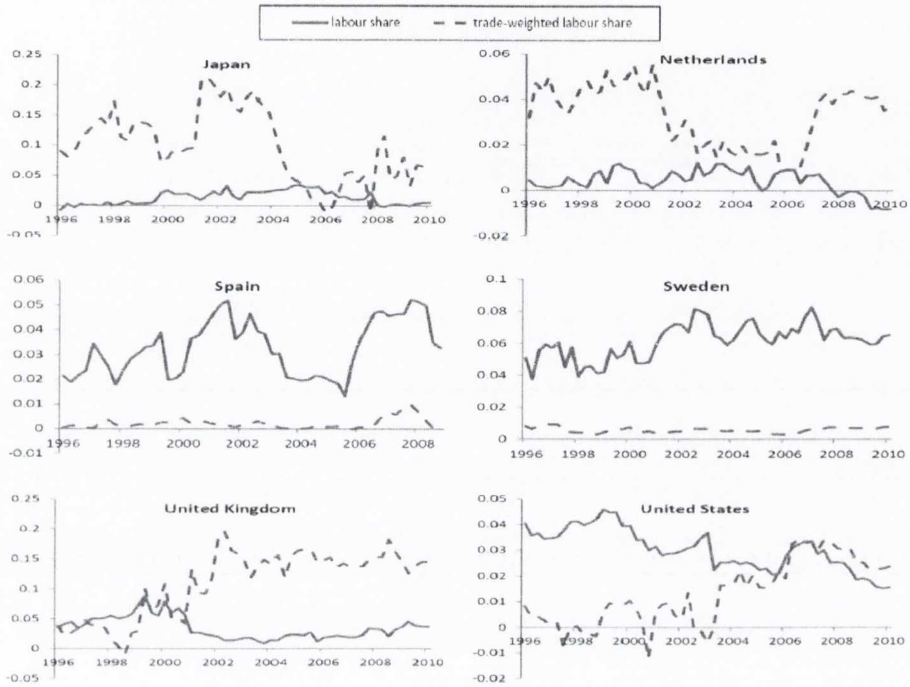
Notes: Inflation is defined as the quarterly percentage change in the GDP deflator. The trade-weighted share is the (log) labour share in each country's ten largest trading partners, weighted by their share in the country's total trade. Data from OECD Economic Outlook and Monthly Statistics of International Trade, Eurostat and national sources.

Figure 3.5: Time variation in the Labour Share and trade-weighted Labour Share coefficients, selected countries



Notes: Solid and dashed lines represent, respectively, the time variation of the s_t and s_t^{trade} parameters from equation (3.21) using a 17-year rolling sample window.

Figure 3.6: Time variation in the Labour Share and trade-weighted Labour Share coefficients, selected countries



Notes: Solid and dashed lines represent, respectively, the time variation of the s_t and s_t^{trade} parameters from equation [3.21] using a 17-year rolling sample window.

Table 3.1: Variable lags used as Instruments in estimation of baseline Model

	π_t	s_t	s_t^{trade}	s_t^{cc}	s_t^{ic}	gap_t	Δn_t	Δoil_t	Rpm_t	Com_t	$wage_t$
Australia	3	3	3	3	3	3	2	2	2	2	2
Canada	4	3	3	3	3	3	2	2	2	2	2
Finland	4	3	3	3	3	3	2	3	2	3	2
France	4	3	3	3	3	4	2	3	2	2	2
Germany	4	4	4	4	4	3	2	2	2	2	2
Italy	3	4	4	4	4	3	2	3	2	2	3
Japan	4	3	3	3	3	3	2	2	2	2	2
Netherlands	4	4	4	4	4	3	2	2	2	2	2
Spain	4	4	4	4	4	2	2	2	2	2	2
Sweden	3	4	4	4	4	2	2	3	2	2	4
UK	4	5	5	5	5	3	2	2	2	2	2
US	4	3	3	3	3	3	2	4	2	2	2

Notes: The table above contains the number of lags of each variable used as instruments in the GMM estimation of baseline model. $wage_t$ is the log wage per capita and is calculated as the log of wages minus the log of employment. Both series are obtained from the OECD's Economic Outlook database. The other variables are described in the section 3.5.

Table 3.2: Baseline open-economy New Keynesian Phillips Curves

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.771***	1.017***	0.749***	0.815***	0.747***	0.868***	0.693***	0.730***	0.768***	0.721***	0.690***	0.854***
	(0.071)	(0.073)	(0.089)	(0.054)	(0.070)	(0.036)	(0.065)	(0.114)	(0.064)	(0.082)	(0.089)	(0.038)
s_t	0.024**	-0.046***	-0.077***	0.028***	0.016***	0.020*	0.011***	0.014**	0.022**	0.039**	0.048***	0.014**
	(0.012)	(0.015)	(0.023)	(0.010)	(0.004)	(0.010)	(0.003)	(0.006)	(0.011)	(0.016)	(0.017)	(0.005)
gap_t	-0.089*	-0.003***	-0.003***	0.001*	0.006***	0.001	-0.001***	0.015*	0.139***	-0.001	-0.003***	-0.001***
	(0.047)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.008)	(0.027)	(0.001)	(0.001)	(0.001)
Δn_t	0.208***	0.090	-0.104	0.503***	-0.149*	-0.083	-0.022	-0.211***	0.053	-0.060	-0.179	0.080**
	(0.074)	(0.090)	(0.093)	(0.132)	(0.088)	(0.065)	(0.043)	(0.074)	(0.037)	(0.108)	(0.129)	(0.037)
Δn_{t+1}	-0.152**	0.057	0.115	-0.550***	0.032	0.041	0.103***	0.145*	-0.161***	0.168	0.564***	-0.039
	(0.072)	(0.063)	(0.114)	(0.165)	(0.079)	(0.090)	(0.028)	(0.078)	(0.034)	(0.119)	(0.101)	(0.039)
Rpm_t	0.065***	0.178***	0.060**	-0.031	-0.027*	0.059**	0.011**	0.013	-0.081***	0.089***	-0.031	0.008
	(0.025)	(0.047)	(0.026)	(0.019)	(0.014)	(0.027)	(0.005)	(0.009)	(0.006)	(0.025)	(0.027)	(0.008)
Imp_t	-0.018	0.008	-0.041***	0.009*	-0.022*	-0.049***	-0.007**	-0.004	-0.009**	-0.030***	-0.023**	-0.004
	(0.013)	(0.019)	(0.010)	(0.005)	(0.012)	(0.009)	(0.004)	(0.004)	(0.004)	(0.007)	(0.011)	(0.004)
Com_t	0.376	-2.633*	-0.917***	0.202	0.447	-0.944***	-0.149**	-0.259**	-0.263***	0.197	-0.198	0.959***
	(0.327)	(1.573)	(0.192)	(0.204)	(0.776)	(0.260)	(0.069)	(0.129)	(0.101)	(0.130)	(0.265)	(0.193)
Δoil_t	0.004	0.002	0.001	-0.007***	0.003**	0.003	0.001	-0.002**	0.010***	-0.007***	0.001	0.002**
	(0.003)	(0.004)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Cons	0.002***	-0.001	0.003***	-0.001	0.002***	0.002***	0.001***	0.002***	0.002***	0.003***	0.008***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
K-P	16.29	15.5	16.67	20.5	17.06	20.6	17.12	21.6	21.45	14.37	11.95	41.69
Obs.	118	118	118	118	118	118	118	118	113	118	118	118
Adj. R^2	0.384	0.248	0.198	0.492	0.351	0.519	0.339	0.406	0.353	0.421	0.277	0.581

Notes: The dependent variable, π_t, is the quarterly change in the (log) GDP deflator. Expected inflation is instrumented using lags of the independent variables. K-P refers to the Kleibergen-Paap test statistic for weak instruments. s_t is the log of the labour share (after imputing labour income to the self-employed). gap_t is the ouput gap. Δn_t is the first difference of log employment. Δoil_t is the change in the real price of oil, Rpm_t is the relative price of non-commodity imports. Imp_t is the share of imports in domestic spending and Com_t is the interaction of Rpm_t and Imp_t. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.3: Hybrid open-economy New Keynesian Phillips Curves

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.552***	0.906***	0.619***	0.579***	0.682***	0.727***	0.565***	0.592***	0.698***	0.714***	0.599***	0.646***
	(0.104)	(0.085)	(0.092)	(0.075)	(0.076)	(0.078)	(0.071)	(0.144)	(0.073)	(0.102)	(0.090)	(0.079)
π_{t-1}	0.224***	0.142**	0.173***	0.313***	0.047	0.144**	0.148***	0.191***	0.069	0.228***	0.160***	0.179***
	(0.066)	(0.067)	(0.058)	(0.040)	(0.047)	(0.060)	(0.042)	(0.062)	(0.045)	(0.075)	(0.056)	(0.039)
s_t	0.023**	-0.038***	-0.076***	0.031***	0.015***	0.020**	0.013***	0.014***	0.023**	0.039***	0.036**	0.016***
	(0.011)	(0.014)	(0.023)	(0.011)	(0.004)	(0.009)	(0.003)	(0.005)	(0.011)	(0.014)	(0.017)	(0.005)
gap_t	-0.082*	-0.003***	-0.003***	0.002***	0.005***	0.001	-0.001***	0.018**	0.130***	-0.001	-0.003***	-0.001***
	(0.043)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.008)	(0.028)	(0.001)	(0.001)	(0.001)
Δn_t	0.179***	0.103	-0.063	0.525***	-0.151*	-0.073	0.025	-0.173**	0.060*	-0.114	-0.210*	0.085**
	(0.067)	(0.083)	(0.085)	(0.177)	(0.088)	(0.069)	(0.039)	(0.068)	(0.036)	(0.109)	(0.126)	(0.035)
Δn_{t+1}	-0.050	0.071	0.077	-0.551***	0.043	0.036	0.122***	0.119*	-0.153***	0.229**	0.591***	-0.038
	(0.063)	(0.063)	(0.112)	(0.166)	(0.082)	(0.091)	(0.023)	(0.066)	(0.033)	(0.114)	(0.111)	(0.039)
Rpm_t	0.061***	0.125**	0.034	-0.018	-0.023	0.049**	0.011**	0.013	-0.080***	0.076***	-0.031	0.007
	(0.021)	(0.050)	(0.026)	(0.013)	(0.015)	(0.025)	(0.005)	(0.009)	(0.006)	(0.023)	(0.026)	(0.007)
Imp_t	-0.025**	0.004	-0.030***	0.006	-0.021*	-0.043***	-0.008**	-0.006	-0.010**	-0.021***	-0.022*	-0.001
	(0.012)	(0.019)	(0.011)	(0.005)	(0.012)	(0.008)	(0.004)	(0.004)	(0.004)	(0.007)	(0.012)	(0.003)
Com_t	0.532	-2.248	-0.850***	0.167	0.405	-0.786***	-0.111*	-0.267***	-0.237**	0.346**	-0.084	1.016***
	(0.334)	(1.526)	(0.214)	(0.162)	(0.758)	(0.266)	(0.063)	(0.099)	(0.104)	(0.135)	(0.265)	(0.179)
Δoil_t	0.006*	0.003	0.002	-0.006***	0.002**	0.002	0.001	-0.001	0.010***	-0.005**	0.001	0.002**
	(0.003)	(0.004)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
Cons.	0.002***	-0.001	0.003***	0.001	0.002***	0.002***	0.001***	0.002***	0.002***	0.002***	0.006***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
K-P	11.59	13.6	11.97	15.69	13.5	12.71	13.61	12.73	22.61	11.67	11.78	12.53
Obs.	118	118	118	118	118	118	118	118	113	118	118	118
Adj. R^2	0.482	0.376	0.272	0.581	0.347	0.589	0.331	0.487	0.391	0.464	0.322	0.652

Notes: The dependent variable, π_t, is the quarterly change in the (log) GDP deflator. Expected inflation is instrumented using lags of the independent variables. K-P refers to the Kleibergen-Paap test statistic for weak instruments. s_t is the log of the labour share (after imputing labour income to the self-employed). gap_t is the ouput gap. Δn_t is the first difference of log employment. Δoil_t is the change in the real price of oil, Rpm_t is the relative price of non-commodity imports. Imp_t is the share of imports in domestic spending and Com_t is the interaction between Rpm_t and Imp_t . *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.4: Baseline open-economy NKPC with trade-weighted Labour Shares

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.756***	0.958***	0.757***	0.809***	0.744***	0.689***	0.618***	0.715***	0.734***	0.712***	0.645***	0.810***
	(0.062)	(0.080)	(0.081)	(0.041)	(0.058)	(0.053)	(0.068)	(0.138)	(0.069)	(0.081)	(0.054)	(0.036)
s_t	0.023**	-0.054***	-0.088***	0.033***	0.015***	0.027***	0.009***	0.015***	0.028**	0.044***	0.039**	0.022***
	(0.011)	(0.016)	(0.023)	(0.007)	(0.004)	(0.010)	(0.003)	(0.006)	(0.012)	(0.017)	(0.017)	(0.005)
gap_t	-0.094**	-0.003***	-0.003***	0.002***	0.006***	0.001	-0.001***	0.018*	0.151***	0.001	-0.003***	-0.001***
	(0.048)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.010)	(0.026)	(0.001)	(0.001)	(0.001)
Δn_t	0.212***	0.070	-0.056	0.638***	-0.176**	0.017	-0.030	-0.174**	0.066*	-0.042	-0.032	0.149***
	(0.071)	(0.084)	(0.094)	(0.105)	(0.075)	(0.054)	(0.036)	(0.077)	(0.040)	(0.099)	(0.107)	(0.041)
Δn_{t+1}	-0.139**	0.052	0.162	-0.746***	0.058	0.181**	0.057*	0.090	-0.161***	0.165	0.602***	-0.028
	(0.060)	(0.063)	(0.108)	(0.130)	(0.070)	(0.083)	(0.030)	(0.075)	(0.036)	(0.110)	(0.088)	(0.038)
Rpm_t	0.072***	0.160***	0.060**	-0.031**	-0.031**	0.052**	0.011**	0.006	-0.081***	0.075***	-0.029	0.007
	(0.022)	(0.050)	(0.030)	(0.016)	(0.012)	(0.025)	(0.005)	(0.010)	(0.006)	(0.026)	(0.023)	(0.008)
Imp_t	-0.016	0.015	-0.042***	0.010**	-0.015	-0.042***	-0.007*	-0.001	-0.008**	-0.029***	-0.019**	-0.007**
	(0.011)	(0.020)	(0.011)	(0.004)	(0.011)	(0.007)	(0.004)	(0.004)	(0.004)	(0.007)	(0.009)	(0.004)
Com_t	0.544**	-2.703*	-0.927***	0.118	0.603	-1.028***	-0.230***	-0.246*	-0.264**	0.283**	-0.238	0.915***
	(0.264)	(1.563)	(0.191)	(0.125)	(0.630)	(0.279)	(0.082)	(0.131)	(0.102)	(0.140)	(0.253)	(0.168)
Δoil_t	0.003	0.002	-0.001	-0.008***	0.002**	0.002	0.001	-0.002**	0.010***	-0.006**	0.001	0.002**
	(0.003)	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
s_t^{trade}	0.039**	0.067**	0.170**	0.008*	0.010**	0.143***	-0.037	0.044*	0.002	0.007***	0.146**	0.023***
	(0.016)	(0.032)	(0.083)	(0.005)	(0.004)	(0.031)	(0.024)	(0.024)	(0.001)	(0.002)	(0.067)	(0.007)
Cons.	0.002***	-0.001	0.003*	0.001	0.002***	0.004***	0.002***	0.003***	0.003***	0.003***	0.006***	0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
K-P	13.49	19.89	45.63	18.52	24.55	20.7	19.83	12.81	19.26	14.32	14.45	19.89
Obs.	118	118	118	118	118	118	118	118	113	118	118	118
Adj. R^2	0.387	0.276	0.213	0.501	0.380	0.557	0.363	0.446	0.364	0.444	0.292	0.598

Notes: The dependent variable, π_t, is the quarterly change in the (log) GDP deflator. Expected inflation is instrumented using lags of the independent variables. K-P refers to the Kleibergen-Paap test statistic for weak instruments. s_t is the log of the labour share (after imputing labour income to the self-employed). gap_t is the ouput gap. Δn_t is the first difference of log employment. Rpm_t is the relative price of non-commodity imports. Imp_t is the share of imports in domestic spending and Com_t is the interaction between Rpm_t and Imp_t. Δoil_t is the change in the real price of oil, s_t^{trade} is the labour share in each country's ten largest trading partners, weighted by their share in the country's overall trade. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.5: Hybrid open-economy NKPC with trade-weighted Labour Shares

