Rates and Redistribution: How Tax and Transfer Progressivity Affects the Transmission of Monetary Policy

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Abstract

Higher levels of tax and transfer progressivity in an economy can make monetary policy more effective by increasing household sensitivity to interest rates, or less effective by acting as an automatic stabiliser. I construct a simple index that measures the level of tax and transfer redistribution — the Reynolds-Smolensky index (RSI). I then use a panel conditionally homogeneous VAR model to find that variation in the RSI can explain 20% of cross-country heterogeneity in monetary policy transmission to output and 8% to prices. Further, all else equal, monetary policy is more effective in the medium-to-long run when taxes and transfers are more progressive. Finally, I find that progressivity is more important for explaining differences in monetary policy transmission across countries than several other structural characteristics, including inequality and variable rate mortgage share.

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Contents

1 Introduction

Do differences in structural characteristics in economies around the world lead to differences in the effectiveness of monetary policy? Or is aggregate effectiveness relatively similar despite the channels of transmission being different? As central banks attempt to build realistic models of the economy, increasing focus has been placed on how to represent heterogenous structural features of economies in these models. A potentially significant structural aspect of an economy for monetary policy transmission is the degree of income redistribution that takes place through taxes and transfers. As well as moving income from high- to low-income earners, taxes and transfers have automatic stabilisation effects which dampen the economy's response to shocks. In this empirical approach, I use a panel VAR model to investigate how tax and transfer progressivity affects monetary policy transmission through different channels.

Redistributive income tax and transfers play an important role in mitigating the transmission of income shocks to consumption. During an economic downturn, household incomes decrease, so less tax revenue is collected, and more transfer payments are made. This means that fiscal policy automatically becomes more stimulatory, to some degree mitigating the adverse demand shock. This *stabilisation effect* of progressive taxes and transfers has been shown in theoretical work to have a negative impact on the effectiveness of monetary policy (Mattesini and Rossi, 2012). Given that automatic stabilisers reduce the volatility of output and consumption in response to macroeconomic shocks, they also dampen the impact of changes in monetary policy on the economy. Mattesini and Rossi (2012), Røed and Strøm (2002), and Fu et al. (2018) also find that greater redistribution on average reduces labour market elasticity, making labour hours less responsive to shocks. These results imply that higher redistribution will reduce the amount that output, consumption, and labour hours respond to monetary policy shocks. In other words, monetary policy may be more effective when there is a low level of redistribution in the economy.

However, as well as acting as an automatic stabiliser, taxes and transfers also affect household levels of savings and liquidity. In doing so, they impact the degree to which households are exposed to interest rate risk. That is, their consumption and saving decisions display a high degree of interest rate elasticity. When households are more interest-rate sensitive, monetary policy is theorised to be more effective. According to Kaplan et al. (2014), there are two types of households that will not have high levels of interest rate elasticity, and thus will be less sensitive to monetary policy shocks. Firstly, households that are poor and as a result, credit constrained — the *hand-to-mouth*. Secondly, the *wealthy* hand-to-mouth — households which spend their entire income in every pay-period, because their significant wealth is tied up in illiquid assets from which they can derive a higher return. Kaplan et al. (2014) estimates that around 40% of households in the United States belong to either the poor or wealthy hand-to-mouth categories. Redistribution through income taxes and transfers allows low-income hand-to-mouth households to accrue savings, and reduces the incomes of the wealthy hand-to-mouth, forcing them to liquidate some of their illiquid assets to allow for continued consumption. Effectively, redistribution incentivises hand-to-mouth households to become *saver* households, decreasing their exposure to income risk, and *increasing* their exposure to interest rate risk. This is also the channel through which inequality has been found to have negative impacts on monetary policy transmission (Pereira da Silva et al., 2022). We can call this the *redistribution effect*, and it provides a basis for theorising that monetary policy may be more effective when there is a *high* level of redistribution in the economy.

To determine the true effect of the level of redistribution on monetary policy transmission, I firstly construct a simple measure of tax and transfer progressivity for a sample of 37 OECD countries from 2000 to 2019.[1] I compute monetary vector autoregression (VAR) models for each country in the sample, and determine impulse response functions of output, prices, consumption, hours worked, and the interest rate in response to a 1 unit contractionary monetary policy shock. I then use a *panel con-*

[1] I use all OECD countries apart from Colombia, due to lack of data available to construct the tax and transfer progressivity index.

ditionally homogeneous VAR (PCHVAR) framework developed in Georgiadis (2014) to calculate impulse responses that differ only when the value of the progressivity index is different. In other words, the impulse responses are *conditioned* on the progressivity index. By regressing the impulse responses calculated by the individual country VARs on those from the PCHVAR model, I can determine the extent to which progressivity explains heterogeneity in cross-country responses to a monetary policy shock.

I find that differences in the tax and transfer progressivity measure explain up to 20% of cross-country heterogeneity in output responses, and 8% for price responses to a monetary policy shock. These results are comparable to those found by Georgiadis (2014) when looking at financial structure and labour market rigidities as structural factors affecting transmission. Using the PCHVAR model, I calculate impulse response functions for 200 different values of the tax and transfer progressivity measure and find that output, prices, consumption, and labour hours are more responsive to the monetary policy shock when progressivity is higher in the medium-to-long run. However, in the short run, I find the opposite result for output, consumption, and labour hours. These results provide evidence that the stabilisation effect dominates in the short run, while the redistribution effect dominates in the medium-to-long run. High progressivity allows households to better smooth their income in response to a contractionary shock, but as a higher proportion of these households will be sensitive to changes in the interest rate, after some lag, monetary policy will have a stronger and more persistent effect.

I show that these results are robust to numerous different specifications, including adding exchange rates and the fiscal deficit as additional endogenous variables in the VAR models, and removing countries with monetary policy constrained by the zero lower bound. I also find that progressivity explains a much larger amount of heterogeneity in cross-country responses to a monetary policy shock than inequality, variable rate mortgage share, capital gains tax rates, or top income tax rates. These results imply that progressivity could be an informative feature to include in New Keynesian models. Additionally, these results provide some support for central banks treating progressivity as a factor of interest when considering whether monetary policy should be tighter or looser relative to other countries to achieve the same effects.

2 Literature Review

2.1 Measuring Progressivity

This thesis was substantially informed by the extensive literature concerning the calculation of tax and transfer progressivity. In a significant early contribution, Kakwani (1977) shows how the difference between the concentration coefficient of taxation and the market income Gini coefficient can be taken to represent the level of redistribution that occurs from taxation. Using a more detailed approach, Sabirianova Peter et al. (2017) and Gerber et al. (2019) construct indices of income tax progressivity based on their own highly comprehensive national income tax schedule datasets. Bénabou (2003) and Heathcote et al. (2017) instead choose to construct an algebraic income tax function which can be calibrated with pre-government and post-government income as well as the threshold income level to find the level of tax progressivity.

However, for the purposes of considering the total redistributive capacity of the economy, I focus on literature that also considers the progressivity of government transfers in its estimation. Musgrave and Thin (1948) and, later, Reynolds and Smolensky (1977) use the absolute change in Gini coefficients before and after taxes and tranfsers to measure redistributive capacity — called the Reynolds-Smolensky index (RSI), which I use in this thesis. Escolano et al. (2010), Heisz and Murphy (2015), and Causa and Hermansen (2021) each construct this index with cross-country OECD data. Petrova (2020) calculates the same measure with data from the European Union Statistics on Income and Living Conditions (EU-SILC) database to derive very similar results to the previous authors. The RSI is a useful measure for several reasons. Along with accounting for transfers as well as taxation, the RSI can be calculated with easily accessible and wide-ranging data from the OECD. Additionally, although different countries vary in the way that they implement taxes and transfers, countries like Australia with a relatively small welfare system may achieve a similar amount of redistribution as countries with much higher taxes and transfers, like Germany, because they rely more on income taxes — which are generally more progressive — and means-tested cash transfers (Joumard et al., 2012). Looking at the difference in inequality created by redistribution avoids encountering difficulty in attempting to compare different types of taxes and transfers which may have different redistributive effects. I build on previous work by providing the most up-to-date calculation of tax and transfer progressivity for OECD countries over, to the best of my knowledge, the longest period in the literature.

2.2 Factors Affecting Monetary Policy Transmission

This thesis also relates to the literature that investigates factors affecting monetary policy transmission.

In theoretical work, Kaplan et al. (2018) demonstrate the impact of monetary policy shocks in heterogeneous-agent New Keynesian (HANK) models. In typical representative-agent New Keynesian (RANK) models, the 'direct' effects of monetary policy are by far the most significant. That is, after a contractionary monetary policy shock, households will be tempted by higher interest rates to increase savings and decrease borrowing. However, when households display income and wealth heterogeneity, the 'indirect' effects are much more substantial than the direct effects. These occur as higher interest rates result in a contraction in labour demand, reducing labour supply and decreasing income and consumption. Kaplan et al. (2018) find that the indirect effects of monetary policy are much more important in HANK models, which can represent the empirically large proportion of households that have low interest rate sensitivity. In these models, the size of the direct and indirect effects is also dependent on fiscal policy and equilibrium feedback effects, making monetary policy harder to fine-tune (Kaplan et al., 2018). As a result, lags are longer and more variable in HANK models than RANK models, with monetary policy less effective overall.