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.551***	0.871***	0.712***	0.592***	0.648***	0.612***	0.523***	0.595***	0.674***	0.518***	0.619***	0.658***
	(0.096)	(0.086)	(0.102)	(0.054)	(0.060)	(0.073)	(0.077)	(0.140)	(0.076)	(0.106)	(0.041)	(0.070)
π_{t-1}	0.177***	0.117*	0.144**	0.280***	0.054	0.185***	0.085**	0.148***	0.090**	0.213***	0.142***	0.239***
	(0.063)	(0.065)	(0.065)	(0.037)	(0.044)	(0.051)	(0.040)	(0.052)	(0.045)	(0.077)	(0.045)	(0.037)
s_t	0.031***	-0.045***	-0.083***	0.026***	0.013***	0.025***	0.010***	0.012**	0.029***	0.047***	0.032**	0.023***
	(0.010)	(0.015)	(0.025)	(0.008)	(0.004)	(0.009)	(0.003)	(0.005)	(0.011)	(0.015)	(0.016)	(0.005)
gap_t	-0.076*	-0.003***	-0.003***	0.002***	0.005***	0.001	-0.001***	0.014*	0.136***	0.001	-0.003***	-0.001***
	(0.044)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.008	(0.028)	(0.001)	(0.001)	(0.001)
Δn_t	0.206***	0.087	-0.041	0.632***	-0.177**	0.011	0.002	-0.151**	0.0719*	-0.077	-0.052	0.146***
	(0.064)	(0.077)	(0.108)	(0.115)	(0.075)	(0.060)	(0.036)	(0.062)	(0.038)	(0.099)	(0.096)	(0.042)
Δn_{t+1}	-0.061	0.066	0.138	-0.711***	0.077	0.183**	0.064**	0.086	-0.150***	0.205*	0.608***	-0.012
	(0.057)	(0.063)	(0.121)	(0.125)	(0.074)	(0.079)	(0.031)	(0.061)	(0.034)	(0.106)	(0.079)	(0.040)
Rpm_t	0.057**	0.114**	0.029	-0.030**	-0.028**	0.039*	0.012**	0.008	-0.080***	0.064***	-0.024	0.008
	(0.025)	(0.052)	(0.034)	(0.012)	(0.013)	(0.022)	(0.005)	(0.009)	(0.006)	(0.023)	(0.020)	(0.007)
Imp_t	-0.023**	0.006	-0.028**	0.010**	-0.013	-0.037***	-0.008**	-0.004	-0.010**	-0.022***	-0.019**	-0.003
	(0.010)	(0.017)	(0.012)	(0.004)	(0.011)	(0.006)	(0.004)	(0.004)	(0.004)	(0.007)	(0.010)	(0.003)
Com_t	0.734***	-2.184	-0.814***	0.208*	0.704	-0.775***	-0.187**	-0.281**	-0.233**	0.426***	-0.119	1.033***
	(0.278)	(1.508)	(0.213)	(0.124)	(0.653)	(0.263)	(0.083)	(0.116)	(0.109)	(0.149)	(0.220)	(0.170)
Δoil_t	0.011	0.003	0.001	-0.006***	0.002**	0.001	0.002*	-0.001	0.0104***	-0.004	-0.001	0.002***
	(0.009)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)
s_t^{trade}	0.030*	0.055*	0.154*	0.005	0.010**	0.129***	-0.033	0.039*	0.001	0.007***	0.129**	0.024***
	(0.017)	(0.029)	(0.082)	(0.005)	(0.004)	(0.028)	(0.025)	(0.022)	(0.001)	(0.002)	(0.052)	(0.007)
Cons.	0.002***	-0.001	0.002	0.001	0.002***	0.004***	0.002***	0.002***	0.003***	0.002***	0.005***	0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
K-P	12.68	12.82	45.63	12.31	15.19	11.88	13.26	12.23	19.95	12.63	12.63	11.89
Obs.	118	118	118	118	118	118	118	118	113	118	118	118
Adj. R^2	0.461	0.375	0.292	0.575	0.38	0.610	0.356	0.525	0.397	0.476	0.331	0.683

Notes: The dependent variable, π_t, is the quarterly change in the (log) GDP deflator. Expected inflation is instrumented using lags of the independent variables. K-P refers to the Kleibergen-Paap test statistic for weak instruments. s_t is the log of the labour share (after imputing labour income to the self-employed). gap_t is the ouput gap. Δn_t is the first difference of log employment. Rpm_t is the relative price of non-commodity imports. Imp_t is the share of imports in domestic spending and Com_t is the interaction between Rpm_t and Imp_t. Δoil_t is the change in the real price of oil, s_t^{trade} is the labour share in each country's ten largest trading partners, weighted by their share in the country's overall trade. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.6: Share of Domestic Labour Share Variance explained by first five Factors

	Factor				
	1	2	3	4	5
Australia	0.22	0.30	0.12	0.00	0.01
Canada	0.30	0.01	0.06	0.00	0.00
Finland	0.28	0.14	0.00	0.01	0.00
France	0.19	0.45	0.10	0.01	0.00
Germany	0.13	0.33	0.14	0.01	0.00
Italy	0.29	0.05	0.25	0.02	0.01
Japan	0.17	0.22	0.03	0.00	0.00
Netherlands	0.58	0.16	0.04	0.01	0.01
Spain	0.29	0.11	0.19	0.03	0.00
Sweden	0.49	0.12	0.18	0.00	0.01
UK	0.57	0.02	0.11	0.02	0.01
US	0.22	0.16	0.03	0.01	0.00

Notes: The table reports the share of the variance of the domestic labour share in each country that is explained by the first five factors.

Table 3.7: Baseline open-economy NKPC with Common and Idiosyncratic Labour Share Components

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.730***	1.071***	0.743***	0.828***	0.714***	0.821***	0.515***	0.748***	0.718***	0.675***	0.656***	0.830***
	(0.059)	(0.097)	(0.078)	(0.040)	(0.076)	(0.034)	(0.089)	(0.102)	(0.065)	(0.094)	(0.097)	(0.042)
s_t^{ic}	0.018**	-0.073***	-0.101**	0.023***	0.011***	0.025*	0.021***	0.012**	0.027**	0.040**	0.118***	0.030***
	(0.007)	(0.028)	(0.046)	(0.008)	(0.004)	(0.014)	(0.005)	(0.006)	(0.011)	(0.019)	(0.015)	(0.005)
gap_t	-0.084***	-0.004***	-0.003***	0.002**	0.005***	0.001	-0.001***	0.012	0.151***	0.001	-0.003***	-0.001***
	(0.028)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.009)	(0.026)	(0.001)	(0.001)	(0.001)
Δn_t	0.207***	0.127	-0.107	0.526***	-0.205**	-0.122**	-0.030	-0.216***	0.0426	-0.073	-0.078	0.088***
	(0.055)	(0.100)	(0.101)	(0.117)	(0.091)	(0.057)	(0.039)	(0.073)	(0.053)	(0.107)	(0.077)	(0.031)
Δn_{t+1}	-0.133***	0.085	0.154	-0.572***	0.126	0.084	0.074**	0.165**	-0.150***	0.208**	0.586***	-0.036
	(0.036)	(0.064)	(0.111)	(0.153)	(0.090)	(0.068)	(0.031)	(0.077)	(0.0361)	(0.095)	(0.102)	(0.035)
Rpm_t	0.065***	0.169***	0.053*	-0.027*	-0.024	0.057***	0.012**	0.014	-0.082***	0.087***	-0.046**	0.010
	(0.016)	(0.041)	(0.029)	(0.016)	(0.016)	(0.022)	(0.006)	(0.009)	(0.007)	(0.019)	(0.021)	(0.007)
Imp_t	-0.013*	0.009	-0.041***	0.007	-0.020	-0.053***	-0.009**	-0.003	-0.008	-0.031***	-0.011	-0.004
	(0.007)	(0.019)	(0.009)	(0.005)	(0.013)	(0.009)	(0.004)	(0.004)	(0.005)	(0.007)	(0.009)	(0.003)
Com_t	0.678***	-2.316	-0.906***	0.129	0.817	-0.799***	-0.159**	-0.268**	-0.255**	0.248*	-0.163	1.025***
	(0.195)	(1.819)	(0.200)	(0.191)	(0.837)	(0.257)	(0.065)	(0.131)	(0.114)	(0.141)	(0.204)	(0.146)
Δoil_t	0.002	0.003	0.001	-0.007***	0.003**	0.003	0.001	-0.002**	0.009***	-0.009***	0.001	0.002**
	(0.002)	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
s_t^{cc}	0.043***	0.233*	-0.069**	0.041***	0.021***	0.019*	0.006**	0.013*	0.0274***	0.047***	0.131***	0.013**
	(0.015)	(0.139)	(0.029)	(0.011)	(0.006)	(0.011)	(0.003)	(0.007)	(0.0101)	(0.017)	(0.013)	(0.007)
Cons.	0.002***	-0.001	0.003**	0.001	0.002***	0.003***	0.002***	0.002***	0.003***	0.003***	0.009***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
K-P	13.94	12.24	23.52	17.49	20.66	20.24	12.68	14.01	12.45	12.79	12.07	25.47
Obs.	118	118	118	118	118	118	118	118	113	118	118	118
Adj. R^2	0.394	0.258	0.203	0.51	0.362	0.524	0.346	0.403	0.361	0.438	0.291	0.593

Notes: The dependent variable, π_t, is the quarterly change in the (log) GDP deflator. Expected inflation is instrumented using lags of the independent variables. K-P refers to the Kleibergen-Paap test statistic for weak instruments. s_t^{ic} and s_t^{cc} are the idiosyncratic and common components of the labour share, respectively. gap_t is the ouput gap. Δn_t is the first difference of log employment. Rpm_t is the relative price of non-commodity imports. Imp_t is the share of imports in domestic spending and Com_t is the interaction between Rpm_t and Imp_t. Δoil_t is the change in the real price of oil. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.8: Hybrid open-economy NKPC with Common and Idiosyncratic Labour Share Components

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.632***	0.998***	0.620***	0.599***	0.653***	0.638***	0.360***	0.577***	0.684***	0.622***	0.594***	0.649***
	(0.059)	(0.112)	(0.087)	(0.053)	(0.085)	(0.052)	(0.091)	(0.133)	(0.082)	(0.092)	(0.098)	(0.065)
π_{t-1}	0.135***	0.096	0.180***	0.308***	0.051	0.211***	0.138***	0.177***	0.079*	0.204***	0.007	0.256***
	(0.039)	(0.074)	(0.059)	(0.047)	(0.051)	(0.037)	(0.048)	(0.055)	(0.044)	(0.064)	(0.054)	(0.037)
s_t^{ic}	0.016**	-0.062**	-0.087**	0.017*	0.010**	0.025**	0.020***	0.009*	0.021**	0.036**	0.096***	0.035***
	(0.007)	(0.027)	(0.043)	(0.010)	(0.004)	(0.012)	(0.006)	(0.005)	(0.011)	(0.017)	(0.016)	(0.005)
gap_t	-0.069***	-0.004***	-0.003***	0.002***	0.004**	0.001	-0.001***	0.014	0.135***	-0.001	-0.003***	-0.001***
	(0.025)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.009)	(0.026)	(0.001)	(0.001)	(0.001)
Δn_t	0.188***	0.130	-0.062	0.452***	-0.241***	-0.115**	-0.001	-0.172***	0.045	-0.118	-0.083	0.067**
	(0.054)	(0.094)	(0.096)	(0.146)	(0.091)	(0.055)	(0.037)	(0.065)	(0.048)	(0.097)	(0.082)	(0.034)
Δn_{t+1}	-0.096**	0.093	0.140	-0.499***	0.161*	0.107*	0.072**	0.138**	-0.141***	0.208**	0.521***	-0.006
	(0.041)	(0.063)	(0.105)	(0.148)	(0.092)	(0.057)	(0.030)	(0.064)	(0.032)	(0.087)	(0.112)	(0.039)
Rpm_t	0.057***	0.133***	0.019	-0.026*	-0.015	0.044**	0.011**	0.012	-0.081***	0.071***	-0.032**	0.007
	(0.016)	(0.048)	(0.031)	(0.015)	(0.016)	(0.018)	(0.005)	(0.008)	(0.006)	(0.020)	(0.035)	(0.006)
Imp_t	-0.014**	0.006	-0.027**	0.008*	-0.019	-0.045***	-0.010**	-0.005	-0.011**	-0.021***	-0.016	-0.001
	(0.006)	(0.021)	(0.012)	(0.005)	(0.012)	(0.006)	(0.004)	(0.004)	(0.004)	(0.006)	(0.009)	(0.003)
Com_t	0.727***	-1.985	-0.815***	0.276	0.636	-0.679***	-0.113	-0.279***	-0.219**	0.318***	-0.150	1.104***
	(0.194)	(1.770)	(0.219)	(0.184)	(0.812)	(0.263)	(0.074)	(0.101)	(0.105)	(0.120)	(0.208)	(0.146)
Δoil_t	0.003	0.004	0.001	-0.006***	0.002**	0.002	0.002*	-0.001	0.011***	-0.006***	0.001	0.002***
	(0.002)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
s_t^{cc}	0.035**	0.234*	-0.067**	0.028**	0.017***	0.016*	0.007***	0.014**	0.023**	0.031**	0.129***	0.010*
	(0.014)	(0.134)	(0.028)	(0.013)	(0.006)	(0.010)	(0.003)	(0.007)	(0.009)	(0.013)	(0.016)	(0.005)
Cons.	0.002***	-0.002	0.002	0.001	0.002***	0.002***	0.002***	0.002***	0.003***	0.002***	0.011***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
K-P	11.53	11.71	17.36	13.8	12.91	16.04	12.51	11.59	13.23	11.89	11.67	11.74
Obs.	118	118	118	118	118	118	118	118	113	118	118	118
Adj. R^2	0.479	0.378	0.269	0.591	0.360	0.575	0.380	0.463	0.387	0.487	0.341	0.664

Notes: The dependent variable, π_t, is the quarterly change in the (log) GDP deflator. Expected inflation is instrumented using lags of the independent variables. K-P refers to the Kleibergen-Paap test statistic for weak instruments. s_t^{ic} and s_t^{cc} are the idiosyncratic and common components of the labour share, respectively. gap_t is the ouput gap. Δn_t is the first difference of log employment. Rpm_t is the relative price of non-commodity imports. Imp_t is the share of imports in domestic spending and Com_t is the interaction between Rpm_t and Imp_t. Δoil_t is the change in the real price of oil. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.9: Estimates of hybrid open-economy NKPC with CPI Inflation

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π^{cpi}_{t+1}	0.506***	0.566***	0.468***	0.519***	0.511***	0.499***	0.559***	0.588***	0.518***	0.552***	0.504***	0.528***
	(0.091)	(0.054)	(0.041)	(0.0628)	(0.075)	(0.042)	(0.108)	(0.079)	(0.068)	(0.060)	(0.078)	(0.082)
π^{cpi}_{t-1}	0.222***	0.346***	0.472***	0.372***	0.269***	0.440***	0.095*	0.159***	0.241***	0.291***	0.260***	0.144***
	(0.069)	(0.026)	(0.035)	(0.0431)	(0.041)	(0.033)	(0.057)	(0.049)	(0.040)	(0.026)	(0.060)	(0.039)
s_t	0.027**	0.009*	0.004**	0.015***	0.017***	0.009**	0.012***	0.011**	0.0123*	0.040**	0.089***	0.026***
	(0.010)	(0.005)	(0.002)	(0.005)	(0.006)	(0.004)	(0.004)	(0.004)	(0.007)	(0.009)	(0.022)	(0.009)
gap_t	-0.076**	0.011***	0.010***	0.001	-0.001	-0.001	-0.001	0.028***	0.082**	0.002	0.001	0.001
	(0.036)	(0.001)	(0.00)	(0.001)	(0.001)	(0.001)	(0.001)	(0.008)	(0.038)	(0.001)	(0.001)	(0.001)
Δn_t	0.165**	-0.242***	0.039*	-0.024	0.267***	-0.038	-0.029	-0.149**	-0.123*	-0.138***	0.233**	0.287***
	(0.071)	(0.044)	(0.021)	(0.142)	(0.079)	(0.035)	(0.074)	(0.069)	(0.070)	(0.048)	(0.103)	(0.103)
Δn_{t+1}	-0.032	0.208***	-0.057*	0.049	-0.156**	0.079***	0.146**	0.092	0.055	0.197***	-0.312**	-0.548***
	(0.060)	(0.041)	(0.030)	(0.173)	(0.067)	(0.025)	(0.060)	(0.064)	(0.048)	(0.049)	(0.144)	(0.097)
Rpm_t	0.057***	0.032**	0.001	0.0312**	-0.071***	0.010	0.025**	-0.002	0.049***	-0.002	0.046	0.036**
	(0.019)	(0.015)	(0.007)	(0.014)	(0.022)	(0.013)	(0.010)	(0.010)	(0.011)	(0.009)	(0.030)	(0.014)
Imp_t	-0.020**	0.001	0.003	-0.0107***	-0.036**	0.006*	0.003	-0.001	0.029***	0.001	-0.018	0.062***
	(0.010)	(0.007)	(0.003)	(0.004)	(0.017)	(0.003)	(0.006)	(0.005)	(0.009)	(0.004)	(0.012)	(0.009)
Com_t	0.768***	-1.918***	0.128*	0.380***	3.349***	0.241*	-0.233	-0.481***	1.532***	0.947***	-0.573*	3.237***
	(0.271)	(0.742)	(0.074)	(0.115)	(1.152)	(0.142)	(0.153)	(0.096)	(0.193)	(0.146)	(0.346)	(0.415)
Δoil_t	0.005	0.003**	0.002*	0.008***	0.012***	0.004***	-0.006***	0.001	-0.002	0.005***	0.007*	0.008***
	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.002)	(0.004)	(0.002)
s^{trade}_t	0.010	-0.001	0.002	0.004	0.028***	0.038**	-0.094**	0.037**	0.002	0.016***	0.156*	-0.024
	(0.020)	(0.011)	(0.019)	(0.004)	(0.008)	(0.015)	(0.048)	(0.015)	(0.003)	(0.002)	(0.085)	(0.018)
Cons.	0.021***	0.012***	0.010***	0.003	0.023***	0.011**	0.010**	0.022***	0.001	0.001*	0.016***	0.004***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
K-P	12.91	12.22	11.98	13.31	14.19	18.00	11.77	12.67	13.52	12.13	13.02	12.38
Obs.	118	118	118	118	118	118	118	118	114	118	118	118
Adj. R^2	0.489	0.594	0.507	0.712	0.519	0.73	0.431	0.596	0.562	0.612	0.445	0.703

Notes: The dependent variable, π^{cpi}_{t+1} , is the quarterly change in the (log) Consumer Price Index. Expected CPI inflation is instrumented using lags of the dependent and independent variables. s^{trade}_t is the labour share in each country's ten largest trading partners, weighted by their share in the country's overall trade. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively. Newey-West standard errors are in parenthesis. The models are estimated over the period Q1 1980 to Q4 2010, except for Spain for which the sample ends in Q3 2009.