Debortoli and Galí (2021) find that two-agent New Keynesian (TANK) models, which divide households into 'constrained' and 'unconstrained', achieve practically the same results as the HANK model, but with greater ease of computation. Connecting this literature to my work, the VAR model is a reduced form model, using the standard identification of a monetary policy shock, and as such can be consistent with general equilibrium models like HANK and TANK. Although monetary policy shocks are unlikely to be perfectly identified in the empirical framework of this thesis, my key findings are derived by comparing the shocks across countries rather than focusing on the magnitude of the shocks themselves.

Given the heterogeneity of agents and the possibilities for modelling them, several previous studies have posited factors in which households can differ, and as such can affect the transmission of monetary policy. For example, Garriga et al. (2016) find evidence that the transmission mechanism is stronger under adjustable-rate mortgages compared with fixed-rate mortgages. Households with adjustable-rate mortgages are more exposed to interest rate risk, and will respond more to a monetary policy shock. Georgiadis (2014) instead considers financial structure, labour market rigidities, and industry mix. He finds that these factors can explain a large proportion of the differences in responses of output to monetary policy shocks across countries. Most relevant to this work, however, is the literature looking at the relationship between inequality and taxation and monetary policy transmission. Pereira da Silva et al. (2022) argue that inequality reduces the effectiveness of monetary policy, supported by evidence from 20 OECD countries since 2002. Voinea and Mihaescu (2009) use Romanian microdata to generate the same result. Matusche and Wacks (2023) use a range of cross-country tests to show that more effective monetary policy is associated with higher levels of wealth inequality. Notably, Ida and Kaminoyama (2023) examine the impacts of tax progressivity on optimal monetary policy in a two-country new Keynesian model. They find that a change in tax progressivity significantly affects the properties of international monetary policy transmission, with its impact depending on the value of constant relative risk-aversion coefficients. Most closely related to this thesis, Mattesini and Rossi (2012) introduce income tax progressivity into the New

Keynesian model, finding that higher income tax progressivity reduces monetary policy effectiveness. As labour income taxation progressivity increases, volatility of output, labour hours, and inflation should decrease, meaning that output and prices will respond less to a monetary policy shock. These results are consistent with the short-term results that I find, although they do not capture the empirical heterogeneity of household liquidity, which is the driver of my medium-to-long term findings.

Building upon this literature, I adapt the panel conditionally homogeneous VAR (PCHVAR) model developed in Georgiadis (2014) to consider tax and transfer progressivity as a time-varying structural factor of economies affecting monetary policy transmission. While Mattesini and Rossi (2012) look exclusively at income tax progressivity, I consider the progressivity of the entire tax and transfer system — in other words, the 'redistributive capacity' of the economy. This is important as in most OECD countries, it is transfers, not taxation, that perform the main role of redistribution (Causa and Hermansen, 2021). Additionally, while the findings of Mattesini and Rossi (2012) are derived theoretically, I use an empirical approach. Finally, I place my results within the context of the literature on inequality and HANK and TANK models and outline their implications for policy. All of the results that I find are consistent with results from existing work. However, by capturing the empirical heterogeneity of households that cannot be observed in standard RANK models, I can display a more complete picture of the effects of progressivity on monetary policy transmission.

3 Data

In this thesis, I focus on a sample of 37 OECD countries, excluding Colombia due to a lack of Gini coefficient data. My empirical model covers a period of 2000:1 to 2019:4 to exclude the effects of the COVID-19 pandemic. A summary of data definitions and sources can be found in the Appendix, in Tables 3 and 4. The bulk of the data used in this thesis is extracted from the OECD statistical database, OECD.Stat. All data are freely accessible.

Firstly, I use annual Gini coefficients for market income and disposable income for the working age population. The Gini coefficient for market income is measured before households taxes and government cash transfers. The Gini coefficient for disposable income is net of direct taxes and transfers. Where there were gaps in these data, the Gini coefficients were linearly interpolated over the missing periods. Cubic spline interpolation was additionally used for robustness, but did not substantially affect the results.[2] To transform these data from yearly to quarterly, Gini coefficients were held constant for the whole year, under assumption that fiscal policy changes affecting progressivity would occur roughly annually. Where available, the new estimates of the Gini coefficient from after the OECD changed its definition of income in 2011 were used.[3]

For Mexico and Hungary, the market income Gini coefficients are not available. Instead, the disposable income Gini coefficient is used for these countries. This means that the Reynolds-Smolensky index for Mexico and Hungary is only computing the level of redistribution from transfers, not from taxes. For robustness, these countries were dropped from the sample, and results were not substantially different.

Quarterly macroeconomic indicators for each country — GDP, the price level, the short-term interest rate, total hours worked and growth in private final consumption expenditure — are also obtained from the OECD.Stat, as well as the interbank rate and size of the money supply (M3). To try and reduce the size of the price puzzles I find in my results, I also control for 1-year ahead US inflation expectations and the 5-year ahead US breakeven rate, which I retrieve from the FRED database. I additionally try including the Global Financial Cycle index from Miranda-Agrippino and Rey (2020) for this purpose.

For the US, Eurozone, and the UK, shadow policy rates were used to address the zero lower bound (ZLB). These data are taken from Wu and Xia (2016, 2017, 2020). Shadow rates for Australia, Canada, Switzerland, New Zealand and Japan are taken

[2]Further robustness analysis suggests that the results I find are driven by cross-country variation as opposed to temporal variation in progressivity, so the treatment of the temporal measure of progressivity should not be substantially important for results.

[3]According to the OECD Terms of Reference, the new definition of income used since 2011 includes the value of goods produced for own consumption as an element of income for the self-employed.

from LJK Macro Finance Analysis. Shadow rates were used in the baseline identification, but for countries without available shadow rate data, the short-term interest rate from OECD.Stat is used. These were also used for Eurozone countries for the years before they joined the Eurozone. For robustness, countries with monetary policy constrained by the zero lower bound during the period for which shadow rates are not available are dropped from the sample in one identification, with no substantial impact on results. Real effective exchange rates are taken from the World Bank Database. Real house price data are from the International Housing Observatory. General government deficit size data are also from the OECD.Stat. So are data describing the share of individuals with equivalent liquid financial wealth less than 25% of the income, a potential measure of the proportion of hand-to-mouth households.

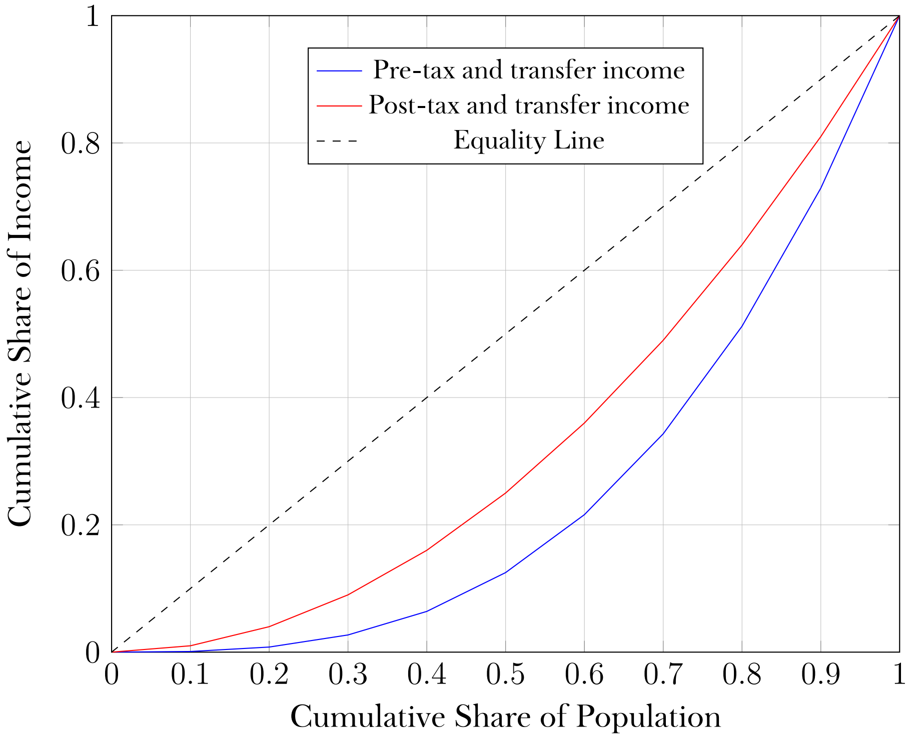
The index of quarterly real commodity prices that I use to control for global economic activity is taken from Baumeister and Guérin (2021). For robustness, the Federal Reserve Index of Real Economic Activity is also used to control for real commodity price changes. To control for Eurozone-wide changes in economic activity, Euro Area GDP from OECD.Stat is used.

I look at a range of alternative conditioning variables, to see their effect on monetary policy transmission. Value added tax rates as of 1 January 2022 are from OECD (2022). Annual capital gains tax rates over the period are from the Tax Foundation. I also use average income tax rates levied on a single without child at 167% of average earnings from OECD.Stat as a measure of high income taxes. An indicator variable distinguishing countries with national-level mortgage interest relief policies is constructed using data from the OECD Affordable Housing Database. Finally, the share of households with adjustable-rate mortgages for European countries over the period is taken from the ECB Statistical Data Warehouse.

4 Measuring Progressivity

There is no perfect or even consensus way to measure the progressivity of a country's tax and transfer system. It is also difficult to find data at the level required for a

Figure 1: *Lorenz Curves in a Progressive Tax and Transfer System*



wide range of countries to facilitate cross-country comparison. Additionally, it is often unclear which taxes or transfers should be included in the measure.

Progressivity for tax systems is defined as occurring when the average tax rate increases with income (Gerber et al., 2019). When this tax revenue is distributed in the form of transfers, these transfers are considered progressive when their distribution is weighted more towards low-income households than the distribution of tax incidence. Considering both the progressivity of taxes and of transfers, the entire system can be considered progressive if the Lorenz curve for post-tax and transfer income is closer to the equality line than that for pre-tax and transfer income, as shown in Figure 1.

I calculate the Reynolds-Smolensky index (RSI) to measure the level of progressivity of the tax and transfer system. The RSI is calculated from two standard measures of inequality, as follows:

$$RSI_{i,t} = G^{pre}_{i,t} - G^{post}_{i,t}$$

For period t and country i, $G^{pre}_{i,t}$ is the Gini coefficient of pre-tax and transfer income distribution and $G^{post}_{i,t}$ is the Gini coefficient of post-tax and transfer income distribution. A larger RSI would indicate a more redistributive tax and transfer system, because the economy becomes more equal after government intervention. An RSI of zero would imply a total lack of redistribution in the economy, as government intervention (or lack thereof) has no influence on equality. In Figure 1, the RSI would give the area between the pre- and post-tax and transfer Lorenz curves.

The RSI is particularly suited to the purposes of this empirical work as it is simple to calculate for countries across time, the data are readily available, and it encompasses taxes as well as transfers. Additionally, there is no concern that particular types of income taxes and transfers are being overlooked, as there might be if directly calculating a measure by looking at the progression of individual taxes or transfers. I have used Gini coefficients for market and disposable income for only the working age population (18- to 65-year-olds) in the construction of the RSI, as done in Causa and Hermansen (2021) to mitigate the issue raised by Hammer et al. (2021) of regressive pension payments overwhelming other forms of transfers in the results. The progression of the RSI for OECD countries over time can be seen in Figure 2, with countries ranked by RSI shown in Figure 3.

Figure 2: *Reynolds-Smolensky Index of OECD Countries, 2000-2019*

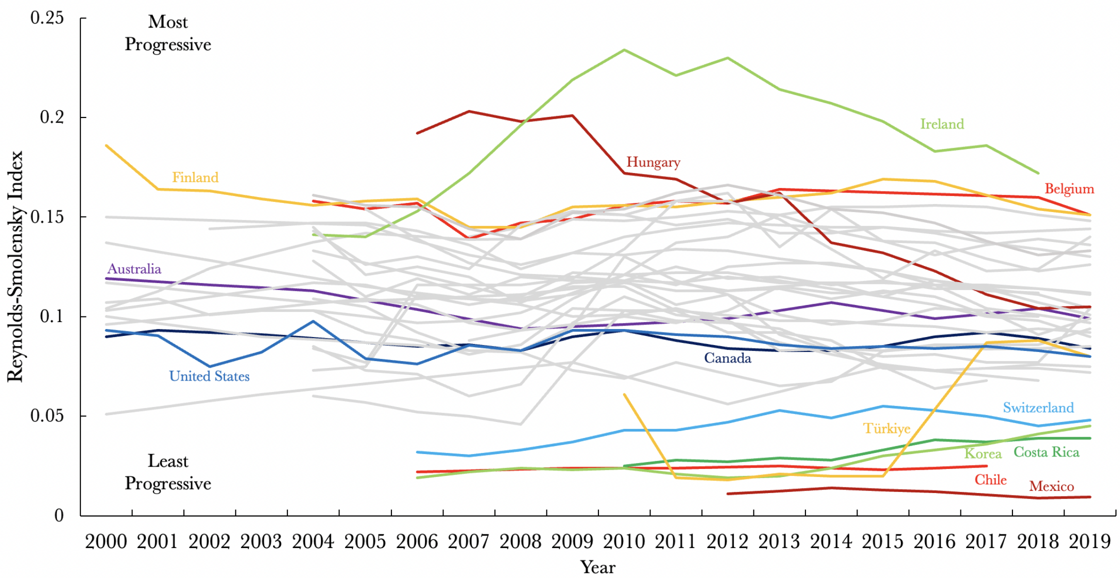
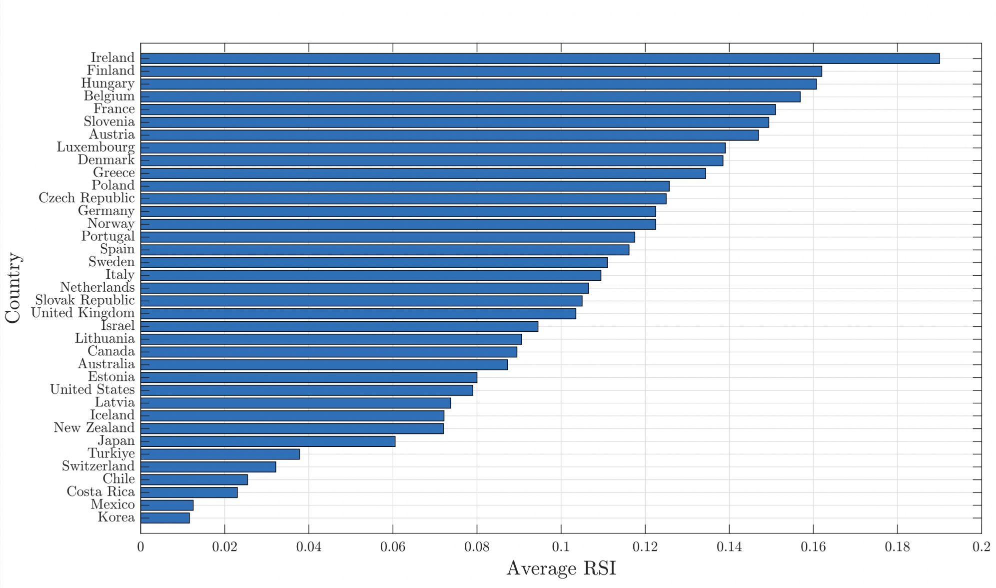


Figure 3: *Countries Ranked By Average RSI, 2000-2019*



Notably, the effect on progressivity of a regressive value-added tax (VAT) — such as the goods and services tax (GST) in Australia — is not captured by the RSI. This is because these taxes are levied on businesses rather than consumers. It is possible that governments may increase the progressivity of their income taxes to make up for implementing a VAT, which would have a neutral effect on the true level of progressivity but increase the country's RSI value. In Section 6.5, I exclude all countries with value-added taxes from my sample and retrieve generally similar results to the baseline identification, suggesting that this is not a significant issue. However, further work could develop a more detailed tax and transfer progressivity index that accounts for value-added taxes.

Another potential issue with the RSI noted in some previous work is that very unequal countries with relatively regressive tax and transfer systems may have the same RSI value as countries that are already relatively equal, and so need to perform less distribution. Vellutini and Benitez (2021) use the *transplant and compare* method of standardising pre-tax distributions to compare the level of redistributive capacity. However, in this thesis, this shortcoming of the RSI is helpful in allowing for the isolation of the effects of progressivity from effects arising from the initial level of inequality. Interestingly, there is no correlation between initial income distribution and tax and transfer progressivity (Table 2). However, there is a strong negative correlation between post-tax and transfer income inequality and progressivity. This implies, perhaps not surprisingly, that countries with higher tax and transfer progressivity are more likely to have more equal distributions of disposable income after taxes and transfers.

It is of course possible that countries may have more progressive policies for a period of time, and then become more equal, but would be shown to have a lower RSI value. In fact, this is helpful for interpretation because it means that the results are capturing the impact of the contemporaneous level of redistribution — not redistribution in the past, which would affect the level of inequality.

Exploring the different types of taxes being levied and benefits being distributed gives some insight into the relative levels of progressivity of different countries assessed by the index. Particularly puzzling might be the relatively high performance of countries such as the Czech Republic, Poland, and Slovakia. These countries have all had or continue to have flat personal income taxes. However, World Bank (2005) shows that the adoption of flat personal income taxes in Slovakia reinforced tax progressivity as tax credits and allowances took on a more important role. In fact, all Eastern European countries with flat taxes also have complex and progressive social security contributions, indirect taxation, and generous tax-free thresholds (Piper and Murphy, 2005).