Table 3.10: OLS estimation of the open-economy NKPC with trade-weighted labour shares

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.390***	0.439***	0.420**	0.559***	0.519***	0.586***	0.439***	0.356**	0.568***	0.537***	0.412***	0.628***
	(0.130)	(0.111)	(0.092)	(0.121)	(0.086)	(0.073)	(0.135)	(0.083)	(0.078)	(0.079)	(0.131)	(0.081)
s_t	0.073***	-0.054**	-0.109**	0.064***	0.014***	0.050*	0.024***	0.032***	0.060***	0.075***	0.039	0.038***
	(0.019)	(0.025)	(0.042)	(0.019)	(0.005)	(0.025)	(0.006)	(0.006)	(0.015)	(0.018)	(0.030)	(0.009)
gap_t	-0.171*	-0.002***	-0.003***	0.001	0.007***	0.001	-0.001	0.043***	0.142	0.001	-0.004***	-0.001
	(0.088)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.011)	(0.093)	(0.001)	(0.002)	(0.001)
Δn_t	0.298**	0.120	0.157	-0.038	-0.301**	0.096	0.092	-0.211**	0.103	0.188	0.012	0.204**
	(0.141)	(0.126)	(0.178)	(0.061)	(0.124)	(0.146)	(0.082)	(0.106)	(0.125)	(0.176)	(0.217)	(0.089)
Δn_{t+1}	0.004	-0.030	0.208	0.109*	0.173	0.298	0.132**	0.067	-0.138	-0.006	0.535**	-0.141*
	(0.144)	(0.138)	(0.151)	(0.058)	(0.131)	(0.193)	(0.066)	(0.106)	(0.113)	(0.185)	(0.208)	(0.073)
Rpm_t	0.080**	0.110*	0.031	-0.010	0.001	0.068	0.023*	0.004	-0.057***	0.094***	0.009	0.027
	(0.036)	(0.060)	(0.044)	(0.041)	(0.023)	(0.060)	(0.014)	(0.019)	(0.017)	(0.033)	(0.056)	(0.019)
Imp_t	-0.035**	0.017	-0.029*	0.029	-0.031	-0.040**	-0.016*	-0.003	-0.001	-0.025*	-0.027	-0.001
	(0.017)	(0.029)	(0.016)	(0.035)	(0.022)	(0.017)	(0.008)	(0.008)	(0.012)	(0.013)	(0.017)	(0.008)
Com_t	1.313**	-4.253***	-0.711*	0.093	-0.651	-0.777	-0.191	-0.244*	-0.247	0.557*	-0.767	1.300***
	(0.514)	(2.750)	(0.386)	(0.305)	(1.252)	(0.743)	(0.148)	(0.145)	(0.287)	(0.307)	(0.505)	(0.364)
Δoil_t	0.013**	0.011*	0.004**	-0.007**	-0.001	-0.001	0.001	-0.002	0.005	-0.007	-0.001	0.001
	(0.007)	(0.006)	(0.002)	(0.003)	(0.002)	(0.005)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.002)
s_t^{trade}	0.016	0.101**	0.246***	0.023*	0.011	0.226***	-0.056	0.083***	0.001	0.009**	0.283***	0.022
	(0.034)	(0.049)	(0.047)	(0.014)	(0.011)	(0.062)	(0.054)	(0.024)	(0.003)	(0.004)	(0.105)	(0.016)
Cons.	0.005***	0.004***	0.009***	-0.001	0.003***	0.005***	0.001***	0.006***	0.005***	0.004***	0.007**	0.002***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Obs.	122	122	122	122	122	122	122	122	116	122	122	122
Adj. R^2	0.509	0.451	0.458	0.632	0.436	0.627	0.664	0.639	0.611	0.576	0.416	0.705

Notes: Ordinary Least Squares estimation of the baseline open-economy NKPC with trade-weighted labour shares. Variables are as defined in previous tables, except for π_{t+1}, which is the first lead of inflation.

Table 3.11: OLS estimation of the open-economy NKPC with common and idiosyncratic labour share components

	Australia	Canada	Finland	France	Germany	Italy	Japan	Netherl.	Spain	Sweden	UK	US
π_{t+1}	0.360*	0.419***	0.406***	0.548***	0.512***	0.590***	0.412***	0.320***	0.526***	0.528***	0.387**	0.615***
	(0.134)	(0.118)	(0.085)	(0.130)	(0.089)	(0.065)	(0.134)	(0.081)	(0.078)	(0.080)	(0.143)	(0.077)
s_t^{ic}	0.039**	-0.099***	-0.124	0.052**	0.010*	0.033	0.027**	0.014	0.064***	0.048*	0.039	0.025*
	(0.019)	(0.026)	(0.094)	(0.023)	(0.006)	(0.029)	(0.013)	(0.010)	(0.021)	(0.026)	(0.032)	(0.014)
gap_t	-0.207**	-0.002**	-0.003***	0.002	0.006***	0.001	-0.001	0.037***	0.133	0.001	-0.004**	-0.001
	(0.083)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.009)	(0.092)	(0.001)	(0.002)	(0.001)
Δn_t	0.347**	0.010	-0.018	0.657	-0.278**	-0.093	0.075	-0.201*	0.093	0.232	-0.083	0.138**
	(0.141)	(0.111)	(0.181)	(0.424)	(0.126)	(0.133)	(0.081)	(0.102)	(0.126)	(0.181)	(0.210)	(0.068)
Δn_{t+1}	0.047	-0.002	0.184	-0.557	0.160	0.185	0.120**	0.105	-0.133	-0.051	0.495***	-0.147**
	(0.133)	(0.137)	(0.167)	(0.573)	(0.131)	(0.202)	(0.057)	(0.110)	(0.114)	(0.188)	(0.186)	(0.074)
Rpm_t	0.085**	0.112**	0.082*	-0.017	0.010	0.090	0.026*	0.009	-0.057***	0.089**	0.016	0.026
	(0.035)	(0.055)	(0.046)	(0.037)	(0.023)	(0.063)	(0.015)	(0.018)	(0.016)	(0.034)	(0.052)	(0.019)
Imp_t	-0.038**	0.016	-0.047***	0.005	-0.024	-0.054***	-0.017**	-0.006	-0.001	-0.024*	-0.037**	0.002
	(0.017)	(0.030)	(0.018)	(0.010)	(0.023)	(0.018)	(0.009)	(0.008)	(0.012)	(0.014)	(0.017)	(0.009)
Com_t	1.201**	-4.963***	-0.908*	-0.019	-0.321	-0.514	-0.191	-0.263**	-0.271	0.370	-0.895*	1.274***
	(0.492)	(2.484)	(0.410)	(0.337)	(1.275)	(0.727)	(0.150)	(0.131)	(0.291)	(0.300)	(0.456)	(0.391)
Δoil_t	0.008	0.011*	0.001	-0.008**	-0.001	0.001	0.001	-0.002	0.005	-0.007*	-0.001	0.001
	(0.006)	(0.006)	(0.003)	(0.003)	(0.002)	(0.005)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.002)
s_t^{cc}	0.130***	-0.296	-0.052	0.090***	0.021**	0.036	0.021***	0.037***	0.059***	0.069***	0.157***	0.035***
	(0.031)	(0.206)	(0.046)	(0.032)	(0.008)	(0.034)	(0.006)	(0.009)	(0.015)	(0.020)	(0.056)	(0.008)
Cons.	0.006***	0.005***	0.006***	-0.001	0.003***	0.005***	0.001***	0.005***	0.005***	0.004***	0.006***	0.002***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Obs	120	120	122	122	122	122	122	122	116	121	122	122
Adj. R^2	0.489	0.443	0.422	0.616	0.429	0.601	0.652	0.616	0.610	0.565	0.398	0.698

Notes: Ordinary Least Squares estimation of the baseline open-economy NKPC with the common and idiosyncratic components of the labour shares. Variables are as defined in previous tables, except for π_{t+1}, which is the (non-instrumented) first lead of inflation.

Chapter 4

Globalisation, Monetary Policy and the Yield Curve

Between June 2004 and June 2005, the ten-year forward rate implied by US treasury securities fell by 150 basis points, despite an almost 200 basis points increase in the Federal Funds Rate. This apparent disconnect between the behaviour of short- and long-term yields puzzled even the chairman of the Federal Reserve Board, who labelled it a "conundrum".[64] Although acknowledging the global nature of the narrowing of yield and risk spreads, Greenspan was sceptical that the conundrum was due to capital flows associated with greater financial globalisation. He suggested that it was unlikely that increased financial integration was responsible as the disconnect was a recent phenomenon, whereas financial flows had been increasing for some time. Since then, there has been considerable evidence supporting the hypothesis that the conundrum was related to an acceleration in foreign official demand for US treasuries (see Warnock and Warnock (2009), Craine and Martin (2009)). While this episode starkly highlighted the potential effects of financial globalisation on the effectiveness of monetary policy, it proved to be only temporary. However, it is likely that the more permanent effects of increased financial integration on the effectiveness of monetary policy are subtle and gradual and therefore difficult to detect. This chapter aims to measure these effects.

[64] Greenspan, Alan, "Federal Reserve Board's semi-annual Monetary Policy Report to the Congress", before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, February 16, 2005.

There are two main channels through which globalisation can influence the effectiveness of monetary policy (Kamin (2010)). First, as economies become more integrated, the influence of external shocks on domestic macroeconomic and financial variables may increase. Therefore, the set of shocks to which central banks must respond increases and the path of the economy becomes more uncertain. Second, globalisation can alter the traditional mechanisms through which monetary policy affects the economy. For example, the effect of policy changes on the exchange rate may become relatively more important.

The central focus of this chapter is the impact of globalisation on the interest rate channel of the monetary transmission mechanism. As financial markets become more integrated, long-term interest rates may increasingly be determined by external factors and less by the stance of domestic monetary policy. Indeed, the effects of financial globalisation, such as those linked to the conundrum episode, create additional difficulties for central banks. When the behaviour of bond yields becomes less correlated with domestic macroeconomic conditions, the appropriate monetary response is more uncertain.

For example, if the decline in yields reflects lower inflation expectations on behalf of global investors, then the appropriate policy response may be to reduce policy rates to prevent ex ante real interest rates from increasing. However, if lower long-term bond yields are excessively stimulatory, the central bank may instead need to increase policy rates (Kamin (2010)). In the limit, the ineffectiveness of an individual country's monetary policy may be complete and Rogoff (2006) argues that, in this case, countries should coordinate their policies and act collectively. However, Woodford (2009) shows that theoretically this may not be the case. He finds in the context of a two-country new-Keynesian model with complete financial market integration and a given path for real activity in both countries, that domestic inflation will always depend on current and expected future domestic monetary policy. Furthermore, even when currencies are perfect substitutes, in which case it is global rather than domestic liquidity that matters for aggregate demand, Woodford (2009) shows that a central bank can still control domestic inflation by varying the interest rate on base money.

The interest rate channel of the traditional monetary transmission mechanism suggests that when central banks change the short-term rate (the monetary instrument), they affect long-term rates (the intermediate target) via the Expectations Hypothesis. The change in long-term rates then influences the interest rate sensitive components of aggregate demand, and thus inflation (the final target). This mechanism can be tested empirically in the form of restrictions on a Cointegrated VAR. For example, a target variable is "controllable" by the central bank if it can be made stationary around a particular target value after adjusting the instrument (Johansen and Juselius (2001)). In econometric terms, if the instrument and target are non-stationary variables and they cointegrate, then the target will adjust to any changes in the instrument in the long run. Although, the transmission of changes in the policy rate to the final target may "exhibit long and variable lags" and is therefore difficult to test empirically, the effect of policy changes on the yield curve should be immediate and thus more amenable to empirical testing.[65]

Therefore, the main contribution of this chapter is an econometric analysis of how globalisation has affected this relation between policy rates and the yield curve. As the Federal Reserve intervenes daily to equate the Federal Funds Rate with the target set by the Federal Open Markets Committee (FOMC), we first test whether cointegrating relations exist between these variables and short-term yields, which have traditionally been the focus of empirical testing of the Expectations Hypothesis. We then consider the spreads between short-, and medium- and long-term yields, and find that they are stationary once a break is included in the cointegrating relations. As this break coincides with the beginning of the conundrum period, we investigate whether long-term yields and foreign official holdings of US Treasuries are cointegrated and find evidence of a long-term relation.

[65] Identifying the effect of changes in the policy rate on the final target variables is also complicated by the frequency of observation of the relevant variables. For example, the Federal Reserve intervenes on a daily basis so that the Federal Funds Rate coincides with the Federal Funds target set by the Federal Open Markets Committee. However, inflation is only measured on a monthly basis and the output gap on a quarterly basis.

We re-estimate the model over a longer sample period using monthly data and test whether the spreads between short- and long-term yields are stationary. The Expectations Hypothesis is strongly rejected and we find evidence for non-stationary term premia. After decomposing each monthly yield into factors that are common across countries and components that are unique to the US, we find that the US-specific components of the yields now cointegrate. We conclude that monetary policy only has short-term effects on the short-end of the yield curve and that the Federal Funds Rate is mainly adjusting to shocks to longer-term rates. The main impact of globalisation is found to be on the term premia associated with the monthly yields.

The chapter is structured as follows. Section 4.1 discusses the existing empirical literature in this area. Section 4.2 outlines our theoretical framework. Section 4.3 presents our econometric model and results for daily and monthly yields. Section 4.4 presents the results from the factor model and section 4.5 concludes.

4.1 Literature

One of the earliest applications of cointegration analysis was to test the Expectations Hypothesis for the short-end of the yield curve, where the cointegrating relations were the stationary spreads between pairs of yields (see Engle and Granger (1987), Campbell and Shiller (1987)). Shea (1992) extended this methodology to include yields on US treasuries with maturities as long as twenty five years. He found that the Expectations Hypothesis appears to hold for short- and medium-term bonds but not for those at the long-end of the yield curve. The latter appeared to be influenced by additional common trends, which he suggested were related to liquidity premia. Johansen and Juselius (2001) implicitly test the Expectations Hypothesis for short-term yields using a Cointegrated VAR and find evidence that the spread between yields is stationary.

Johansen and Juselius (2001) also integrate the Expectations Hypothesis into the monetary transmission mechanism and specify how a monetary control rule can be tested as a restriction on a VAR process. While their primary focus is on whether the Federal Reserve can "control" its ultimate target, the inflation rate, they also examine whether the monetary instrument (the Federal Funds Rate target) cointegrates with an intermediate target (the three- and six-month bond yields). They argue that since these yields are influenced by a stochastic trend in shocks to the yields themselves, rather than shocks to the Federal Funds target, the Federal Reserve cannot "control" its intermediate target. However, they do find that the Federal Funds Rate target has significant short-run effects on the yields. We adopt the Johansen and Juselius (2001) integrated framework for the relation between the monetary instrument and the term-structure, but we focus more on describing the short- and long-term dynamics of the yield curve, rather than on the "controllability" of short-term interest rates with which they are concerned.

More recently, Giese (2008) examines the relation between short- and long-term yields on US treasuries using a Cointegrated VAR and finds that, although spreads between yields are non-stationary, differences between spreads are stationary. In her framework, this implied two stochastic trends relating the level and the slope of the yield curve.[66] Parts of our approach are similar to Giese (2008) in that we use a Cointegrated VAR to capture the term structure of interest rates. However, our focus is not primarily on modelling the time-series properties of the level, slope and curvature of the yield curve, but instead on the relation between changes in short-term rates, particularly the policy rate, and long-term rates. In addition, Giese (2008) does not consider the international dimension of yields, which is of particular interest to us.

Some studies have investigated whether the monetary transmission mechanism has changed in general, while others have specifically focused on the contribution of globalisation. The latter have typically involved examining whether the impact of shocks to the monetary instrument on macroeconomic variables has weakened as the influence of global factors on these variables has increased. Using intra-daily data for the US, Faust et al (2007) find that the

[66] Litterman and Scheinkman (1991) found that the term structure of interest rates can be described by three factors, interpreted as the "level", "slope" and "curvature" of the yield curve.

response to surprise policy announcements by the FOMC across the term structure did not change over the period 1987 to 2002. Boivin and Giannoni (2008) estimate a Factor Augmented VAR (FAVAR) using US data for the period 1984 to 2005 and find that international factors have become more important for domestic macroeconomic variables especially the long-term interest rate, but that the transmission of monetary policy has not changed.[67]

Boivin et al (2010) again use a FAVAR to determine whether the US monetary transmission mechanism changed between the pre-1979 and post-1984 periods. They find that inflation, particularly expected inflation, and real output responded less to monetary policy shocks in the latter period and they suggest that this may be due to more reactive central banks, as measured by the coefficients in a policy reaction function. Thus, one way in which long-term interest rates may become less responsive to changes in short-term rates, is via the expectations channel. With a constant real interest rate, long-term interest rates will be relatively less responsive if inflation expectations are well anchored. However, it may be globalisation that is driving this decline in expected inflation (see Ciccarelli and Mojon (2010)).

A recent set of contributions to the literature has investigated whether the yield curve has global factors. However, these studies do not relate these factors to the monetary transmission mechanism. Diebold, Li and Yue (2008) estimate global factors for four major countries based on monthly data for the period 1985 to 2002 and find a dominant global level factor (reflecting global inflation) and an important slope factor (reflecting the global business cycle). They find that the importance of global factors increases with the maturity of bonds but, of all the countries in the sample, these factors are least important for the US. Kaminska, Meldrum and Smith (2011) use a three country affine term structure model to decompose forward rates into expectations of the short-rate, term premia and a convexity effect. They find common level and slope factors for the US, UK and euro area over the period 1992 to 2008 and relate these factors to global inflation and global economic activity, respectively. Local factors are

[67] A FAVAR uses a large dataset of macroeconomic indicators related to real activity, prices, interest rates, stock prices and money and credit aggregates, to extract common factors across countries.

also necessary to explain the behaviour of yields, with monetary policy being the most important local factor. While the focus of Kaminska et al (2011) is on modelling the commonalities across yields, we concentrate instead on the country-specific relation between yields of different maturities, once these commonalities have been removed. Therefore, although we also extract common factors, we instead concentrate on the idiosyncratic component.

Several authors have focused on a recent particular episode, the "conundrum", in which globalisation may have affected US long-term interest rates, but not specifically on how it has affected the relation between short- and long-term rates. Warnock and Warnock (2009) use monthly Treasury International Capital System (TIC) data to examine the effect of foreign official purchases of US Treasury and agency securities on short- and long-term Treasury yields. They find that these holdings had no effect on short-term yields but reduced the ten-year yields by up to 90 basis points in 2005. Craine and Martin (2009) use weekly data on foreign official holdings from the Federal Reserve Board's H4.1 release to examine whether this, or other factors such as an increase in the supply of these bonds, and surprise macroeconomic and monetary announcements, caused the fall in long-term yields. They find that the ten-year forward rate was at least 50 basis points lower in 2005 due to increased foreign holdings of US treasuries.

However, others have offered a different explanation for the behaviour of lower long-term interest rates during the conundrum period. Kim and Wright (2006) estimate a three factor affine model of the term structure of US yields and find that the term-premium fell significantly during the period 2004-2005. Similarly, Backus and Wright (2007) argue that the conundrum reflected a fall in the term-premium, although they do not explain which factors may be driving this. They suggest, however, that it could not primarily be due to increased official demand for treasuries, as similar declines in forward rates were observed in other countries. Gürkaynak and Wright (2010) estimate a term structure model with latent factors between 1971 and 2009 and find that term premia were lowest in the period 2004 to

2005. Finally, Smith and Taylor (2009) suggest that the conundrum was due to the perception among market participants that the coefficient on inflation in the Federal Reserve's policy rule had fallen and therefore, that future short-term interest rates would be lower.

Bernanke, Reinhart and Sack (2004) point to another episode when external factors significantly influenced long-term US interest rates. In a term-structure model with inflation and the output gap as factors, they find that treasury yields declined significantly during periods of substantial intervention by the Bank of Japan in the foreign exchange market between 2000 and 2004. The savings glut hypothesis is a closely related explanation as to how globalisation may have affected long-term yields. For example, Byrne et al (2010) show that the correlation between long-term interest rates across countries is actually greater than the correlation between short- and long-term interest rates within countries and that this correlation has been increasing over time. Using data for eight countries from 1988 to 2006, they find that the first principal component of long-term interest rates cointegrates with a measure of global foreign exchange reserves, which they suggest highlights the importance of the "global savings glut" in explaining lower long-term interest rates.

The conundrum episode is important in our model of daily yields, as it constitutes a structural break in the relation between short- and long-term rates. However, in testing for a cointegrating relation between long-term rates and foreign official demand for US treasuries, we also contribute to the debate on its origins. We now briefly outline the theoretical framework underpinning the yield curve and how it relates to our econometric model.

4.2 The Expectations Hypothesis and Monetary Policy

The "strong" form of the Expectations Hypothesis (EH) asserts that the term premium is zero and therefore that yields simply reflect expected short-term rates in the future. Given that the yield curve usually has a positive slope, this would imply ever-increasing future short-term rates. An empirically more reasonable assumption is to allow for a term premium but to assume that it is constant. This is the "weak" form of the EH and implies that any changes in yields must be related to changes in future expected short-term rates and the expected path of monetary policy.

Let $P_t(n)$ be the price at time t of a zero-coupon bond with n-years to maturity. The annual yield on this bond between t and $t+n$ can be written as:

$$y_t(n) = \frac{1}{n}\ln(P_t(n))$$

Yields on an n-period zero-coupon bond can also be written as the average of forward rates over the duration of the bond:

$$y_t(n) = \frac{1}{n}\sum_{i=1}^{n} f_t^i$$

The strong form of the EH assumes that investors are risk neutral and thus the risk premium that they require to hold long maturity bonds is zero. In this case, the i-period forward rate at time t is the expected short-term interest rate r at time $t+i-1$:

$$f_t^i = E_t r_{t+i-1}$$

The weak form of the EH suggests that investors demand a risk or term premium as compensation for holding long-term bonds.[68] Forward rates therefore include a term premium, b, and this premium may be maturity specific but is assumed to be constant:

$$f_t^i = E_t r_{t+i-1} + b_t^i$$

Therefore, according to the weak form of the EH, yields on zero-coupon bonds can be expressed as the average of expected future short-term rates plus a term premium:

[68] For example, this risk may take the form of higher than expected inflation or uncertainty about the path of future policy rates, and thus the resale value of the bond if it is sold prior to maturity.

$$y_t(n) = \frac{1}{n}\sum_{i=1}^{n}(E_t r_{t+i-1} + b_t^i)$$

An even weaker form of the EH, which we test in this chapter, allows the term premium to be time-varying but assumes that it is stationary. Empirical testing of the EH using Vector Error Correction (VECM) or Cointegrated VAR (CVAR) models focuses on examining whether the spreads between short-term rates and longer-term yields are stationary.

The spread between the yield on an n-period bond and the risk-free rate is given by the weighted average of future changes in the short-rate:

$$\begin{aligned} y_t(n) - y_t(1) &= [\frac{1}{n}\sum_{i=1}^{n}(E_t r_{t+i-1})] - r_t + \sum_{i=1}^{n} b_t^i \\ &= (\frac{1}{n} - 1)r_t + \frac{1}{n}\sum_{i=1}^{n=1} E_t r_{t+i} + \frac{1}{n}\sum_{i=1}^{n-1} b_t^i \\ &= \frac{1}{n}\sum_{i=1}^{n-1}(n-i)E_t(\Delta r_{t+i}) + \frac{1}{n}\sum_{i=1}^{n-1} b_t^i \end{aligned}$$

As bond yields are generally integrated of order one, then their first-differences, Δr_{t+i}, will be stationary. If the spread $y_t(n) - y_t(1)$ is non-stationary, then the term premium must be non-stationary. However, if pairs of spreads are stationary then the weighted differences between each yield's term premium must also be stationary.[69] For any constant weight c:

$$\begin{aligned} [y_t(n) - y_t(m)] - c[y_t(m) - y_t(1)] = \frac{1}{n}\sum_{i=1}^{n-1}(n-i)E_t(\Delta r_{t+i}) - \frac{1+c}{m}\sum_{i=1}^{m-1}(m-i) \\ E_t(\Delta r_{t+i}) + \frac{1}{n}\sum_{i=1}^{n-1} b_t^i - \frac{1+c}{m}\sum_{i=1}^{m-1} b_t^i \end{aligned}$$

The weighted difference between spreads expresses the curvature of the yield curve when

69 Intuitively, if the term premia cointegrate, this suggests that investors' *relative* preferences over bonds with different maturities are constant.

the yields are not equally spaced along the yield curve, as shown by Giese (2008). This has important implications for empirical testing of the EH. Unless the econometric model allows for cointegrating term premia, it may reject any long-term relation between short-, medium- and long-term yields.

The expectations hypothesis therefore, provides the theoretical framework for investigating the transmission of changes in the monetary policy instrument, for example the Federal Funds Rate or its target, to the rest of the term structure. This constitutes the first part of the monetary transmission mechanism, where the central bank seeks to "control" its intermediate target through changes in its instrument.

4.3 A Cointegrated VAR Model

The focus of this chapter is on how globalisation has affected the relation between short- and long-term rates. Cointegration analysis is particularly useful in the latter context as it allows us to determine whether there is a long-term relation between the policy rate and the term-structure of interest rates. In our daily model we focus on the period around the conundrum episode and examine whether we can detect a change in the nature of this relation and, if so, if it can be related to foreign official demand for US treasuries. We then examine this relation over the period between 1990 and 2007 using monthly data to allow for feedback from the yields to the policy rate. We leave it to the following section to investigate fully how globalisation has affected the monthly yield curve.

4.3.1 A Daily Model

The Federal Reserve intervenes daily in order to match the prevailing rate in the market for federal funds with the target for the Federal Funds Rate set by the FOMC. Therefore, we first examine whether the Federal Funds Rate closely follows its target and whether the target strongly influences other short-term rates. The presence of a cointegrating relation between the policy and short rates implies that the EH holds for at least the short-end of the yield curve. We then extend the analysis to include medium- and longer-term yields and test whether the spreads between these yields and those at the short-end of the yield curve are stationary, as the EH would imply.

Daily data for the Federal Funds Rate and its target are from the FRED database of the Federal Reserve Bank of St. Louis, while the yields for three- and six-month, and one-, five- and ten-year zero-coupon US treasuries are taken from the updated dataset of Gurkaynak, Sack and Wright (2007). The daily models are estimated for the period 1 April 2003 to 31 March 2007, the sample being truncated at this latter date due to the significant increase in the volatility of financial markets at the onset of the financial crisis.[70] This provides a sample of 1044 observations. Figure 4.1 plots these variables over our sample period. From the top panel in Figure 4.1, it is clear that, not only has the Federal Funds Rate (FFR) tracked its target very closely, but that the three- and six-month yields have also reacted strongly to changes in the policy rate. The lower panel in Figure 4.1 shows that co-movement with the Federal Funds Rate target is decreasing with the maturity of the bonds, with the five- and ten-year yields appearing invariant to changes in shorter-term rates.

Short-term Yields

To examine the relation between the FFR and its target, and the short-end of the yield curve, we estimate a Cointegrated VAR with the following form:

$$\Delta x_t = \alpha(\beta', \beta_0)\begin{pmatrix} x_{t-1} \\ 1 \end{pmatrix} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + A_0 z_t + \phi D_t + \varepsilon_t \tag{4.1}$$

where $\varepsilon_t \sim iidN(0, \Omega)$, $x'_t = [ffr, G3m, G6m]$ is a vector of endogenous variables, $z_t = [Trg_t]$ is the Federal Funds Rate target and, as it is set periodically by the FOMC, it is treated as exogenous. The constant, β_0, is restricted to the cointegrating relations. D_t is a vector of dummy variables that control for particularly large shocks affecting the interest rates during the sample period.

[70] We found a significant increase in Autoregressive Conditional Heteroskedasticity (ARCH) effects when later data were included.

Likelihood ratio tests suggested that two lags were sufficient to capture the persistence of short-run effects. The results of the misspecification tests on the VAR(2) model are presented in Table 4.1. The multivariate test of no first-order serial correlation is not rejected at the five percent level, while the null hypothesis of no ARCH effects is only rejected for the Federal Funds Rate. Normality (Jarque-Bera test) is rejected for the three endogenous variables, although this is due to excess kurtosis rather than skewness (not reported). As VAR parameter estimates have been shown to be robust to ARCH effects and kurtosis, these rejections should not significantly affect our analysis (see Gonzalo and Ng (2001) and Juselius (2006) for a discussion). We also test whether any of the endogenous variables may actually be weakly exogenous and this is clearly rejected.[71]

To determine the rank (r) of the $\Pi = \alpha\beta$ matrix, or the number of cointegrating relations, we consider both the Johansen Trace test and the characteristic roots of the process. Table 4.1 shows that the trace test suggests $r = 2$ and this choice of rank leaves 0.877 as the largest root in the model. As this is consistent with a stationary process that exhibits slow mean-reversion, it appears to be a reasonable choice of rank. Our finding of two cointegrating relations and one stochastic trend among the three endogenous variables is supportive of the Expectations Hypothesis, which implies that the spreads between non-stationary yields (here, the three- and six-month yields) and the yield with the shortest maturity (here, the FFR) should be stationary.

Table 4.2 presents the overidentified cointegrating relations and adjustment coefficients, as well as the short-run parameters from the Γ_1 matrix. This restricted model was accepted with a $\chi^2(2)$ statistic of 0.4 and a p-value of 0.72.[72] Further restrictions of exact and non-exact spreads between the FFR and the target in the first cointegrating relation, $\widehat{\beta}_1$, were rejected.

71 A weakly exogenous variable is affected only by its own shocks in the long run and not by those to other variables. This implies a zero-row in the matrix of adjustment coefficients.

72 The restrictions on the CVAR can be formulated by specifying the number of free parameters, s_i in each β vector: $\beta = (H_1\varphi_1, ..., H_r\varphi_r)$ where β is $(p_1 \times r)$, p_1 is the dimension of the CVAR, φ_i are $(s_i \times 1)$ coefficient matrices and H_i are $(p_1 \times s_i)$ design matrices which are used to determine the free parameters in each cointegrating vector. These restrictions are then tested using a likelihood-ratio test (see Juselius (2006)).

The first cointegrating relation is between the FFR, the target and the three-month yield, and the FFR is strongly adjusting to this relation. This relation is evident in the top panel of Figure 4.1 where all three rates display significant long-run (and short-run) comovement. It suggests that the FOMC reacts to short-term rates by targeting the FFR. Although the three- and six-month yields are not adjusting to this relation, the latter is only marginally insignificant. The second relation, is the exact spread between the three- and six-month yields and thus provides evidence for the EH for the short-end of the yield curve. Both of these yields are strongly adjusting to this relation, implying that any deviation from the spread is quickly corrected by the market. A recursive test of the constancy of the log-likelihood and the cointegrating relations did not reveal any parameter instability over the sample period.[73]

Table 4.2 also presents information about the short-run effects of the endogenous and exogenous variables. The most important finding given the focus of this chapter is that the contemporaneous and lagged changes in the target have significant effects on nearly all the endogenous variables, as would be expected from changes in monetary policy. Although, changes in the target by the FOMC have clear short-run effects on short-term yields, Johansen and Juselius (2001) argue that for these yields to serve as intermediate targets in the monetary transmission they must also be affected by shocks to the target in the long run. To see which shocks are driving these yields in the long-term, we can look at the C-matrix shown in Table 4.3 which is derived from the Moving-Average (MA) representation of the VAR:

$$x_t = C\sum_{i=1}^{t}\varepsilon_i + C^*(L)\varepsilon_t + \widetilde{X}_0 \tag{4.2}$$

where $C = \widetilde{\beta}_\perp \alpha'_\perp$, $\widetilde{\beta}_\perp = \beta_\perp(\alpha'_\perp \Gamma \beta_\perp)^{-1}$. C^* is a stationary process and $\widetilde{X}_0$ are the initial conditions. The model contains one stochastic trend, which as $\alpha_\perp$ parameters show, mainly comprises shocks to the three- and six-month yields. The loading parameters show that the

[73] The recursive test of the log-likelihood estimates the model over a baseline period at the beginning of the sample and then recursively tests whether subsequent observations follow the same model. Under the null hypothesis of constant parameters, the 5% confidence value of the test is 1.36. (see Juselius (2006), chapter 9).

FFR is not strongly affected by the cumulated shocks to the yields. As the yields are not affected by the shocks to the FFR in the long run, this would imply that these yields cannot serve as intermediate targets according to the methodology of Johansen and Juselius (2001). We have shown that changes in the monetary instrument (the target) have strong short-run effects on both the FFR and the yields but that, in the long-run, these yields are affected by shocks not related to the conduct of monetary policy.

The Daily Term Structure

The previous section showed that the EH holds in general for short-term yields and therefore that there was a close relation between changes in the policy rates and short-term yields during the conundrum period. As we are interested in examining the transmission of monetary shocks across the yield curve, we now extend our analysis to include medium- and long-term yields. In order to limit the dimension of the CVAR and having shown that the homogenous spread between the three- and six-month yields is stationary, we exclude the latter from this model. We re-estimate the model in equation (4.1) with a vector of endogenous variables that now includes the FFR, the three-month yield, and the one-, five- and ten-year zero-coupon yields: x_t'=$[ffr$,$G3m$,$G1y$,$G5y$,$G10y]$. Likelihood tests for the appropriate lag-length in this model suggest that three lags are now needed to account for short-run persistence after including the longer-term yields. Table 4.4 presents the misspecification tests for this model. Multivariate normality is again rejected, with the univariate tests suggesting that only the ten-year yield is normally distributed. We expect that our parameter estimates are robust to this rejection, as it is again due to excess kurtosis rather than skewness. As in the previous analysis, the estimates should also be robust to the moderate ARCH effects in the FFR. We find that none of the variables can be considered weakly exogenous.

Table 4.4 also shows the results of the trace test and the characteristic roots of the process. The trace test suggests a rank of $r = 4$, which implies one unit root process. This leaves a large root of 0.931 in the model. As this may be consistent with a slow mean-reverting process or with a unit root process that cannot be detected due to the low power of the trace test, we also look at the unrestricted adjustment coefficients presented in Table 4.5. The fourth column of this table shows that one-, five- and ten-year yields are strongly adjusting to a fourth cointegrating relation. Therefore, this evidence suggests $r = 4$.

The over-identified cointegrating relations, adjustment coefficients and short-run parameters are shown in Table 4.6. This model was accepted with a $\chi^2(9)$ statistic of 15.132 and a p-value of 0.1. Recursive tests on the constancy of the likelihood suggested that the parameters in the model are not constant. Figure 4.2 illustrates that a break appears to have occurred in the cointegration relations in the middle of 2004, the point at which the dashed R1(t) line representing the parameters of the cointegrating relations exceed the five percent confidence value 1.36. This suggests that a level shift occurred in the relation between yields around this time.

As no such instability was evident in the model with short-term yields, this instability must be related to longer-term yields. This suggests that the model is capturing the Greenspan "conundrum" when the FFR and short-term yields became disconnected from long-term yields. Furthermore, the timing of the break coincides with a period when foreign central banks and finance ministries were rapidly increasing their holdings of mainly long-term US government securities, as documented in Craine and Martin (2009) and Warnock and Warnock (2009). This demand increased the price of long-term US treasuries and resulted in a fall in long-term yields, even though short-term rates were rising. We return to the possible connection between long-term rates and official holdings below. In the current framework, we control for this change in the behaviour of long- relative to short-rates by including a structural break in the model in mid-July 2004.[74]

The first cointegrating relation is the non-exact spread between the three-month yield and

[74] The model is not sensitive to our choice for the specific date of the break. The results are similar when a break is placed at any date between June and August 2004. We chose the middle of July as it is the mid-point of this range and is close to the date that the Federal Reserve began its tightening cycle.

the ten-year yield. The break dummy is significant, again indicating that there was a change in the relation between short- and long-rates during this period and that a break or level shift is needed to make this relation stationary. The FFR, and the five- and ten-year rates are all significantly adjusting to this spread. The second cointegrating relation is the same relation between the FFR, its target rate and the three-month yield as in the model with short-term yields and, as before, only the FFR is adjusting.

The final two relations are the exact spreads between the three-month yield and one- and five-year yields, respectively. It is interesting that the break dummy is significant in both relations and it implies that the yields on treasuries with maturities as short as one year also became disconnected from those at the short-end of the yield curve. Adjustment to the one-, five- and ten-year spreads is almost identical. The main difference is that the three-month rate appears only to adjust to the one-year spread.

Table 4.6 also presents the short-run effects of changes in each of the exogenous and endogenous variables. It is clear that changes in the FFR target by the FOMC have no contemporaneous or lagged effects on treasuries with maturities of one year or more over our sample period. Further, the short-run behaviour of these yields is mainly driven by lagged own-changes and the lagged changes of the other yields, although lagged changes in the three-month yield do have a significant effect on current changes in the one-year yield.

To determine what drives these yields in the long-term we can look at the C-matrix presented in Table 4.7. With five endogenous variables and $r = 4$, there is one stochastic trend and this mainly comprises shocks to the five- and ten-year yields. The loading coefficients, $\widetilde{\beta}_{\perp}$, show that the FFR does not load strongly on this trend, and therefore we can conclude that it is mainly affected by changes in the target, as shown in Table 4.6. The other variables load on the trend according to their coefficients from the cointegrating relations. As before, shocks to the FFR have no long-run effects on the yields.