Overall, the ranking of countries over time by tax and transfer progressivity (Figure 3) is very similar to those calculated over different time periods with OECD data by Escolano et al. (2010), Heisz and Murphy (2015), and Causa and Hermansen (2021), and with the EU-SILC database in Petrova (2020). A numerical ranking of countries by RSI, as well as complete RSI data can be found in the Appendix in Subsection A.2.

5 Empirical Methodology

5.1 Country VAR Models

I apply a similar routine to Georgiadis (2014) to measure the impact of the level of redistribution through taxes and transfers on monetary policy transmission. To begin, I obtain impulse response functions for the impact of a 100 basis point contractionary monetary policy shock on output using country-specific VAR models. I construct individual VAR models for the 37 countries in the sample, as shown below:

$$\boldsymbol{y}_{i,t} = \boldsymbol{\delta}_i + \sum_{j=1}^{p} \boldsymbol{A}_{i,j} \cdot \boldsymbol{y}_{i,t-j} + \sum_{j=0}^{q} \boldsymbol{D}_{i,j} \cdot \boldsymbol{x}_{i,t-j} + \boldsymbol{u}_{i,t}, \quad \boldsymbol{u}_{i,t} \overset{\text{i.i.d.}}{\sim} \left(\boldsymbol{0}, \sum_{u,i}\right) \tag{1}$$

Above, $i = 1, 2, \ldots, N$ indexes countries, while $t = 1, 2, \ldots, T$ indexes time. $\boldsymbol{y}_{i,t}$ is a vector of endogenous variables: output, the price level, consumption, total hours worked (all in logs), and the short term real interest rate. I use Cholesky decomposition with the interest rate ordered last. $\boldsymbol{x}_{i,t}$ is the exogenous variable, real commodity prices, which controls for changes in interest rates in response to global economic activity. $\boldsymbol{A}_{i,j}$ and $\boldsymbol{D}_{i,j}$ are coefficient matrices for the endogenous and exogenous variables respectively. The endogenous and exogenous variables have a lag orders of $p = 2$ and $q = 0$ in the baseline identification.

5.2 Panel Conditionally Homogeneous VAR Model

Next, I construct a panel conditionally homogeneous VAR (PCHVAR) model, based on Georgiadis (2014). This model allows impulse responses to only vary across countries to the extent that they experience heterogeneity in a *conditioning variable*, in this case tax and transfer progressivity. The benefit of the PCHVAR model is that this conditioning variable can vary across time and between countries, meaning that the model will generate time-varying impulse response functions. I calculate the PCHVAR model as follows:

$$\boldsymbol{y}_{i,t} = \boldsymbol{\delta}_i + \sum_{j=1}^{p} \boldsymbol{A}(RSI_{i,t}) \cdot \boldsymbol{y}_{i,t-j} + \sum_{j=0}^{q} \boldsymbol{D}_{i,j} \cdot \boldsymbol{x}_{i,t-j} + \boldsymbol{u}_{i,t}, \quad \boldsymbol{u}_{i,t} \overset{\text{i.i.d.}}{\sim} \left(\boldsymbol{0}, \sum_{u}\right) \tag{2}$$

Here, $\boldsymbol{y}_{i,t}$ is a vector of the same endogenous variables as before. $RSI_{i,t}$ is the Reynolds-Smolensky index (the measure of progressivity) of country i at time t. $\boldsymbol{A}(RSI_{i,t})$ is a coefficient matrix, with each element $\boldsymbol{a}_{sm}$ being a function of the country's Reynolds-Smolensky index, $RSI_{i,t}$. As such, the dynamics of two countries are the same only when their progressivity index value $RSI_{i,t}$ is the same, thereby being *conditionally homogeneous*. I approximate the scalar coefficients $\boldsymbol{a}_{sm}(RSI_{i,t})$ using a scalar polynomial of $RSI_{i,t}$, $\boldsymbol{\pi}(RSI_{i,t})$ as follows:

$$\boldsymbol{a}_{sm}(RSI_{i,t}) = \boldsymbol{\pi}(RSI_{i,t}) \cdot \boldsymbol{\lambda}_{sm} \tag{3}$$

Here, $\boldsymbol{\pi}(RSI_{i,t})$ is a vector with polynomials in $RSI_{i,t}$, and λ_j is a vector of polynomial coefficients which can be found using ordinary least squares. Since the progression of RSI values across my sample is relatively linear (Figure 4), in my baseline identification it is appropriate to use a polynomial of order 1. A nonlinear progression of RSI values in the data would indicate that a nonlinear polynomial should be used for estimation.[4] This allows $\boldsymbol{a}_{sm}(RSI_{i,t})$ to be written as:

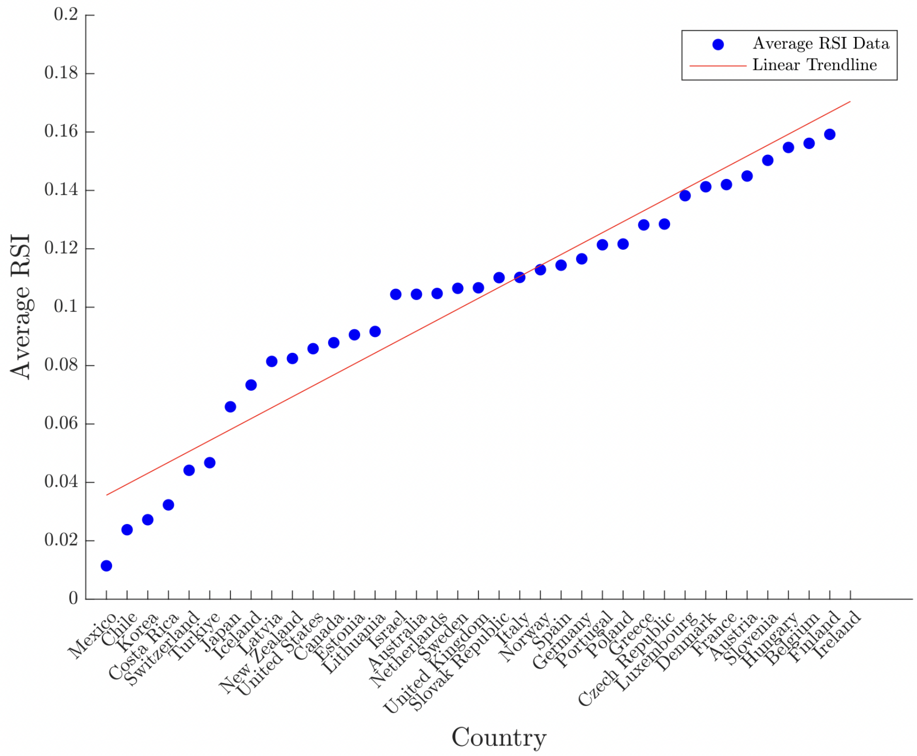
$$\boldsymbol{a}_{sm}(RSI_{i,t}) = \lambda_{0,sm} + \lambda_{1,sm} \cdot RSI_{i,t} \tag{4}$$

Finding the coefficients $\lambda_{0,sm}$ and $\lambda_{1,sm}$ allows for the matrix $\boldsymbol{A}$ to be recovered. For a standard fixed effects panel model, the order of the polynomial in Equation 3 would be 0. That is, the impulse responses would have no relationship to the value of $RSI_{i,t}$.

Next, I generate 200 values of the conditioning variable, $RSI_{i,t}$, to span the range of values that appear in my sample. For each value of the conditioning variable, I

[4] Georgiadis (2014) uses a cubic polynomial for estimation with different conditioning variables. The results of this thesis are robust to similarly using a cubic polynomial instead of a linear polynomial for estimation.

Figure 4: *Sample Values of Conditioning Variable*



calculate the corresponding impulse response functions for the PCHVAR model, again using Cholesky decomposition with the interest rate ordered last. This results in 200 different impulse response functions, which I then map to each corresponding value of the conditioning variable for each country in each period. The simple average of the impulse responses is taken over each time period for each country and horizon, as follows, where $h = 0, 1, 2, \ldots, 24$ is the response horizon:

$$\widehat{\boldsymbol{ir}}_{ih}^{PCHVAR} \equiv T^{-1} \cdot \widehat{\boldsymbol{IR}}_{it}(h) \tag{5}$$

Finally, I regress the impulse responses obtained from the individual country VAR models on those from the PCHVAR model, as set out below:

$$\widehat{\boldsymbol{ir}}_{ih}^{(v,Country)} = \alpha_h^{(v)} + \beta_h^{(v)} \cdot \widehat{\boldsymbol{ir}}_{ih}^{(v,PCHVAR)} + \delta_{ih}^{(v)} \tag{6}$$

Here, and v is the choice of endogenous variable. The R^2 of this regression represents a measure of the fraction of cross-country heterogeneity in monetary policy transmission accounted for by cross-country differences in tax and transfer progressivity.