Foreign Official Treasury Demand and the Conundrum

We now return to the possible connection between the break in the transmission mechanism and official purchases of long-term treasuries. The cointegrated VAR is an ideal framework to investigate whether a long-term relation exists between long-term yields and official holdings of long-term treasuries. The H4.1 release from the Federal Reserve provides the weekly total of foreign official holdings of US treasuries at the Federal Reserve Bank of New York and these official holdings, scaled by total US government debt, are plotted in Figure 4.3.[75] It is clear that official demand for US treasuries began to increase rapidly towards the end of 2003 and beginning of 2004. We therefore test whether a cointegrating relation exists between the five- and ten-year yields and the holding of these bonds by foreign central banks and finance ministries.[76]

Table 4.8 presents the results of the model with these three endogenous variables, estimated using weekly data covering the period 5 January 2000 to 28 March 2007. The trace test and the unrestricted adjustment coefficients suggested a rank $r = 2$ and thus two cointegrating relations. The over-identified CVAR(2) was accepted with a $\chi^2(2)$ statistic of 4.29 and p-value of 0.117. The first relation is the exact spread between the five- and ten-year yields and is stationary around a constant. Foreign official holdings of US treasuries tend to increase when the yields deviate from this relation. The second relation is between the ten-year rate and official holdings with both of the yields adjusting to this relation. Therefore, both the ten-year rate and foreign official demand for US Treasuries move together in the long-run. The short-run parameters indicate that the lagged change in the five-year yields influences the change in the ten-year yield, while the lagged change in the latter has a sig-

[75] http://www.federalreserve.gov/releases/h41/

[76] The H4.1 release provides the most timely (weekly) data on foreign official holdings of US securities but includes only those holdings held at the Federal Reserve Bank of New York. A more complete estimate of foreign official holdings at the monthly level is available from Bertraut and Tyron (2007) who combine annual TIC survey data with monthly transactions data. However, using monthly data would significantly reduce the number of observations over the sample period and thus, the power of the trace test. We do identify similar cointegrating relations to those in the weekly model when we use monthly data, but given the lower power of the trace test, this model is unlikely to be well-specified. The correlation between the H4.1 series and that estimated by Bertraut and Tyron (2007) is 0.85 over our sample period.

nificant effect on foreign official holdings. The long-run impact matrix indicates that only shocks to foreign official demand have permanent effects on the yields.

Our analysis of the daily data has provided some evidence that yields on treasuries of different maturities are cointegrated, as the Expectations Hypothesis would predict. We also find a break in the transmission of changes in short-rates to longer-term rates. We show that this can be explained by the close relation between long-term rates and foreign official holdings of US securities. This approach has treated changes in policy rates as exogenous, which is a valid assumption with daily data. However, to allow feedback from longer-term rates to policy changes, we now look at the transmission between short- and long-term yields using monthly data. In the following section, we then examine whether the nature of the transmission mechanism changes, once the global factors that influence monthly yields have been removed.

4.3.2 A Monthly Model

In the daily model, changes in the policy rate were treated as exogenous and therefore no feedback was permitted from long-term rates. However, at the monthly level central banks may react to changes in economic conditions which are reflected in these rates. Further, while the FFR and its target rate may deviate on a daily basis, they are indistinguishable at monthly frequencies. We therefore re-examine the relation between short- and long-term yields using monthly zero-coupon yield data from Wright (2011) and we use the FFR to reflect changes in the policy rate. The variables are the monthly counterparts of the yields used in the daily model. The sample covers the period from January 1990 to March 2007, which provides 207 observations. Figure 4.4 plots the FFR, the three- and six-month zero-coupon yields, and the one-, five- and ten-year yields on US treasuries over this period. It is clear that there is strong comovement across yields of all maturities apart from a short-period between 2004 and 2005.

A CVAR Model of the Monthly Term Structure

The estimating equation for the monthly model is similar to equation (4.1) except that the exogenous FFR target, z_t, is now excluded. The vector of endogenous variables, x_t=[ffr_t,$G3m_t$,$G6m_t$, $G5y$,$G10y$], contains the six variables plotted in Figure 4.4. Likelihood ratio tests found that two lags were necessary to capture the short-run persistence. Table 4.9 presents the results of the misspecification tests and tests for the weak exogeneity of the variables. ARCH effects are not significant in the monthly model, while normality is only rejected for the FFR and short-term yields. As before, this is due to excess kurtosis rather than skewness. First- and second-order autocorrelation is rejected. We also find that the ten-year yield can be considered to be weakly exogenous, while the one-year yield is marginally so. A test of joint exogeneity of both the one- and ten-year yields was strongly rejected and so only the latter is treated as weakly-exogenous.

Table 4.9 also reports the results of the trace test and the characteristic roots for the rank suggested by that test. The trace test suggests four cointegrating relations which implies two unit root processes. This choice of rank leaves 0.877 as the largest stationary root in the model. For confirmation that this choice is reasonable, we can also look at the unrestricted adjustment coefficients presented in Table 4.10. It is clear that there is significant adjustment to four cointegrating vectors and thus $r = 4$ appears to be a suitable description of the number of stationary relations in the model.

The four over-identified cointegrating relations, adjustment coefficients and short-run parameters are shown in Table 4.11. This model was accepted with a $\chi^2(10)$ statistic of 13.0 and a p-value of 0.223. The first relation is the non-exact spread between the FFR and the six-month yield, which is stationary around the constant. Only the FFR adjusts to this relation. The second relation is the spread between the FFR and the three-month yield. It is interesting that the latter is the adjusting variable, given that the former adjusts in the first relation. The third cointegrating relation represents the stationary curvature of the yield curve at mediumto long-maturities and the three-month through five-year yields are all significantly adjusting to this relation.[77] The final cointegrating relation is the weighted spread between short-and long-term yields.[78] Adjustment to the third and fourth relation is very similar, although the one-year yield is marginally insignificant in the latter.

Table 4.11 also presents estimates of the short-run parameters in the model. The FFR is mainly influenced by lagged changes in long-term yields, the three-month yield and its own lag in the short-run. The three-month yield is mainly affected by the lagged change in the FFR and one-year yields, while short-run persistence in long-term yields is mainly a result of lagged changes in these yields. Interestingly, given the focus of this chapter, the FFR has no short-run effect on any yield in our dataset, apart from the yield on the three-month bond.

Tests for the constancy of the log-likelihood did not reveal any parameter instability. This is surprising given our finding of a structural break in the daily model in 2004. However, the conundrum period was a temporary episode and is likely to be less significant at the monthly level in the context of a sample that begins in 1990. We therefore assume that the parameters in the model have remained stable over the sample period.

Common Trends and the Structural MA Model

We now turn to the stochastic trends in the model. Table 4.12 shows that the first common trend comprises shocks to the weakly exogenous ten-year rate, while the second common trend is mainly driven by shocks to the six-month and one-year yields and, to a lesser extent, the five-year yield. The loadings to the first common trend are in a narrow range between 0.69 and 1.27 and suggest that each yield is affected similarly by shocks to the ten-year yield. Therefore, the first common trend is likely to be a level factor. The loadings to the second common trend are similar up to one year and then decline. This may indicate a slope factor with positive shocks to the six-month and one and five-year yields increasing the slope and

[77] The third cointegration relation has the form: $\beta_3' x_t = 0.57(G5y_t - G1y_t) - 0.43(G10y_t - G5y_t)$.

[78] The fourth cointegrating relation can be expressed as: $\beta_4' x_t = 0.78(G5y_t - ffr) - 0.22(G10y_t - G5y_t) - 0.07$.

resulting in a large negative effect on short-yields (see Giese (2008)).

As the residuals are correlated in the MA representation, we now attempt to separate the residuals, ε_t, into permanent and transitory shocks, u_t. We therefore form the $\widetilde{C} = CB^{-1}$ matrix from a rotation of the C-matrix where only the $p - r = 2$ linear combinations of the structural shocks have permanent effects and r shocks have only transitory effects. This gives the "structural MA" representation:

$$x_t = CB^{-1}\sum_{i=1}^{t} u_i + C^*(L)B^{-1}u_t + \widetilde{X}_0 \tag{4.3}$$

where $\varepsilon_t = B^{-1}u_t$ and $\widetilde{X}_0$ are initial conditions. The B matrix shows which linear combinations of the shocks generate the transitory and permanent effects. As there are two permanent shocks in the model, it is necessary to impose a zero-restriction on one of the shocks in order to identify the $\widetilde{C}$ matrix. As the ten-year rate was found to be weakly exogenous this suggests that cumulated shocks to the ten-year rate are not correlated with the shocks to the other yields. Therefore, we place the zero-restriction on the ten-year yield in the second permanent shock.

The (normalised) structural impact matrix is presented in Table 4.13. The first $r = 4$ columns indicate the long-run effects of transitory shocks, while the last $p - r = 2$ columns indicate the long-run effects of the permanent shocks. The coefficients indicate how each variable loads on the permanent shock. The loadings on the first permanent shock are in a relatively narrow range between 0.617 and 1 and therefore this shock may represent a level factor. The loadings on the second permanent shock are similar up to the one-year yield but are much smaller on the five-year yield. This suggests that the second permanent shock represents a slope factor.

Table 4.13 also presents the rotation matrix, B, which indicates the extent to which the permanent and transitory shocks are influenced by the shocks to each variables. As we are primarily interested in the permanent shocks, we focus on the last two rows of the B-matrix which represent the first and second permanent shocks, respectively. The first permanent shock mainly comprises shocks to medium- and long-term yields and the second permanent shock is mainly determined by shocks to the spread between the six-month and one-year yields. Therefore, although it is difficult to give the permanent shocks a precise economic interpretation, it appears reasonable to conclude that the two permanent shocks and common trends represent shocks to the level and slope of the yield curve.

4.4 Globalisation and the Monthly Term Structure

We now attempt to determine how globalisation has affected the monthly term-structure, and specifically, the transmission of changes in monetary policy across the term structure. In the daily model, we found a break in the relation between short- and long-rates that strongly coincided with the sharp increase in the purchase of long-term treasuries by foreign central banks. However, no such break was evident when monthly data was used. In any case, the impact of globalisation on the transmission between short- and long yields may be gradual and therefore a clear break in the transmission may be difficult to detect. The aim of this section is to separate the domestic factors from the global factors that influence each yield and analyse whether the Expectations Hypothesis holds when only domestic factors are considered. Further, if globalisation dampens the effect of changes in monetary policy on yields of every maturity, we should observe a much stronger influence of changes in monetary policy on yields across the term structure, once global factors have been excluded.

4.4.1 Global Factors and Idiosyncratic Components

We extract the global and US-specific factors from each yield using a factor model of the form:

$$X_t = \Lambda F_t + e_t \tag{4.4}$$

where X_t is a $T \times N$ matrix of yields for N countries, F_t is a $r \times T$ vector of factors common to all countries and Λ is a $N \times r$ matrix of factor loadings with $r \leq N$. e_t is a $T \times N$ vector of idiosyncratic components, which can exhibit weak cross-sectional dependence and weak serial correlation. We estimate F_t by conducting principal component analysis on X_t and obtain the idiosyncratic component from a regression of the yields on the estimated factors.

As the yields are non-stationary and it is not known whether this non-stationarity has a pervasive (common) or an idiosyncratic source, the factors will not be consistently estimated by principal components analysis in a panel with a cross-sectional dimension of the size in our sample. Similarly, the dimension is not sufficiently large to use the Bai and Ng (2004) common-idiosyncratic (I-C) methodology to obtain the number of factors as this requires $N \geq 40$ for consistent estimation. Our approach is to adopt the Bai and Ng (2004) method of conducting principal components analysis on the first differences of the yields and then re-cumulating the estimates to form the factors. However, we ascertain the appropriate number of factors from the proportion of variance explained rather than from the information criteria that Bai and Ng (2004) propose.

Zero-coupon yields on government bonds for eight countries with the same maturities as in the previous section are taken from the dataset of Wright (2011) and the sample period is chosen to coincide with that of the previous section.[79] The yields are plotted in Figures 4.5 through 4.9. It is clear that there has been a downward trend in long-term yields across all countries since the beginning of the 1990s, whereas short-term yields only exhibited a clear downward trend in the first half of that decade.

We find that three factors are sufficient to account for the majority of variation in each yield as additional factors have eigenvalues less than one. Table 4.14 reports the loadings of each US yield on each of the common factors affecting that yield, as well as the proportion of each yield's variance that is unique to the US. The first factor has the largest effect on yields and increases with maturity. The second factor mainly affects medium-term maturities,

[79] The sample includes the following countries: Australia, Canada, Germany, Japan, New Zealand, Switzerland, United Kingdom and United States.

while the third factor primarily influences the three-month, one- and ten-year yields. The proportion of each yield's variance that is unique to the US declines with maturity, indicating that globalisation has a larger effect on long- relative to short-term yields.

We also examine whether the source of the non-stationarity of yields is due to factors, idiosyncratic components, or both. The order of integration of the idiosyncratic component of each yield has important implications for our analysis. As we are primarily interested in whether there is a stronger relation between short- and long-term yields when global influences on yields are removed, the finding of stationary idiosyncratic components would indicate that there is no long-run relation between the US-specific component of yields on government bonds of different maturities. This would imply that the long-run relation between yields is being driven by factors common to other countries.

Therefore, we conduct Augmented Dickey-Fuller (ADF) unit root tests on the factors and idiosyncratic components to determine whether the non-stationarity is pervasive (common to all countries) or idiosyncratic (unique to the US).[80] The results of these tests are reported in Table 4.15 and show that the source of non-stationarity is both pervasive and idiosyncratic. The null hypothesis of a unit root in the levels of the factors and idiosyncratic component is only rejected for the second factor of the six-month, and one- and five-year yields. Table 4.15 also reports the results of unit root tests on the first differences and they are found to be stationary.

4.4.2 A CVAR Model of Idiosyncratic Components

Our finding of non-stationary idiosyncratic components allows us to continue with our analysis and examine the long-run relation between the US-specific components of zero-coupon treasury yields. Therefore, we re-estimate equation (4.1) with the estimated idiosyncratic components as the endogenous variables in the model. We also include the Federal Funds Rate in order to measure changes in monetary policy, as in the monthly model in the

80 We also conducted Phillips-Perron unit roots tests and obtained similar results to the ADF tests.

previous section. The model is estimated over the period February 1990 to March 2007, providing 206 observations. Likelihood ratio tests indicated that two lags were again sufficient to capture short-run persistence at monthly frequencies. Table 4.16 presents the results of the misspecification tests on this model. The model appears to be well specified apart from the rejection of normality for the FFR and the three-month yield. This is again due to excess kurtosis rather than skewness and therefore should not affect the estimated parameters. Table 4.16 shows that none of the variables can be considered weakly exogenous, in contrast to the monthly model of non-factored yields in the previous section, which found that the ten-year yield was exogenous. This indicates that the exogeneity is due to global factors.

Table 4.16 also reports the results of the trace test and the characteristic roots in the model. The former suggests that there are at least two cointegrating relations. However, the unrestricted coefficients reported in Table 4.17 show that there is strong adjustment to five cointegrating relations. A rank of five leaves 0.931 as the largest stationary root in the model, which may correspond to a slow mean-reverting process. On balance, and particularly given the large t-statistics on the adjustment coefficients to the five relations, we choose $r = 5$.

The over-identified cointegrating relations, adjustment coefficients and short-run parameters are presented in Table 4.18. The model is accepted with a $\chi^2(8)$ statistic of 12.8 and a $p-$value of 0.117. The five cointegrating vectors are the five exact spreads relative to the FFR. This suggests that we observe greater evidence for the Expectations Hypothesis once we focus on the idiosyncratic components of the yields. Each variable is adjusting, again suggesting that the FFR is not a weakly exogenous variable, but instead reacts to changes in the yields. Most of the short-term persistence in the model comes from the FFR and three-month yield at the short- to medium-term maturities and the ten-year yield at medium- to longer-term maturities. Finally, Table 4.19 indicates that the stochastic trend in the idiosyncratic components comprises shocks to the spreads between the yields. Shocks to the FFR do not have permanent effects, consistent with our earlier findings.

Comparing the model with non-factored yields in the previous section with the model with idiosyncratic components, we can see the effects of financial globalisation. In the former, there is no clear evidence for the Expectations Hypothesis, except perhaps at the short-end of the yield curve. In addition, the stochastic trends are given by shocks to the level and slope of the yield curve. When we focus on the US-specific components of yields, we find much stronger evidence for the EH while the stochastic trend is mainly given by shocks to the spreads between the idiosyncratic components. The short-run effects of changes in the FFR are similar in both models, indicating that the short-term effects of monetary policy are not influenced by global factors.

4.5 Conclusions

We examine the relation between policy rates and the term-structure of interest rates and analyse how globalisation has affected this relation. Using a Cointegrated VAR with daily data on US yields, we find that the spreads between short- and long-term yields are stationary but that the parameters of the cointegrating relations changed during the conundrum period. We find that changes in the Federal Funds Rate target have significant short-run effects on the short-end of the yield curve but that, in the long-run, yields are mainly influenced by shocks to long-term yields. We then consider whether the change in the behaviour of long-term yields during the conundrum period may be related to foreign official demand for US Treasuries. We find clear evidence of a long-run relation between long-term yields and foreign official Treasury holdings, which is consistent with the findings of Warnock and Warnock (2009) and Craine and Martin (2009).

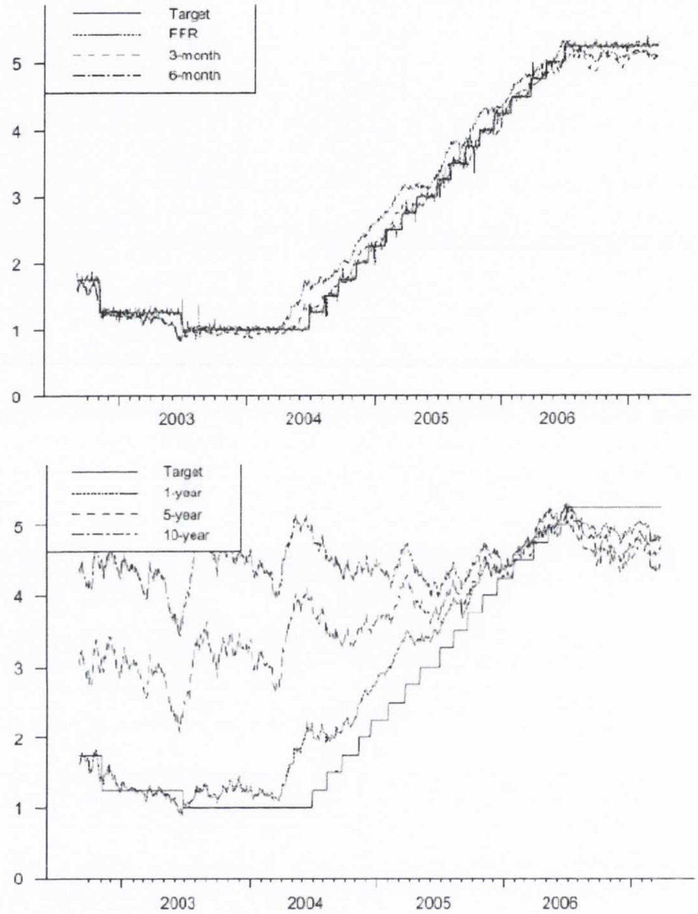
To account for the possibly more gradual effects of financial globalisation, we re-estimate the cointegrated VAR model using monthly yield data since 1990. We first show that, although the spreads between short-term yields are stationary, the spreads between short- and long-term yields are non-stationary. This is consistent with the findings of Shea (1992) and Giese (2008), who show that the yield curve is characterised by more than one stochastic trend at the long-end of the term structure and suggest that the failure of the Expectations Hypothesis is due to non-stationary term premia. We show that the weighted-spreads between yields, which describe the curvature of the yield curve, are stationary and therefore, that term premia at different maturities cointegrate. The monthly yields in our model are influenced by two stochastic trends which have the approximate interpretation of level and slope factors.

We then attempt to remove the effects of globalisation by obtaining each yield's idiosyncratic component from a regression of the yields on three factors common to a sample of eight countries. When we re-estimate the cointegrated VAR with these idiosyncratic components we find that the Federal Funds Rate and each of the yields are cointegrated. The stochastic trend driving the yields now comprises shocks to the spreads between yields. As there is no clearly exogenous idiosyncratic component, the economic interpretation of this stochastic trend is unclear. However, as the Expectations Hypothesis holds for all idiosyncratic components in this model, the term premium associated with each yield must now be stationary. This suggests that the stochastic trend related to term premia is influenced by global factors. Indeed, Wright (2011) shows that the downward trend in long-term yields across countries is the result of a decline in term premia due to lower uncertainty about inflation.

Our results are also consistent with the findings of Diebold et al (2008) who find a global level factor relating to "global inflation" and a global slope factor relating to a "global business cycle". However, Diebold et al (2008) model these factors as stationary but persistent processes. Therefore, an interesting extension of our analysis would be to examine how our estimated common factors, which are mainly non-stationary, load on measures of global inflation, for example as constructed by Ciccarelli and Mojon (2010), and global real economic activity.

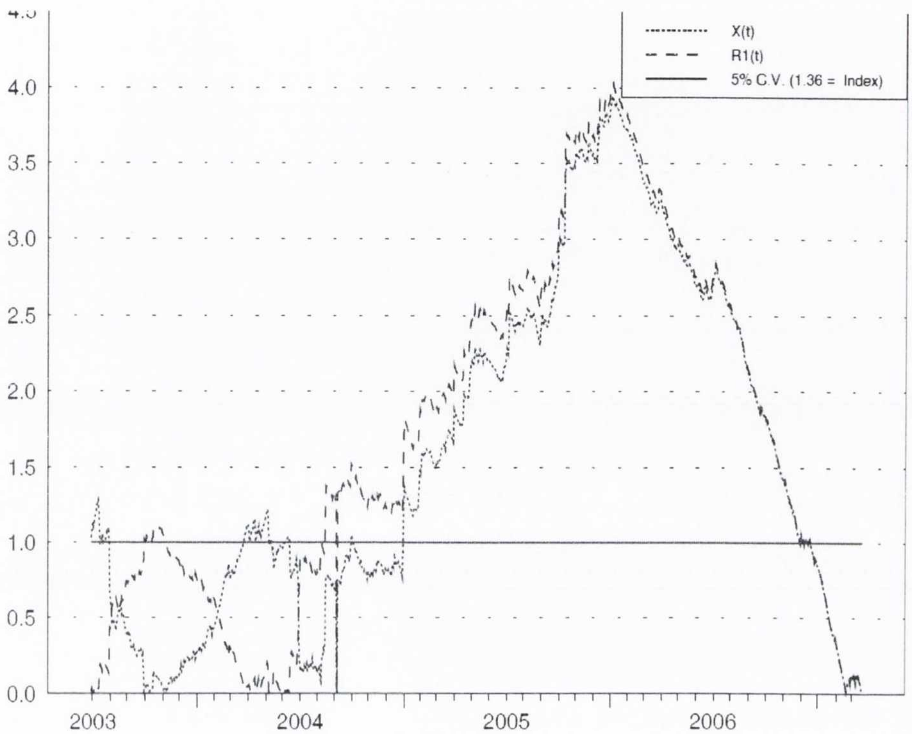
How do our findings relate to the globalisation and effectiveness of monetary policy debate? Woodford (2009) shows that a central bank will always be able to control domestic inflation regardless of the level of financial integration because it can influence the opportunity cost of holding money. Our results show that changes in the policy rate have significant short-run effects on the short-end of the yield curve and therefore that, in the context of Woodford's model, monetary policy would still be effective in controlling inflation. However, Kamin (2010) suggests globalisation may make the conduct of monetary policy more complex because it increases the range of shocks to which a central bank must respond. We find that, in the long run, yields are mainly affected by shocks to the level and slope of the yield curve. In terms of the yield curve, the main impact of globalisation appears to be on the term premium, possibly related to uncertainty about global inflation or real output. It is in this sense that global factors have important implications for the conduct of monetary policy.

Figure 4.1: Daily Federal Funds Rate, Target and zero-coupon US Yields



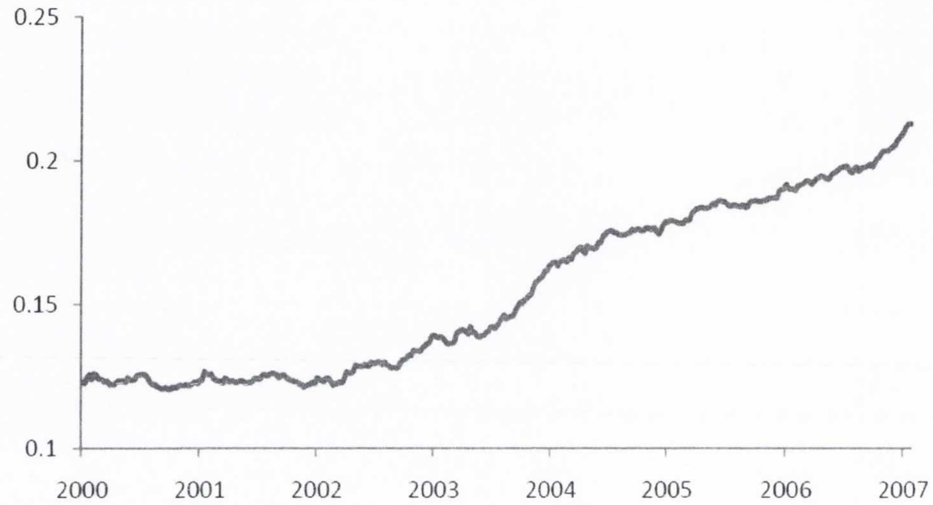
Source: Daily Federal Funds Rate and Target for the period 1 April 2003 to 31 March 2007 are taken from the FRED database. The daily 3- and 6-month, 1-, 5- and 10-year zero-coupon yields are taken from the dataset of Gurkaynak, Sack and Wright (2007).

Figure 4.2: Test for constancy of the log-likelihood for daily model



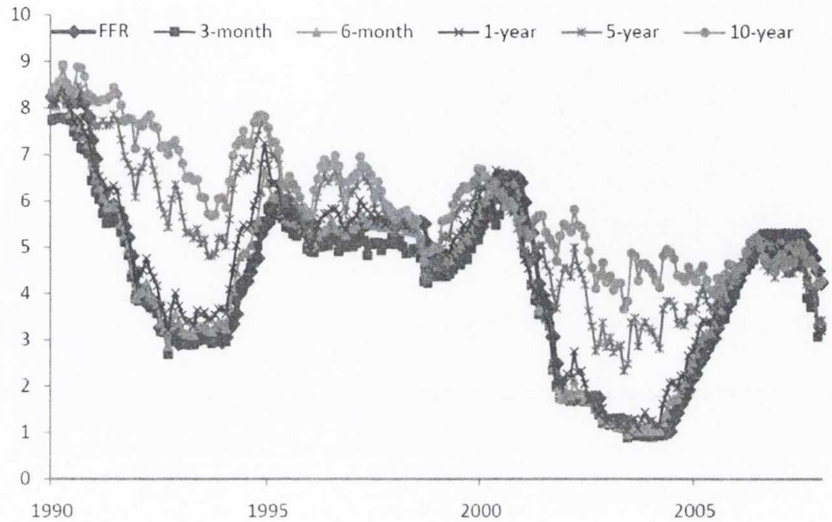
Notes: X(1) measures the constancy of the log-likelihood for the full model while R(1) measures the constancy of the "concentrated" model where the short-run effects are concentrated out of the log-likelihood.

Figure 4.3: Foreign Official Treasury Holdings as a share of US Government Debt



Notes: Foreign official holdings of US treasury securities from the Federal Reserve H4.1 release. Total US government debt is taken from the *FRED* database.

Figure 4.4: Monthly US zero-coupon Yields



Notes: zero-coupon yields on US treasuries of selected maturities from Wright (2011).

Figure 4.5: 3-month zero-coupon Yields

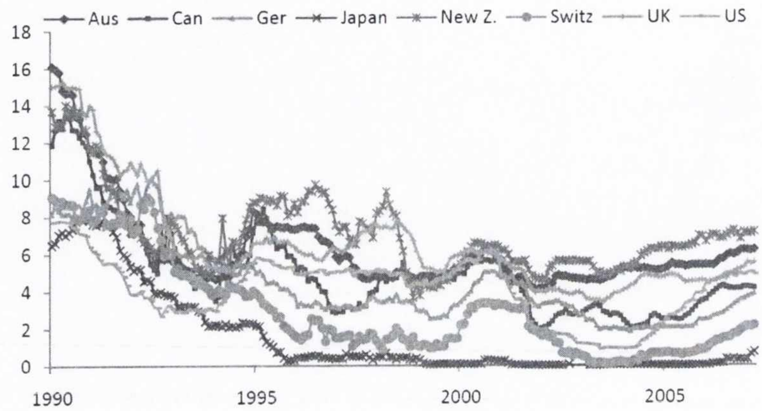


Figure 4.6: 6-month zero-coupon Yields

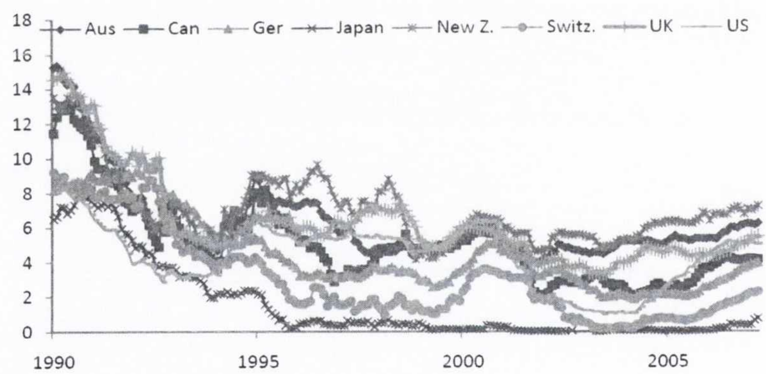


Figure 4.7: 1-year zero-coupon Yields

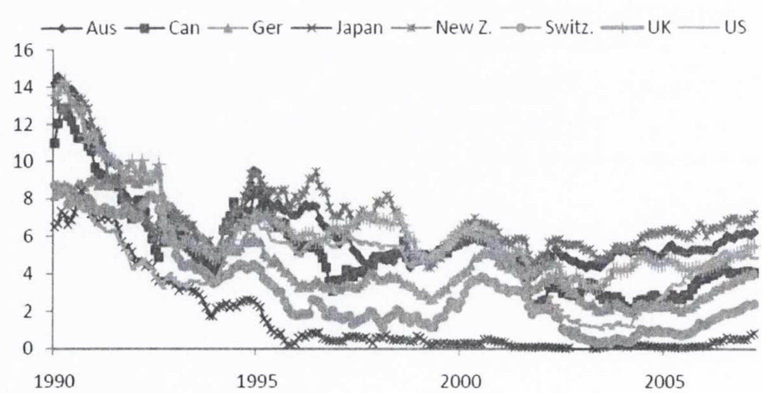


Figure 4.8: 5-year zero-coupon Yields

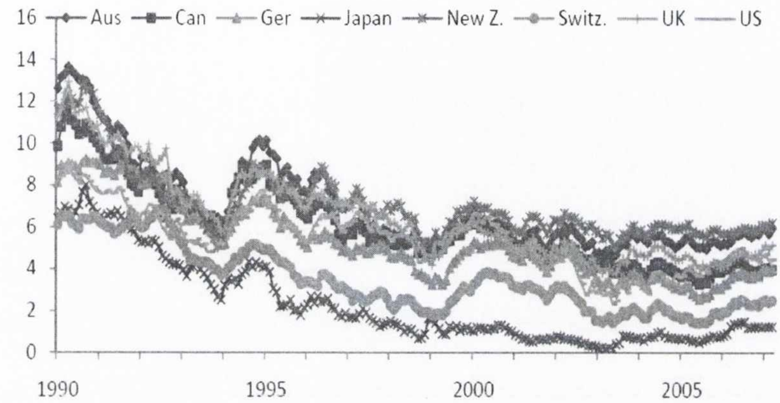
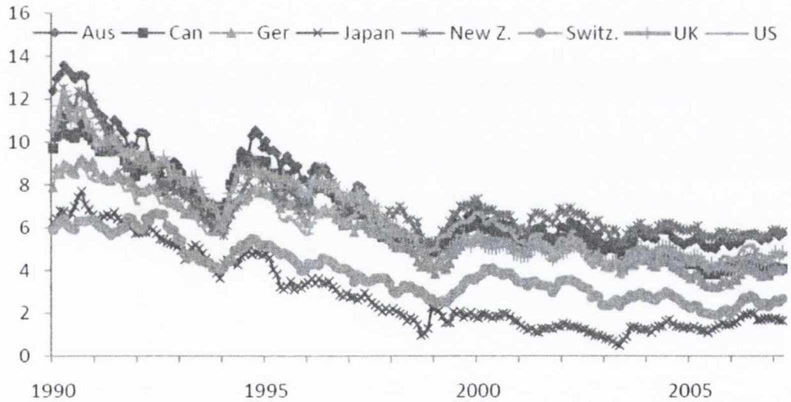


Figure 4.9: 10-year zero-coupon Yields



Source: zero-coupon yield data for Figures 4.5 to 4.9 are from Wright (2011).

Table 4.1: Misspecification tests, characteristic roots and weak exogeneity for daily model with short-term yields

Univariate tests	Δffr_t	$\Delta G3m_t$	$\Delta G6m_t$
ARCH (2)	35.4 [0.000]	5.5 [0.071]	1.1 [0.569]
J.-B.(2)	78.7 [0.000]	58.3 [0.000]	38.3 [0.002]
Trace test	295 (42)	66 (25)	**10** (12)
$Ch.Roots_{(r=2)}$	1.0	0.877	0.381
$W.Exogeneity_{\chi^2(r=2)}$	210.5 [0.000]	44.5 [0.000]	20.0 [0.000]
Multivariate tests			
Autocorrelation	$LM(1)$: $\chi^2(9) = 17.8$ [0.081]		
Normality	$\chi^2(6) = 93.1$ [0.001]		

Notes: Tests on the daily model including the Federal Funds Rate from the FRED database, and the three- and six-month zero-coupon yields from the dataset of Gurkaynak, Sack and Wright (2007). p-values are in brackets.

Table 4.2: Cointegrating relations, adjustment coefficients and short-term parameters for daily model with short-term yields

Cointegrating Vectors, β			Adjustment coefficients, α		
Var.	$\widehat{\beta}_1$	$\widehat{\beta}_2$	Eq.	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$
ffr_t	**1.0**	0.0	Δffr_t	**−0.51** (−17.8)	0.00 (0.1)
$G3m_t$	**−0.15** (−7.6)	**1.0**	$\Delta G3m_t$	0.02 (1.2)	**−0.05** (−8.5)
$G6m_t$	0.0	**−1.0**	$\Delta G6m_t$	0.03 (1.7)	**−0.04** (−6.1)
Trg_t	**−0.86** (−43.8)	0.0			
Constant	−0.01 (−1.4)	**0.01** (4.7)			

Short-Run Parameters

	Γ_1				$\mathbf{A}_0$
	Δffr_{t-1}	$\Delta G3m_{t-1}$	$\Delta G6m_{t-1}$	ΔTrg_{t-1}	ΔTrg_t
Δffr	**0.06** (2.4)	−0.01 (−0.0)	**−0.26** (−3.6)	0.07 (1.7)	**0.335** (8.0)
$\Delta G3m$	0.02 (1.2)	0.04 (1.0)	−0.04 (−1.0)	**−0.08** (−3.5)	**−0.06** (−2.8)
$\Delta G6m$	0.01 (0.4)	**0.2** (4.8)	**−0.18** (−4.3)	**−0.05** (−2.3)	**−0.05** (−2.1)

Notes: Overidentified cointegrating relations, adjustment coefficients and short-run parameters. t-statistics are in parentheses and significant coefficients are in bold-face. The data are daily zero-coupon yields for the period 1 April 2003 to 31 March 2007 from the dataset of Gurkaynak, Sack and Wright (2007).

Table 4.3: The long-run impact matrix, common trends and loadings for daily model of short-term yields

Long-Run Impact matrix, C					
	$\widehat{\varepsilon}_{ffr}$	$\widehat{\varepsilon}_{g3m}$	$\widehat{\varepsilon}_{g6m}$	$\tilde{\beta}_{\perp}$	$\alpha_{\perp}$
ffr	0.02 (1.0)	**−0.51** (−1.9)	**0.67** (2.4)	0.67 (2.4)	0.03 (1.1)
$G3m$	0.13 (1.0)	**−3.44** (−1.9)	**4.47** (2.4)	4.47 (2.4)	−0.77 (−8.0)
$G6m$	0.13 (1.0)	**−3.44** (−1.9)	**4.47** (2.4)	4.47 (2.4)	1.0

Notes: Long run impact of shocks to the Federal Funds Rate, three- and six-month Treasury zero-coupon yields, along with the common trends and corresponding loadings. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.4: Misspecification tests, characteristic roots and weak exogeneity for daily model with long-term yields

Univariate tests	Δffr_t	$\Delta G3m_t$	$\Delta G1y_t$	$\Delta G5y_t$	$\Delta G10y_t$
ARCH (3)	8.3 [0.049]	7.1 [0.061]	5.9 [0.113]	3.2 [0.362]	4.0 [0.259]
J.-B.(3)	134.2 [0.000]	65.4 [0.000]	56.1 [0.000]	6.6 [0.037]	5.2 [0.076]
Trace test	361 (79)	112 (54)	43 (35)	**19** (20)	7 (9)
$Ch.Roots_{(r=4)}$	1.0	0.931	0.901	0.844	0.442
$W.Exogeneity_{\chi^2(r=4)}$	252.7 [0.000]	56.8 [0.000]	19.5 [0.001]	11.4 [0.023]	11.4 [0.023]
Multivariate tests					
Autocorrelation	$LM(1)$: $\chi^2(25) = 35.2$ [0.071]		$LM(2)$: 33.1 [0.129]		
Normality	$\chi^2(10) = 150.5$ [0.000]				

Notes: Daily model includes the Federal Funds Rate from the FRED database, and the three-month, one-, five- and ten-year zero-coupon yields from the dataset of Gurkaynak, Sack and Wright (2007). p-values are in brackets.