Notably, using the PCHVAR impulse responses functions as the regressor creates a generated regressor problem. This is likely to result in some attenuation bias in the results, causing the R^2 values to be biased downwards. However, this means that the true R^2 values are likely to be greater than estimated in our results, reinforcing any findings of significance.

6 Main Results

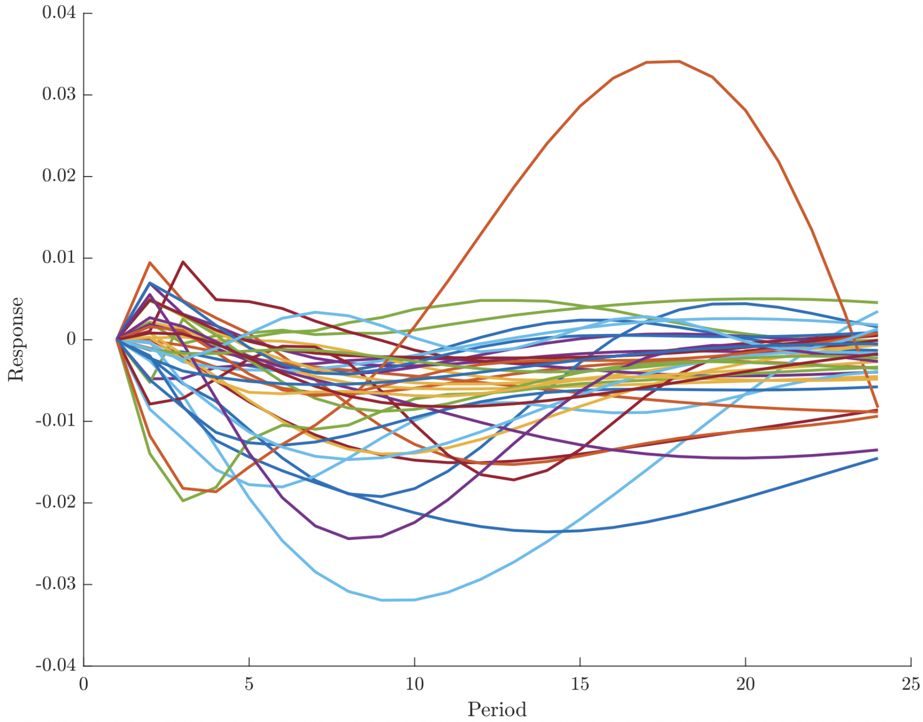
6.1 Country VAR Impulse Responses

I first examine the different responses of countries in the sample to a 1 unit contractionary monetary policy shock using Equation 1. The impulse responses for output and prices are shown in Figures 5 and 6.

For almost all countries in the sample (with the main exceptions being Mexico and Costa Rica), the estimated impulse responses follow theory, with the contractionary monetary policy shock causing a decrease in prices and output over the horizon period. Across countries, however, the persistence of this decrease varies.

The impulse responses for around half the countries in the sample show price puzzles lasting for approximately a year. In other words, prices initially increase in response to the monetary policy shock. These price puzzles indicate that for the countries for which they occur, the monetary policy shock is being imperfectly identified in the short term, possibly due to inflation expectations being unaccounted for in the model (Bishop and Tulip, 2017). Price puzzles are thought to occur when patterns in the data reflect the central bank tightening interest rates in expectation of further inflation in the future. Including a Global Financial Cycle index, 1-year-ahead US inflation expectations, and the 5-year-ahead US breakeven rate in the model as controls were able to slightly decrease the output and price puzzles, but were not sufficient to completely eliminate them. Further work could use country-specific inflation ex-

Figure 5: *Individual Country VAR Impulse Responses for Output*

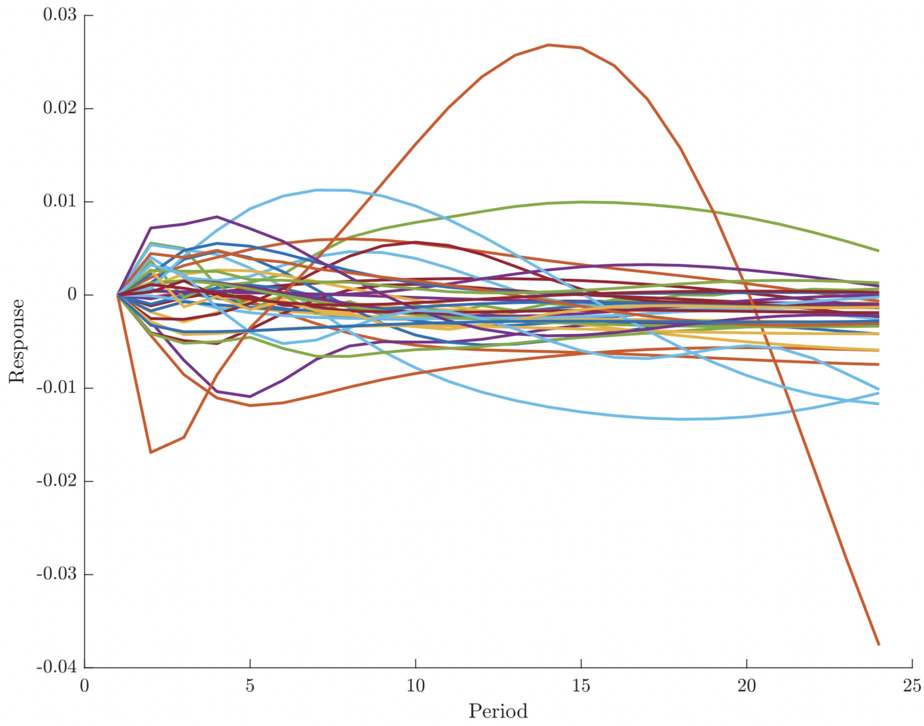


Note: Output responses for each of the 37 OECD countries in the sample are shown in response to a 1 percentage point contractionary monetary policy shock, i.e. a 1 unit increase in the interest rate.

pectations data to mitigate this issue. Looking to comparable literature, Georgiadis (2014), using a simpler monetary VAR of output, prices, and the real interest rate, similarly finds output and price puzzles for countries in his sample. He discards countries with significant price puzzles from his sample. Using the sample of countries in Georgiadis (2014), the impulse responses that I derive look very similar to his (see Appendix Figures 25 and 26). However, I include the complete sample in my work to avoid selecting out countries with particular characteristics that could be related to both the likelihood of a price puzzle occurring and the level of progressivity.

Despite the price puzzle being a potential issue for interpretation of the short term in the subsequent results, I can still make reasonable inferences about the medium-to-long term. Additionally, my conclusions are derived from the heterogeneity of responses to the monetary policy shock, not the magnitudes of the shocks themselves, meaning that the shocks do not have to be perfectly identified to draw conclusions

Figure 6: *Individual Country VAR Impulse Responses for Prices*



Note: Price responses for each of the 37 OECD countries in the sample are shown in response to a 1 percentage point contractionary monetary policy shock, i.e. a 1 unit increase in the interest rate.

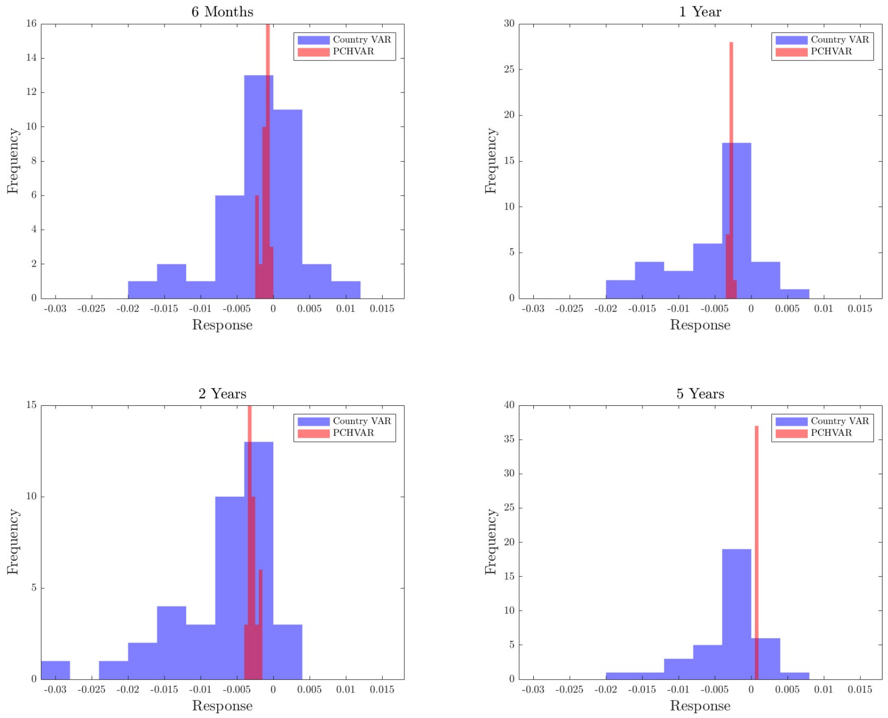
from the data.