Table 4.5: Unrestricted adjustment coefficients for daily model with long-term yields

Unrestricted Adjustment coefficients, $\widehat{\alpha}^u$					
	$\widehat{\alpha}_1^u$	$\widehat{\alpha}_2^u$	$\widehat{\alpha}_3^u$	$\widehat{\alpha}_4^u$	$\widehat{\alpha}_5^u$
Δffr	**0.02** (15.6)	**0.003** (2.2)	0.001 (0.3)	−0.002 (−0.3)	−0.002 (−0.3)
$\Delta G3m$	**0.003** (4.1)	**−0.01** (−6.7)	**0.002** (2.8)	−0.001 (−0.4)	−0.002 (−0.5)
$\Delta G1y$	0.001 (0.7)	−0.002 (−1.3)	**0.003** (2.2)	**−0.004** (−3.1)	0.002 (1.4)
$\Delta G5y$	−0.002 (−1.0)	0.002 (1.2)	**0.01** (3.2)	**−0.01** (−3.0)	0.001 (0.5)
$\Delta G10y$	−0.002 (−1.5)	0.002 (1.4)	**0.004** (2.7)	**−0.01** (−3.4)	−0.001 (−0.1)

Notes: Daily model includes the Federal Funds Rate and Target taken from the FRED database and the three-month, one-, five- and ten-year zero-coupon yields from the dataset of Gurkaynak, Sack and Wright (2007). t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.6: Cointegrating relations, adjustment coefficients and short-run parameters for daily model with long-term yields

Cointegration Vectors, β				
Var.	$\widehat{\beta}_1$	$\widehat{\beta}_2$	$\widehat{\beta}_3$	$\widehat{\beta}_4$
ffr_t	0.0	**1.0**	0.0	0.0
$G3m_t$	**1.0**	**−0.21**	**1.0**	**1.0**
		(−10.3)		
$G1y_t$	0.0	0.0	**−1.0**	0.0
$G5y_t$	0.0	0.0	0.0	**−1.0**
$G10y_t$	**−0.84**	0.0	0.0	0.0
	(−13.2)			
Trg_t	0.0	**−0.8**	0.0	0.0
		(−40.4)		
break	**−3.91**	0.0	**−0.52**	**2.77**
	(−3.2)		(3.8)	(3.6)
Constant	**−0.75**	0.0	0.0	0.0
	(−2.6)			

Adjustment Coefficients, α				
Eq.	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$	$\widehat{\alpha}_3$	$\widehat{\alpha}_4$
Δffr_t	**−0.05**	**−0.6**	**−0.05**	**−0.08**
	(−3.9)	(−15.2)	(−2.8)	(−3.8)
$\Delta G3m_t$	0.01	−0.03	**−0.02**	−0.01
	(−0.6)	(−1.3)	(2.6)	(−0.9)
$\Delta G1y_t$	−0.01	−0.01	−0.01	−0.02
	(−1.4)	(−0.1)	(−0.8)	(−1.3)
$\Delta G5y_t$	**−0.05**	0.02	**−0.04**	**−0.08**
	(−3.2)	(0.5)	(−2.0)	(−3.0)
$\Delta G10y_t$	**−0.04**	0.04	**−0.04**	**−0.07**
	(−3.0)	(1.0)	(−1.9)	(−2.8)

Short-run adjustment coefficients, Γ_1							A_0
Δ	ffr_{t-1}	$G3m_{t-1}$	$G1y_{t-1}$	$G5y_{t-1}$	$G10y_{t-1}$	Trg_{t-1}	Trg_t
ffr_t	**0.07**	**−0.3**	0.2	−0.06	−0.06	−0.01	**0.40**
	(1.9)	(−4.5)	(1.9)	(−0.3)	(−0.5)	(−0.3)	(8.4)
$G3m_t$	0.02	0.03	0.06	−0.003	−0.06	**−0.13**	**−0.05**
	(1.1)	(1.0)	(1.2)	(−0.1)	(−0.9)	(−5.7)	(−2.3)
$G1y_t$	0.03	**0.11**	**0.16**	**−0.33**	**0.2**	−0.03	0.01
	(1.0)	(2.1)	(2.0)	(−2.7)	(2.0)	(−0.8)	(0.2)
$G5y_t$	−0.01	0.12	**0.22**	**−0.39**	**0.3**	−0.04	−0.01
	(−0.1)	(1.6)	(1.9)	(−2.1)	(2.0)	(−0.7)	(−0.1)
$G10y_t$	−0.01	0.07	0.1	**−0.35**	**0.34**	−0.02	−0.05
	(−0.1)	(1.0)	(1.0)	(−2.1)	(2.4)	(−0.4)	(−0.8)

Notes: Over-identified relations for the daily model. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.7: The long-run impact matrix, common trends and loadings for daily model with long-term yields

Long-Run Impact Matrix, C							
	$\widehat{\varepsilon}_{ffr}$	$\widehat{\varepsilon}_{g3m}$	$\widehat{\varepsilon}_{g1y}$	$\widehat{\varepsilon}_{g5y}$	$\widehat{\varepsilon}_{g10y}$	$\breve{\beta}_{\perp}$	$\alpha'_{\perp}$
ffr_t	0.01 (1.4)	−0.01 (−0.2)	0.11 (1.1)	**−0.44** (−4.4)	**−0.46** (5.1)	0.5	0.03
$G3m_t$	0.06 (1.4)	−0.07 (−0.2)	0.51 (1.1)	**−2.1** (−4.4)	**−2.19** (5.1)	2.2	−0.03
$G1y_t$	0.06 (1.4)	−0.07 (−0.2)	0.51 (1.1)	**−2.1** (−4.4)	**−2.19** (5.1)	2.2	0.23
$G5y_t$	0.06 (1.4)	−0.07 (−0.2)	0.51 (1.1)	**−2.1** (−4.4)	**−2.19** (5.1)	2.2	−0.96
$G10y_t$	0.08 (1.4)	−0.08 (−0.2)	0.61 (1.1)	−2.**5** (−4.4)	**−2.61** (5.1)	2.6	1.0

Notes: Long-run impact of shocks to the Federal Funds Rate, three-month, and one-, five- and ten-year zero-coupon Treasury yields, together with the common trends and corresponding loadings. The model is estimated for the period 1 April 2003 to 31 March 2007 using the dataset of Gurkaynak, Sack and Wright (2007). The Federal Funds Rate is taken from the FRED database. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.8: Equilibrium Correction and long-run impacts from model with Foreign Official Holdings of US treasuries

Cointegrating relations, β			Adjustment coefficients, α		
Var.	$\widehat{\beta}_1$	$\widehat{\beta}_2$	Eqn.	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$
$G5y$	**−1.0**	0.0	$\Delta G5y$	−0.01 (−1.6)	**0.03** (3.9)
$G10y$	**1.0**	**−2.93** (−41.5)	$\Delta G10y$	−0.01 (−1.7)	**0.03** (3.5)
official	0.0	**1.0**	Δofficial	**0.001** (8.6)	−0.001 (−1.1)
constant	**2.39** (6.8)	0.0			
Short-Run Parameters, Γ_1					
	$\Delta G5y$	$\Delta G10y$	Δofficial		
$\Delta G5y$	0.32 (1.6)	−0.25 (−1.2)	−0.93 (−0.7)		
$\Delta G10y$	**0.36** (1.9)	−0.29 (−1.4)	−0.7 (−0.6)		
Δofficial	0.01 (1.2)	**−0.02** (−2.1)	−0.06 (−0.9)		
Long-Run Impact Matrix, C				loadings	CT_1
	$\widehat{\varepsilon}_{G5y}$	$\widehat{\varepsilon}_{G10y}$	$\widehat{\varepsilon}_{official}$	$\widetilde{\beta}_{\perp}$	$\alpha'_{\perp}$
$G5y$	−0.35 (−1.2)	0.42 (1.3)	**0.34** (2.1)	0.42	−0.85
$G10y$	−0.35 (−1.2)	0.42 (1.3)	**0.34** (2.1)	0.42	1.0
official	−1.03 (−1.2)	1.23 (1.3)	**0.99** (2.1)	1.23	0.82

Notes: Cointegration relations, adjustment coefficients, short-run parameters and long-run impact matrix from model with the five- and ten-year yields and foreign official holdings of US securities. The model is estimated using weekly data from 5 January 2000 to 28 March 2007. Official holdings data are taken from the Federal Reserve's H4.1 release. Yield data is from Gurkaynak, Sack and Wright (2007). t-statistics are in parentheses and significant coefficients are in bold.

Table 4.9: Misspecification tests, characteristic roots and weak exogeneity for the monthly model

Univariate tests	Δffr_t	$\Delta G3m_t$	$\Delta G6m_t$	$\Delta G1y_t$	$\Delta G5y_t$	$\Delta G10y_t$
ARCH (2)	5.2 [0.073]	0.2 [0.891]	2.9 [0.236]	4.1 [0.132]	0.2 [0.913]	0.6 [0.725]
J.-B.(2)	35.9 [0.000]	19.3 [0.000]	21.3 [0.002]	6.1 [0.055]	1.6 [0.449]	1.9 [0.389]
Trace test	272 (104)	156 (77)	92 (54)	48 (35)	**17** (20)	3 (9)
$Ch.Roots$ $(r=4)$	1.0	1.0	0.877	0.811	0.531	0.487
$W.Exogeneity$ $\chi^2(r=4)$	120.5 [0.000]	52.7 [0.000]	23.9 [0.000]	10.8 [0.056]	11.1 [0.030]	7.0 [0.225]
Multivariate tests						
Autocorrelation	LM(1): $\chi^2(36) = 48.9$ [0.081]			LM(2): 45.2 [0.141]		
Normality	$\chi^2(12) = 93.1$ [0.001]					

Notes: Tests on the monthly model including the Federal Funds Rate from the FRED database, and the three-and six-month, one-, five- and ten-year zero-coupon yields from Wright (2011). p-values are in brackets.

Table 4.10: Unrestricted adjustment coefficients for the monthly model

	Unrestricted Adjustment coefficients, $\widehat{\alpha}^u$					
Eq.	$\widehat{\alpha}_1^u$	$\widehat{\alpha}_2^u$	$\widehat{\alpha}_3^u$	$\widehat{\alpha}_4^u$	$\widehat{\alpha}_5^u$	$\widehat{\alpha}_6^u$
Δffr_t	**0.08** (12.8)	0.01 (0.7)	**0.01** (2.2)	0.01 (1.0)	−0.01 (−0.1)	0.01 (0.1)
$\Delta G3m_t$	**0.05** (5.1)	**−0.06** (−5.4)	−0.01 (−0.4)	**0.03** (2.8)	−0.01 (−0.3)	0.01 (0.8)
$\Delta G6m_t$	**0.03** (2.8)	**−0.03** (−2.9)	**0.02** (2.1)	**0.03** (2.2)	−0.01 (−1.2)	0.013 (1.2)
$\Delta G1y_t$	0.02 (1.7)	**−0.031** (−2.2)	0.02 (1.6)	0.01 (0.6)	−0.02 (−1.4)	0.02 (1.4)
$\Delta G5y_t$	−0.01 (−0.6)	**−0.05** (−2.4)	**0.04** (2.1)	−0.03 (−1.4)	−0.01 (−0.3)	0.03 (1.5)
$\Delta G10y_t$	−0.02 (−1.2)	−0.02 (−0.8)	**0.04** (2.0)	−0.02 (−1.2)	0.008 (0.5)	0.03 (1.6)

Note: Monthly model includes the Federal Funds Rate taken from the FRED database and the three- and six-month, one-, five- and ten-year zero-coupon yields from Wright (2011). The model is estimated for the period January 1990 to March 2007. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.11: Cointegrating relations, adjustment coefficients and short-run parameters for the monthly model

Cointegration vectors, β					Adjustment Coefficients, α				
Var.	$\widehat{\beta}_1$	$\widehat{\beta}_2$	$\widehat{\beta}_3$	$\widehat{\beta}_4$	Eq.	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$	$\widehat{\alpha}_3$	$\widehat{\alpha}_4$
ffr_t	**−1.01** (−91.5)	**−0.93** (97.9)	0.0	**−0.78** (−47.0)	Δffr_t	**0.7** (4.5)	−0.11 (−1.4)	−0.05 (−0.5)	0.14 (1.4)
$G3m_t$	0.0	**1.0**	0.0	0.0	$\Delta G3m_t$	0.22 (0.8)	**−0.55** (−3.9)	−0.48 (−2.8)	**−0.38** (−2.1)
$G6m_t$	**1.0**	0.0	0.0	0.0	$\Delta G6m_t$	−0.28 (−0.9)	−0.07 (−0.4)	**−0.46** (−2.4)	**−0.49** (−2.4)
$G1y_t$	0.0	0.0	**−0.57** (−22.3)	0.0	$\Delta G1y_t$	−0.18 (−0.5)	−0.04 (−0.2)	**−0.32** (−1.9)	−0.36 (−1.7)
$G5y_t$	0.0	0.0	**1.0**	**1.0**	$\Delta G5y_t$	−0.56 (−1.0)	0.04 (0.1)	**−0.5** (−1.9)	**−0.53** (−1.9)
$G10y_t$	0.0	0.0	**−0.43** (−16.9)	**−0.22** (−13.1)	$\Delta G10y_t$	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Constant	**0.13** (4.3)	0.0	0.0	**−0.07** (−3.7)					

Short Run Adjustment Coefficients, Γ_1

Δ	ffr_{t-1}	$G3m_{t-1}$	$G6m_{t-1}$	$G1y_{t-1}$	$G5y_{t-1}$	$G10y_{t-1}$
ffr_t	−0.1 (−1.9)	**0.17** (2.2)	−0.33 (−1.8)	0.26 (1.6)	**−0.28** (−2.5)	**0.18** (2.0)
$G3m_t$	**−0.17** (−1.9)	−0.04 (−0.3)	0.39 (1.2)	**−0.48** (−1.9)	0.26 (1.3)	−0.09 (−0.5)
$G6m_t$	−0.04 (−0.4)	0.12 (0.8)	−0.01 (−0.1)	−0.09 (−0.3)	0.01 (0.1)	0.1 (0.5)
$G1y_t$	−0.12 (−0.8)	0.15 (0.7)	0.07 (0.2)	−0.06 (−0.1)	−0.22 (−0.7)	0.32 (1.3)
$G5y_t$	−0.3 (−1.6)	0.14 (0.5)	0.11 (0.2)	0.24 (0.4)	**−0.7** (−2.1)	**0.67** (2.1)
$G10y_t$	−0.15 (−0.9)	0.16 (0.7)	−0.24 (−0.4)	0.54 (1.1)	**−0.73** (−2.1)	**0.61** (2.1)

Notes: over-identified relations for the monthly model including the Federal Funds Rate, taken from the FRED database, and the three- and six-month, one-, five- and ten-year zero-coupon yields from Wright (2011). The model is estimated for the period January 1990 to March 2007. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.12: Common trends and loadings in the monthly model

Common Trends, $\alpha_\perp$			Loadings, $\tilde{\beta}_\perp$:	
	CT_1	CT_2	CT_1	CT_2
ffr	0.0	−0.05	0.79	−1.89
$G3m$	0.0	−0.08	0.74	−1.75
$G6m$	0.0	1.0	0.80	−1.91
$G1y$	0.0	−0.79	0.69	−2.35
$G5y$	0.0	−0.33	0.93	−1.26
$G10y$	1.0	0.0	1.27	0.26

Notes: two common trends comprising shocks to the Federal Funds Rate, three-month, and one-, five- and ten-year zero-coupon Treasury yields, together with the loadings to both common trends.

Table 4.13: The structural long-run impact matrix and rotation matrix

Structural Long-Run Impact Matrix, $\breve{C} = CB^{-1}$						
	T_1	T_2	T_3	T_4	P_1	P_2
ffr	0.0	0.0	0.0	0.0	0.935	0.830
$G3m$	0.0	0.0	0.0	0.0	0.869	0.772
$G6m$	0.0	0.0	0.0	0.0	0.945	0.839
$G1y$	0.0	0.0	0.0	0.0	1.000	1.000
$G5y$	0.0	0.0	0.0	0.0	0.837	0.575
$G10y$	0.0	0.0	0.0	0.0	0.617	0.000
Rotation Matrix, B						
	$\widehat{\varepsilon}_{ffr}$	$\widehat{\varepsilon}_{g3m}$	$\widehat{\varepsilon}_{g6m}$	$\widehat{\varepsilon}_{g1y}$	$\widehat{\varepsilon}_{g5y}$	$\widehat{\varepsilon}_{g10y}$
T_1	1.000	0.006	−0.180	0.110	0.114	−0.148
T_2	−0.443	1.000	0.012	−0.449	0.711	−0.745
T_3	−0.110	−0.446	1.000	−0.571	0.391	−0.360
T_4	−0.125	0.101	−0.494	1.000	−0.962	0.434
P_1	−0.162	0.192	−0.240	0.846	−0.987	1.000
P_2	−0.038	−0.088	1.000	−0.818	−0.298	0.470

Notes: Long run impact of structural shocks to the Federal Funds Rate, three-month, and one-, five- and ten-year zero-coupon treasury yields, together with the rotation matrix of orthogonal transitory and permanent shocks.

Table 4.14: Unique US variance and loadings of US yields to common factors

Yield	factor 1	factor 2	factor 3	Unique var.
$G3m$	0.665	0.066	-0.256	0.49
$G6m$	0.734	-0.092	-0.086	0.45
$G1y$	0.752	-0.209	-0.144	0.37
$G5y$	0.809	-0.226	-0.075	0.29
$G10y$	0.834	0.016	-0.178	0.27

Notes: estimates of loadings of each US yield on the three common factors and the proportion of variance of each yield explained by the idiosyncratic component using data from Wright (2011).