6.2 Explanatory Power of Progressivity Measure

Figures 7 and 8 show the distributions of country VAR and PCHVAR impulse responses for each country at key horizon points, showing that conditioning the IRFs on RSI results in some variation in impulse responses, but not as much as occurs when these responses are allowed to vary based on other factors, as in the country VAR models.

Figures 9 and 10 show the output of regressing the impulse responses from the individual country VARs estimated in Equation 1 on the corresponding impulse responses generated by the PCHVAR model using Equation 5. This regression is outlined in Equation 6. The R^2 values of these regressions are the proportions of cross-

Figure 7: *Impulse Responses at Key Horizons for Output*



Note: Output responses for each of the 37 OECD countries in the sample are shown in response to a 1 percentage point contractionary monetary policy shock, i.e. a 1 unit increase in the interest rate.

country heterogeneity in impulse responses that are explained by the progressivity measure. This can be thought of as the *explanatory power* of the RSI, with regards to explaining differences in monetary policy transmission across countries. Maximum and mean R^2 values for each endogenous variable of interest over the medium-to-long run horizon are displayed in Table 1. Statistical significance at the 5% level is determined by bootstrapped 95% confidence intervals.

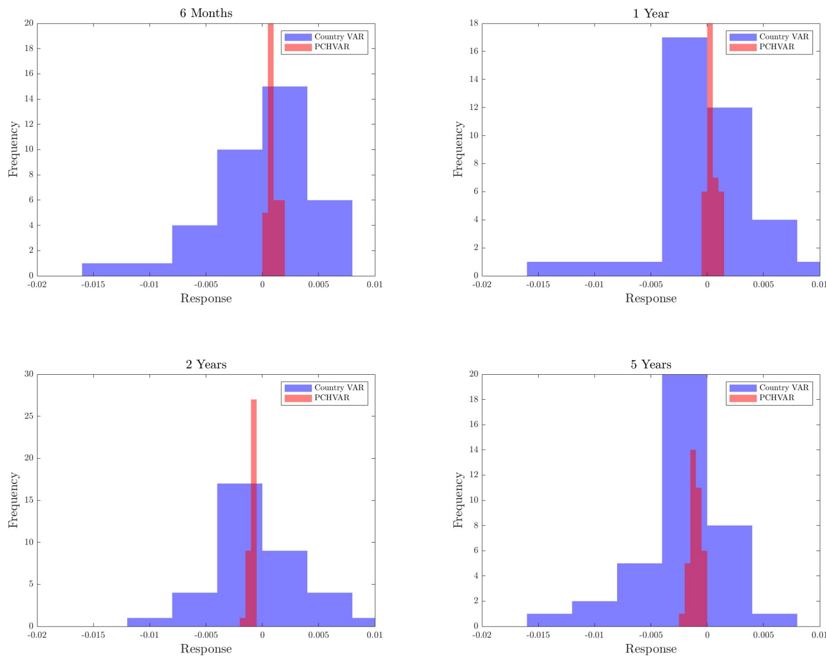
Looking at the progression of the R^2 value in the top left panel of Figure 9, varia-

Table 1: *Results from Regressing Country IRFs on PCHVAR IRFs*

	Output	**Prices**	**Consumption**	**Hours Worked**	**Interest Rate**
Maximum	0.280*	0.080	0.210*	0.087	0.116*
Mean	0.235*	0.041	0.096	0.057	0.058

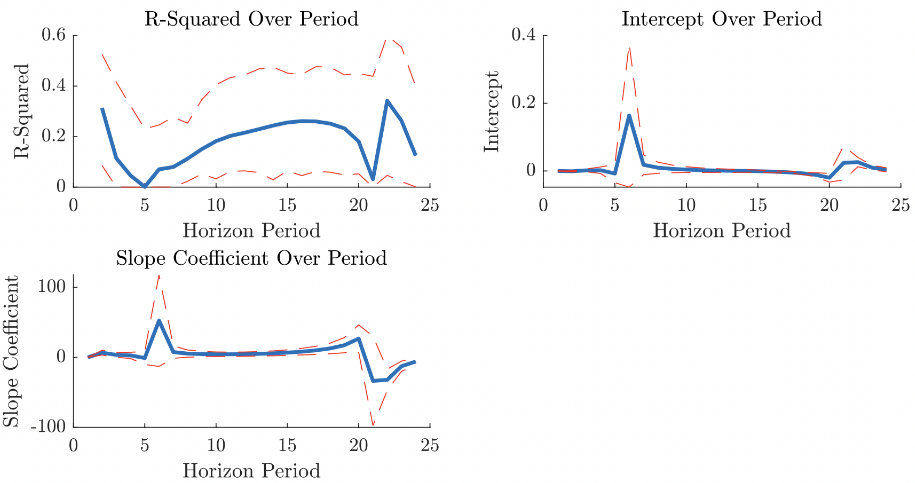
Note: Results are displayed for the period 2-5 years after the shock occurs. Statistical significance at the 5% level is represented by *. Results are rounded to 3 decimal places.

Figure 8: *Impulse Responses at Key Horizons for Prices*



Note: Price responses for each of the 37 OECD countries in the sample are shown in response to a 1 percentage point contractionary monetary policy shock, i.e. a 1 unit increase in the interest rate.

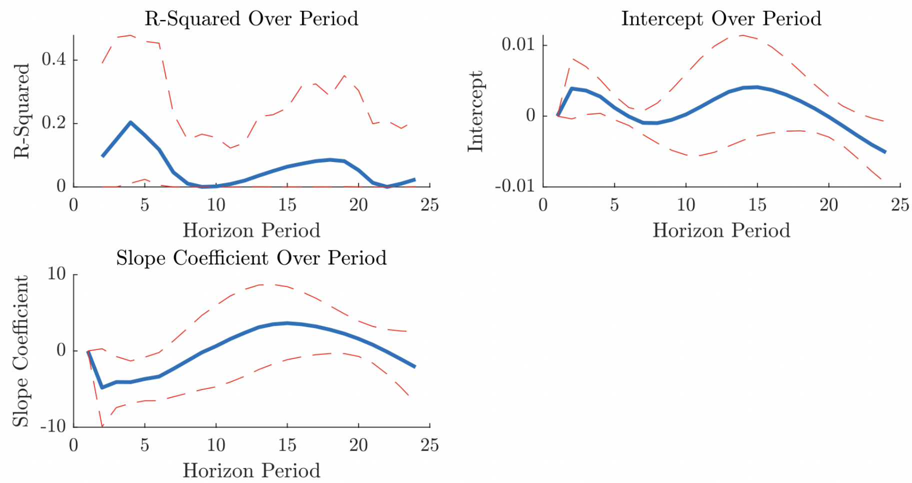
Figure 9: *Regressing PCHVAR IRFs on Country IRFs for Output*



Note: Red dashed lines indicate bootstrapped 95% confidence intervals.

tion in the progressivity measure explains around 20% of heterogeneity in responses of output, with the bulk of this effect occurring 2-5 years after the shock occurs. Importantly, at 5% significance, we can also reject that the effect is null during this period. The mean amount explained by the progressivity index for this period is 23.5%, but reaches almost 30% at its peak. Notably, Georgiadis (2014) finds similar results using financial structure and industry mix as conditioning variables, with these explaining around 40% and 20% of heterogeneity, respectively. Figure 10 shows that the progressivity

Figure 10: *Regressing PCHVAR IRFs on Country IRFs for Prices*



Note: Red dashed lines indicate bootstrapped 95% confidence intervals.

measure explains up to 8% of heterogeneity in responses of prices over the medium-to-long term with a similar persistence. Here, we cannot reject the null hypothesis that the impact on the response of prices is greater than zero (Table 1). These results are similar to those found by Georgiadis (2014) for financial structure and industry mix in the medium term, although have less explanatory power than those variables in the long term.

Additionally, at its peak, the RSI explains around 21% of cross-country heterogeneity in consumption. This result is statistically significant. We can also reject the null for the result that the maximum explanatory power of the RSI for interest rate responses is just over 11%. Results for labour hours are not statistically significant, but here the RSI is shown to explain up to 8% of heterogeneity.

6.3 Impulse Responses in Different Progressivity Settings

While the results in the previous section show the extent to which the RSI is important for explaining heterogeneity in monetary policy transmission, another key question whether this transmission is more effective when progressivity is higher or lower. There are two main channels through which progressivity can affect monetary policy transmission:

1. **Stabilisation Effect**

   Firstly, taxes and transfers act as automatic stabilisers by reducing the volatility of output in response to shocks. They effectively work to increase the size of the fiscal multiplier, acting countercyclically to dampen the effects of monetary policy transmission. Higher progressivity should then result in less effective monetary policy transmission (Mattesini and Rossi, 2012).

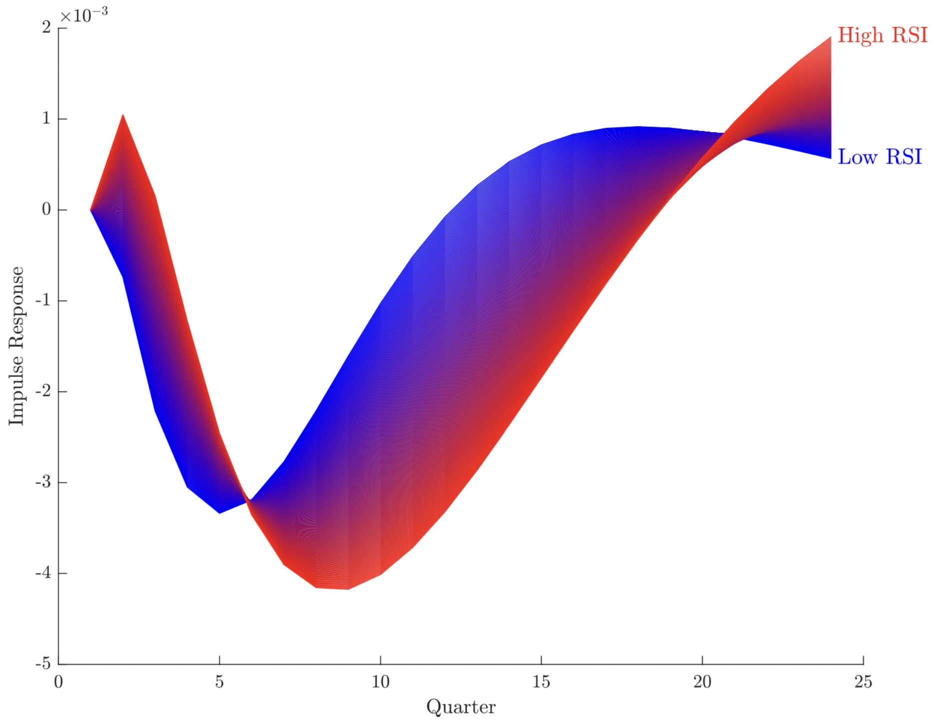
2. **Redistribution Effect**

   Secondly, high levels of redistribution allow more households to save and accrue liquid assets. When wealthier households are taxed more, they are less able to rely solely on their incomes for consumption, making more liquid assets relatively more desirable. With lower levels of redistribution, there are more poor and wealthy hand-to-mouth households that consume their entire income in every pay-period (Kaplan et al., 2018). As such, higher progressivity increases the proportion of households that are exposed to interest rate risk, and are more sensitive to monetary policy decisions. Higher progressivity should then result in *more* effective monetary policy transmission.

To determine if either, both, or none of the above channels are important in the results I find, I consider the impulse responses generated by the PCHVAR model in Equation 2 for each value of the Reynolds-Smolensky index in the sample range.

These responses vary substantially according to the value of the RSI they are conditioned on. Looking first to the responses of output in Figure 11, the monetary policy

Figure 11: *Impulse Responses for Different RSI Values: Output*

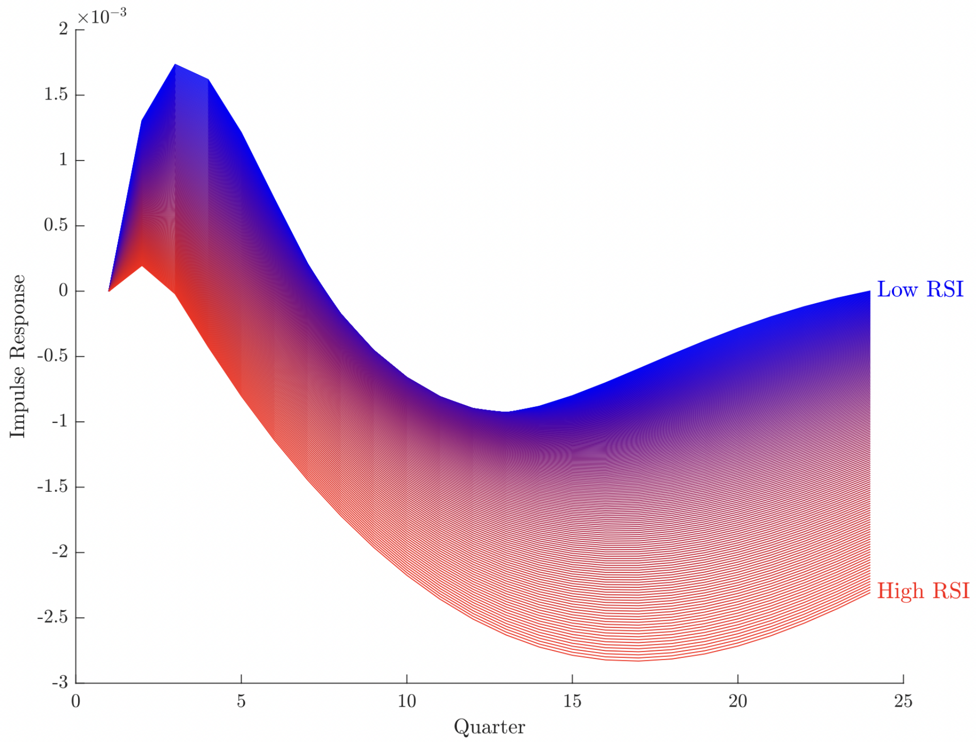


Note: Impulse responses of output shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock.

shock has a greater contractionary effect 2 to 5 years after the shock occurs in a more progressive setting. This is also the period in which the country IRFs constructed from the PCHVAR results can explain the most cross-country variation in responses of output. Settings with greater tax and transfer progressivity will have fewer households that are considered hand-to-mouth, in other words, relatively insensitive to changes in the interest rate. Instead, there will be more saver households that are following their Euler equations to smooth their income over time, and as such will be more interest-rate sensitive. Because there are more households that are interest-rate sensitive in this setting, monetary policy transmission has a greater effect. These results indicate that the *redistribution effect* is dominating the *stabilisation effect* over this period.

In the short term, it appears that transmission is more effective when progressivity is *lower*. Higher levels of taxes and transfers in high progressivity settings help households to smooth their incomes in response to a shock, meaning that households are initally able to maintain high levels of consumption, offsetting the contractionary impact of the shock. In other words, while the redistribution effect dominates in the long term, the stabilisation effect dominates in the short term.

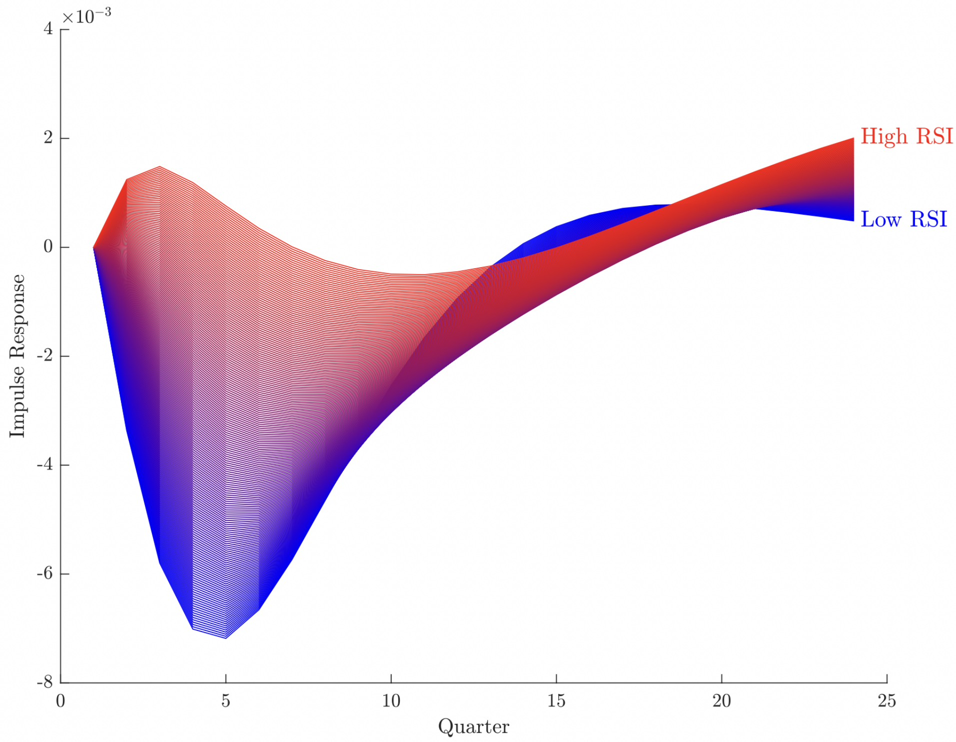
Figure 12: *Impulse Responses for Prices with Different RSI Values*



Note: Impulse responses of prices shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock.