Table 4.15: Tests of stationarity on common factors and US idiosyncratic component

Yield		factor 1	factor 2	factor 3	Idiosyn.
$G3m$	level	-0.51	-1.38	-1.18	-0.52
	diff.	-6.14***	-7.97***	-11.78***	-6.43***
$G6m$	level	-0.57	-1.7*	-1.16	-0.59
	diff.	-6.74***	-8.34***	-9.34***	-6.68***
$G1y$	level	-0.65	-1.8*	-1.19	-0.73
	diff.	-7.29***	-9.12***	-10.3***	-7.38***
$G5y$	level	-1.23	-2.07**	-1.26	-1.36
	diff.	-8.64***	-9.48***	-9.86***	-9.19***
$G10y$	level	-1.61	-1.58	-2.35**	-1.39
	diff.	-9.32***	-10.83***	-10.56***	-9.47***

Notes: Augmented Dickey-Fuller unit root tests on the levels and first-differences of each of the common factors and idiosyncratic components. Lag length for the tests are given by 4(min(N,T)/100)^1/4 as in Bai and Ng (2004). *,**,*** indicate rejection of a unit-root at the ten, five and one percent levels respectively.

Table 4.16: Misspecification tests, characteristic roots and weak exogeneity for the monthly model of idiosyncratic components of US yields

Univariate tests	Δffr_t	$\Delta G3m_t$	$\Delta G6m_t$	$\Delta G1y_t$	$\Delta G5y_t$	$\Delta G10y_t$
ARCH (2)	5.1 [0.083]	5.42 [0.066]	3.88 [0.143]	2.49 [0.288]	1.46 [0.482]	0.83 [0.662]
J.-B.(2)	11.83 [0.003]	9.4 [0.039]	5.18 [0.079]	1.33 [0.515]	1.71 [0.425]	2.55 [0.286]
Trace test	199 (118)	109 (89)	**57** (63)	35 (43)	22 (26)	9 (12)
$Ch.Roots_{(r=5)}$	1.0	0.934	0.901	0.901	0.834	0.781
$W.Exogeneity$ $\chi^2(r=5)$	19.7 [0.001]	22.39 [0.000]	12.5 [0.021]	12.43 [0.023]	14.2 [0.014]	13.8 [0.017]
Multivariate tests						
Autocorrelation	LM(1): $\chi^2(36) = 48.6$ [0.078]		LM(2): 43.3 [0.187]			
Normality	$\chi^2(12) = 86.1$ [0.003]					

Notes: Tests on model with idiosyncratic components of the three-and six-month, one-, five- and ten-year zero-coupon yields estimated using Wright (2011), along with the Federal Funds Rate from the FRED database. p-values are in brackets.

Table 4.17: Unrestricted adjustment coefficients from monthly model of idiosyncratic components

Unrestricted Adjustment coefficients, $\widehat{\alpha}^u$					
Eq.	$\widehat{\alpha}_1^u$	$\widehat{\alpha}_2^u$	$\widehat{\alpha}_3^u$	$\widehat{\alpha}_4^u$	$\widehat{\alpha}_5^u$
Δffr_t	**0.28** (3.9)	−0.08 (−1.0)	**−0.23** (−1.9)	**0.11** (2.6)	−0.05 (−1.7)
$\Delta G3m_t$	**0.27** (4.5)	−1.0 (−1.5)	0.09 (0.8)	−0.03 (−0.79)	**−0.07** (−2.8)
$\Delta G6m_t$	0.02 (0.25)	**−0.26** (−3.4)	−0.08 (−0.7)	−0.03 (−0.9)	**−0.08** (−2.7)
$\Delta G1y_t$	**−0.21** (−2.3)	**−0.23** (2.2)	−0.12 (0.8)	0.05 (1.0)	**−0.11** (−3.0)
$\Delta G5y_t$	**−0.35** (−2.8)	−0.13 (−0.1)	**−0.57** (−2.6)	−0.12 (−1.6)	**−0.12** (−2.3)
$\Delta G10y_t$	**−0.28** (−2.4)	−0.06 (−0.5)	**−0.62** (−3.1)	**−0.12** (1.9)	−0.08 (−1.6)

Notes: Monthly model of idiosyncratic components of three- and six-month and one-, five- and ten-year US zero-coupon Treasury yields. The model is estimated for the period January 1990 to March 2007. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.18: Cointegrating relations, adjustment coefficients and short-run parameters for model with US idiosyncratic components

Cointegration vectors, β						
Var.	$\widehat{\beta}_1$	$\widehat{\beta}_2$	$\widehat{\beta}_3$	$\widehat{\beta}_4$	$\widehat{\beta}_5$	
ffr_t	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	
$G3m_t$	**−1.0**					
$G6m_t$		**−1.0**				
$G1y_t$			**−1.0**			
$G5y_t$				**−1.0**		
$G10y_t$					**−1.0**	
Constant	0.0	0.0	**−0.66** (−18.3)	**−0.45** (−15.2)	0.0	
Adjustment coefficients, α						
Eq.	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$	$\widehat{\alpha}_3$	$\widehat{\alpha}_4$	$\widehat{\alpha}_5$	
Δffr_t	0.1 (1.6)	**−0.17** (−2.1)	**−0.41** (−3.8)	**0.15** (1.9)	−0.05 (−1.0)	
$\Delta G3m_t$	−0.003 (−0.1)	**0.24** (3.6)	**−0.34** (−3.9)	0.07 (1.0)	−0.01 (−0.3)	
$\Delta G6m_t$	**−0.18** (−2.9)	**−0.25** (−3.3)	−0.07 (−0.7)	−0.003 (0.03)	−0.01 (−0.2)	
$\Delta G1y_t$	**−0.27** (−3.5)	**0.23** (2.3)	0.09 (0.7)	0.05 (−0.4)	−0.09 (−1.4)	
$\Delta G5y_t$	**−0.32** (−3.0)	**0.25** (1.9)	0.02 (0.1)	**0.33** (2.3)	**−0.26** (−3.1)	
$\Delta G10y_t$	**−0.28** (−2.8)	0.21 (1.7)	0.03 (0.15)	**0.27** (2.0)	**−0.2** (−2.5)	
Short Run Adjustment Coefficients, Γ_1						
Δ	ffr_{t-1}	$G3m_{t-1}$	$G6m_{t-1}$	$G1y_{t-1}$	$G5y_{t-1}$	$G10y_{t-1}$
ffr_t	**0.3** (4.3)	0.22 (1.4)	−0.27 (−0.8)	0.24 (0.8)	−0.04 (−0.2)	0.04 (0.2)
$G3m_t$	0.07 (1.2)	−0.1 (−0.7)	0.2 (0.6)	−0.09 (−0.4)	0.02 (0.1)	0.03 (0.2)
$G6m_t$	**0.11** (1.9)	**0.25** (1.9)	0.03 (−0.1)	−0.18 (−0.7)	−0.16 (−0.7)	0.2 (1.1)
$G1y_t$	0.08 (0.9)	**0.41** (2.1)	0.09 (0.2)	0.14 (0.4)	−0.34 (−1.6)	**0.41** (1.9)
$G5y_t$	−0.03 (−0.3)	0.35 (1.3)	0.43 (0.8)	0.04 (0.1)	−0.63 (−1.6)	**0.76** (2.4)
$G10y_t$	0.02 (0.2)	0.15 (0.6)	0.48 (0.9)	−0.03 (−0.1)	−0.49 (−1.3)	**0.58** (2.0)

Notes: over-identified relations for the model including the Federal Funds Rate and idiosyncratic components of the three-month, one-, five- and ten-year zero-coupon US Treasury yields estimated from Wright (2011). The model is estimated for the period January 1990 to March 2007. t-statistics are in parentheses and significant coefficients are in bold-face.

Table 4.19: The long-run impact matrix, common trends and loadings for the model with US idiosyncratic components

Long-Run Impact matrix, C								
	$\widehat{\varepsilon}_{ffr}$	$\widehat{\varepsilon}_{g3m}$	$\widehat{\varepsilon}_{g6m}$	$\widehat{\varepsilon}_{g1y}$	$\widehat{\varepsilon}_{g5y}$	$\widehat{\varepsilon}_{g10y}$	$\breve{B}_{\perp}$	$\alpha_{\perp}$
ffr	−0.52 (−0.3)	3.21 (1.8)	**−6.1** (−2.0)	**4.76** (2.1)	**−3.47** (−2.0)	**2.95** (1.9)	−6.1	0.1
$G3m$	−0.33 (−0.6)	3.21 (1.8)	**−6.1** (−2.0)	**4.76** (2.1)	**−3.47** (−2.0)	**2.95** (1.9)	−6.1	−0.52
$G6m$	−0.33 (−0.6)	3.21 (1.8)	**−6.1** (−2.0)	**4.76** (2.1)	**−3.47** (−2.0)	**2.95** (1.9)	−6.1	1.0
$G1y$	−0.33 (−0.6)	3.21 (1.8)	**−6.1** (−2.0)	**4.76** (2.1)	**−3.47** (−2.0)	**2.95** (1.9)	−6.1	−0.78
$G5y$	−0.33 (−0.6)	3.21 (1.8)	**−6.1** (−2.0)	**4.76** (2.1)	**−3.47** (−2.0)	**2.95** (1.9)	−6.1	0.56
$G10y$	−0.33 (−0.6)	3.21 (1.8)	**−6.1** (−2.0)	**4.76** (2.1)	**−3.47** (−2.0)	**2.95** (1.9)	−6.1	−0.48

Notes: Long-run impact of shocks to the Federal Funds Rate and the idiosyncratic components of the three- and six-month, and one-, five- and ten-year zero-coupon US Treasury yields, together with the common trends and their corresponding loadings. t-statistics are in parentheses and significant coefficients are in bold-face.

Chapter 5

Conclusions

This thesis studies the impact of globalisation on labour markets, inflation and monetary policy. Some authors argue that the failure of macroeconomic models to accurately incorporate the influence of international factors on the domestic economy will lead to significant errors in policy-making (Borio and Filardo (2007)). Moreover, the increasing influence of global forces on domestic macroeconomic variables, such as long-term interest rates, and the declining sensitivity of inflation to domestic excess demand suggests that monetary policy is losing traction. This argument implies that, in the limit, central banks will have to coordinate if they are to control global output, inflation and interest rates (Rogoff (2006)). This thesis examines the empirical validity of these hypotheses.

Chapter 2 examines the impact of factor, product and financial market integration on the labour share of income. The main contribution of this chapter is an examination of the impact of offshoring on the domestic labour share. We approximate the aggregate level of offshoring with outflows and outward stocks of FDI. Moreover, we distinguish between total flows of FDI and those that are destined for emerging economies. The latter is likely to be driven by labour cost differentials. However, we find that it is the magnitude of total FDI outflows, rather than the destination of those outflows, that has a negative and significant effect on the labour share in advanced economies. One interpretation of these findings is that the tasks that are being offshored to low-wage economies are no longer being performed in advanced countries as workers in these countries are moving along the distribution of skilled tasks. However, labour cost differentials between countries with similar skill levels will be arbitraged by capital flows and this is leading to greater wage restraint among workers.

A potentially interesting extension of this analysis would be to decompose FDI outflows into greenfield FDI and those that represent Mergers and Acquistions, and investigate whether the nature of FDI outflows has different consequences for the labour share in advanced countries. If FDI flows to emerging economies mostly take the form of greenfield FDI, then the costs associated with establishing production facilities abroad may insulate domestic workers from competition from low-wage labour markets. An alternative approach would be to utilise the data on trade in intermediate goods from the OECD's new Bilateral Trade Database by Industry and End-use Category. This data could permit a further refinement of our analysis in terms of addressing the question of whether competition between workers in advanced and emerging economies occurs primarily through trade in final or intermediate goods.

We also contribute to the literature in conducting a more formal analysis of an indirect channel through which globalisation can affect the labour share. This channel operates via a weakening of the influence of labour market institutions on the labour share due to a perceived increase in the elasticity of demand for domestic workers. Our results suggest that this channel may be important. In particular, we find that import penetration and the relative price of exports tends to weaken the influence of trade unions, the labour tax wedge and employment protection legislation, while import penetration tends to strengthen the inverse relation between the benefit replacement ratio and the labour share.

It is also important to note, in general, that the direct effect of labour market institutions is sensitive to the assumption of country fixed effects. In most studies, cross-country heterogeneity is simply assumed and the inclusion of country fixed effects is not theoretically motivated. We consider an alternative fixed effect where heterogeneity is assumed to derive from particular features of the labour market. The impact of bargaining institutions is much stronger when we group countries according to these features. An interesting extension of this work would be to employ a statistical matching procedure which would enable us to group countries according to how they load on common components of particular characteristics of the labour market.

Chapter 3 examines how globalisation has affected the relation between domestic inflation and marginal cost in the context of the open-economy New Keynesian Phillips Curve. Our main contribution is to show that foreign marginal cost, as approximated by the trade-weighted labour share, has a significant but quantitatively small effect on domestic inflation. This effect is independent of other channels through which globalisation can affect the pricing behaviour of domestic firms, such as the influence of import penetration and relative imports on firms' desired markups. We suggest that this measure of international inflation pressure is capturing strategic complementarities in domestic wage- and price-setting that are not reflected in our approximate measure of import competition. Indeed, chapter 2 finds evidence that there are other channels through which globalisation leads to wage-restraint among domestic workers, apart from the traditional import-competition channel. In future work, we intend to explore possible extensions of the structural open-economy New Keynesian model, as outlined for example in Guerrieri et al (2010), in order to incorporate this finding. In addition, our findings suggest that the import-competition channel has an important effect on desired markups and thus on inflation. These results complement those of Sbordone (2009) and Guerrieri et al (2010), who estimate structural models of US inflation assuming variable elasticities of demand.

The second contribution of chapter 3 is to show that domestic marginal cost has a significant global component. The decomposition of the domestic labour share into an idiosyncratic, or country-specific, component and a common component, is as far as we are aware, new to empirical studies of the New Keynesian Phillips Curve. Our results complement those of Monacelli and Sala (2009) and Ciccarelli and Mojon (2010) who find that inflation has a significant global component.

Chapter 3 also provides evidence in favour of real rigidities in some economies. In particular, we show that employment adjustment costs may be an important source of inflation inertia and may therefore influence the pro-cyclicality of the real marginal cost measure. In addition, we show that inflation expectations have a significant, although quantitatively small, backward-looking component, which supports the use of the hybrid version of the New Keynesian Phillips Curve when modelling inflation dynamics.

What are the implications of these findings for monetary policy makers? We suggest that, although foreign marginal cost has a statistically significant effect on domestic inflation, its quantitative impact is small. Therefore, our results do not imply that the central bank's reaction function needs to be modified to incorporate this channel. However, it will still be important to monitor fluctuations in the global labour share because of the significant co-movement of domestic and global marginal cost.

Chapter 4 addresses the question of whether financial globalisation significantly impacts on the interest rate channel of the monetary transmission mechanism. It contributes to the academic literature on both the symptoms and causes of the "conundrum" period in which short- and long-term yields appeared to become disconnected. The natural framework for analysing the relation between yields of different maturities is the Expectations Hypothesis but has not been utilised in the literature on the conundrum. Moreover, in treating the yields as non-stationary, and testing for cointegrating between pairs of yields, we allow for a much weaker form of the Expectations Hypothesis to hold in which term premia can be time-varying but are stationary. One of the key findings of chapter 4 is that the Expectations Hypothesis holds for daily zero-coupon data over the period but that this is conditional on allowing for a break in the cointegrating relations in mid-2004. Furthermore, we show that the break affected the yields on bonds with maturities as low as one year. The focus in the literature has been on the disconnect between short-term and long-term yields. However, we show that the relation between short- and medium-term yields also changed during this period.

We contribute to the literature on the causes of the conundrum by examining the impact of foreign official purchases of US Treasury securities on long-term Treasury yields. We find that the ten-year Treasury yield cointegrates with our measure of foreign official holdings of US Treasuries. More importantly, however, we find that the stochastic trend driving the five- and ten-year yields mainly comprises accumulated shocks to foreign official holdings. One implication of this finding is that any decline in foreign official holdings, due for example to greater portfolio diversification on the part of central banks, could have important consequences for financial conditions in the United States.

Chapter 4 also contributes to the literature on the impact of global factors on the yield curve and shows that these factors, contrary to the assumptions in much of the literature, are non-stationary. Moreover, we find these factors appear to be acting solely on the term premium. The potentially interesting extension that follows from this analysis is to explore which part of the term premium is affected by financial globalisation. The term premium has two components: an inflation risk premium and a risk premium attached to the real interest rate (Rudebusch et al (2006)). Wright (2011) finds evidence that the decline in the term premium across countries reflects a reduction in inflation uncertainty. One direction in which we could extend our framework is to investigate how our estimated global factors load on the common components of a measure of inflation uncertainty. Similarly, as the real interest rate risk premium reflects uncertainty about the evolution of real economic activity, it may be possible to gain further insight into the behaviour of the term premium by examining how these factors are related to the volatility of global output.

Our finding that the Expectations Hypothesis holds once the impact of global factors has been removed is new to the literature. We also provide empirical evidence that these factors affect both the level and slope of the yield curve via the accumulation of shocks to yields at the middle and long-end of the term structure. As the Federal Funds Rate is an adjusting variable, this implies that the Federal Reserve is responding to these shocks. This, therefore, is one of the channels through which globalisation affects the conduct of monetary policy.

It is important to note that the Federal Reserve can still influence short-term yields in the short run. Woodford (2009) shows that financial globalisation does not affect the ability of a central bank to control domestic inflation if it can influence the opportunity cost of holding money through changes in short-term interest rates. Our analysis therefore suggests that, although financial globalisation may weaken the relation between short- and long-term interest rates, it does not impair the Federal Reserve's ability to target a particular inflation rate. However, a decoupling of short- and long-term rates could have implications for other objectives of the central bank such as financial stability. Indeed, the conundrum coincided with a period in which inflation was remarkably low and stable, but during which the financial imbalances that resulted in the recent financial crisis were developing.

The central conclusion of this thesis is that globalisation, whether in the form of factor, goods or financial markets integration, has important implications for policy makers. Although the impact is stronger through certain channels than others, the omission of external factors from macroeconomic models, could, in some cases, result in the use of severely misspecified models.

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