Figure 12 shows that prices are persistently lower after the shock in high progressivity settings, with this differential increasing in the medium-to-long term. These results are consistent with the theory that monetary policy will be more effective in settings with more saver households. However, there is also clearly a price puzzle for all levels of the progressivity index that lasts for around a year. This means that it is likely that the short-term responses of prices are being incorrectly identified.

Figure 13: *Impulse Responses for Consumption with Different RSI Values*



Note: Impulse responses of consumption shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock.

The results that I find for consumption shown in Figure 13 are more complicated. In the short term, I find support for the theory that government transfers in high progressivity settings supplement incomes and boost consumption, while consumption plummets in low progressivity settings. I find that consumption levels remain highest in the most progressive settings for almost the whole period, only surpassed by consumption levels in the *lowest* progressivity settings between around 2 to 5 years after the shock. This means that for most of the horizon period, in the highest progressivity settings, consumption maintained by government transfers is sufficient to offset the countervailing effect of drop in aggregate demand resulting from the monetary policy shock.

However, in the lowest progressivity settings, despite consumption initially plummeting with low levels of redistribution, the contractionary effects of the monetary policy shock are lower overall, resulting in consumption bouncing back to higher levels than in the most progressive settings between 3 to 5 years after the shock. In the medium-to-long term, consumption remains lowest for moderately progressive settings. In these settings, monetary policy still has a relatively large contractionary impact, and households receive only a moderate amount of government support. This means that the stabilisation effect is still unable to offset the contractionary redistribution effect in the medium-to-long run.

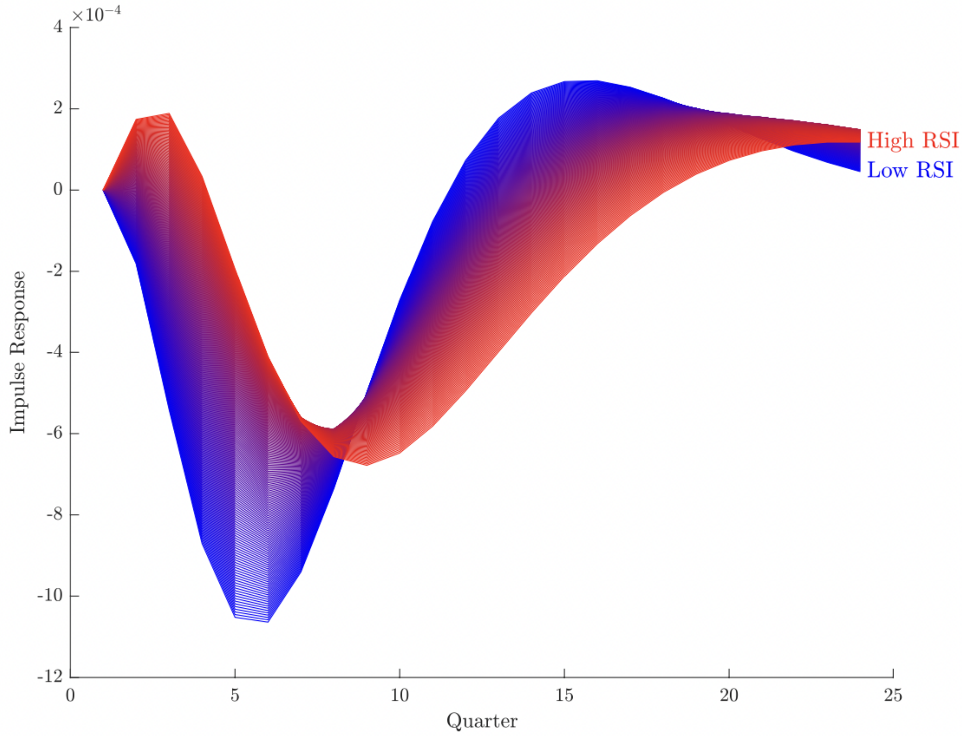
In line with theory, Figure 14 shows the impulse responses for labour hours, which follow a closer pattern to output than to consumption. This indicates that the heterogeneity in responses of labour hours under different progressivity settings is telling a story about labour demand as opposed to labour supply. If these differences were due to labour supply, households would most likely supply less labour in the high progressivity settings in the short run, where their incomes are being supplemented by the largest transfers. However, the opposite is true. In other words, while differences in changes in consumption are mostly explained by changes in household income, changes in labour hours are mostly explained by changes in interest rates.

Finally, Figure 15 shows the impulse responses of the interest rate. The interest rate initially increases further in all progressivity settings, but remains the highest in the high progressivity settings until around 4 years after the monetary policy shock. This is logical with respect to the Taylor Rule given that the effects of the shock are less contractionary in high progressivity settings for around 2 years after the shock with regards to output and labour hours, and up to 3 years for consumption.

6.4 Sources of Variation

A key question for interpretation is whether the results are being driven by variation of the progressivity index within or across countries. If it was the case that across-country variation in progressivity was relatively unimportant, it would be impossible to conclude that this variation could explain heterogenous monetary policies across countries. To determine the extent to which within country variation occurs, I calcu-

Figure 14: *Impulse Responses for Hours Worked with Different RSI Values*

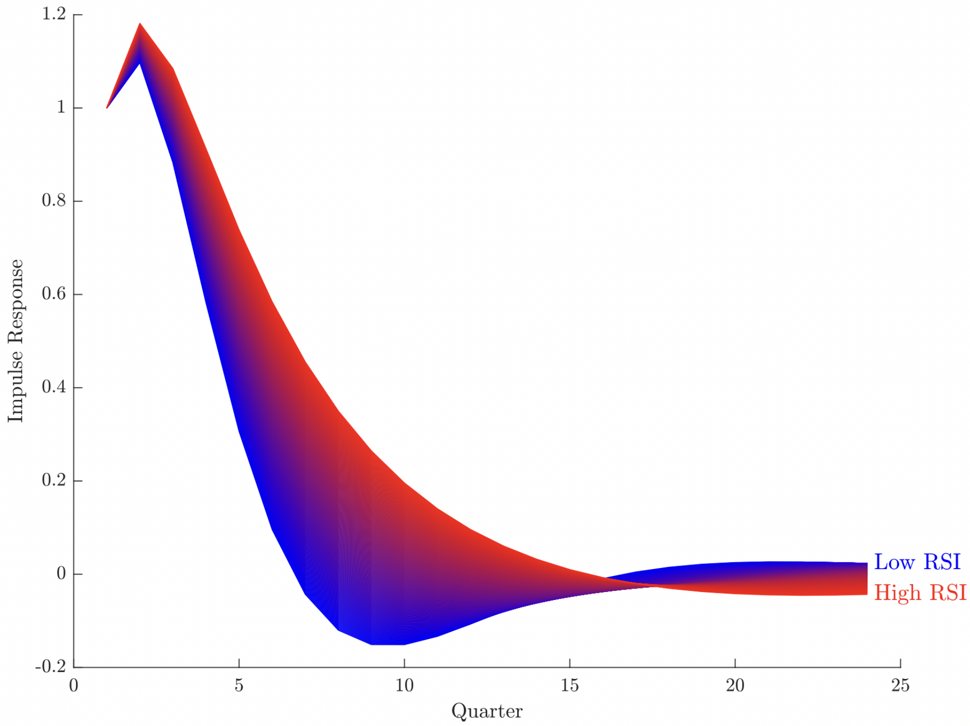


Note: Impulse responses of hours worked shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock.

late lines of best fit for the progression of RSI values over time for each country, and find the mean slope to be large and negative. In other words, on average, countries decline in progressivity over the period. Removing the most extreme positive outlier (Türkiye) and negative outlier (Hungary) turns the mean slope small and positive, which is a result that is more consistent with global progressivity trends that are described in Gerber et al. (2019). However, dropping Türkiye and Hungary from the sample has a trivial impact on the resulting IRFs from the PCVHAR model. Since results are unaffected by excluding the countries that vary the most over the period in terms of progressivity, this suggests that results are relatively insensitive to within country variation.

To further test for the importance of the time dimension, I replace the time-varying progressivity index as the conditioning variable with the value of the index at the beginning of the sample, the end of the sample, and the average for each coun-

Figure 15: *Impulse Responses for the Interest Rate with Different RSI Values*



Note: Impulse responses of the interest rate shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock.

try. This created some difficulty, as including time-invariant conditioning variables in the PCHVAR model resulted in eigenvalues greater than unity, leading to explosive PCHVAR impulse responses at very high levels of the RSI. To handle this, when creating the impulse responses for each country from the PCHVAR model, each country RSI value is mapped onto by only the *well-behaved* PCHVAR impulse response with the closest corresponding generated RSI value. The well-behaved PCHVAR impulse responses for each of these three identifications are similar to each other and to baseline in the medium-to-long run (see Appendix Figure 27), providing further evidence that across-country variation in progressivity matters more to the results than within country variation.

6.5 Robustness

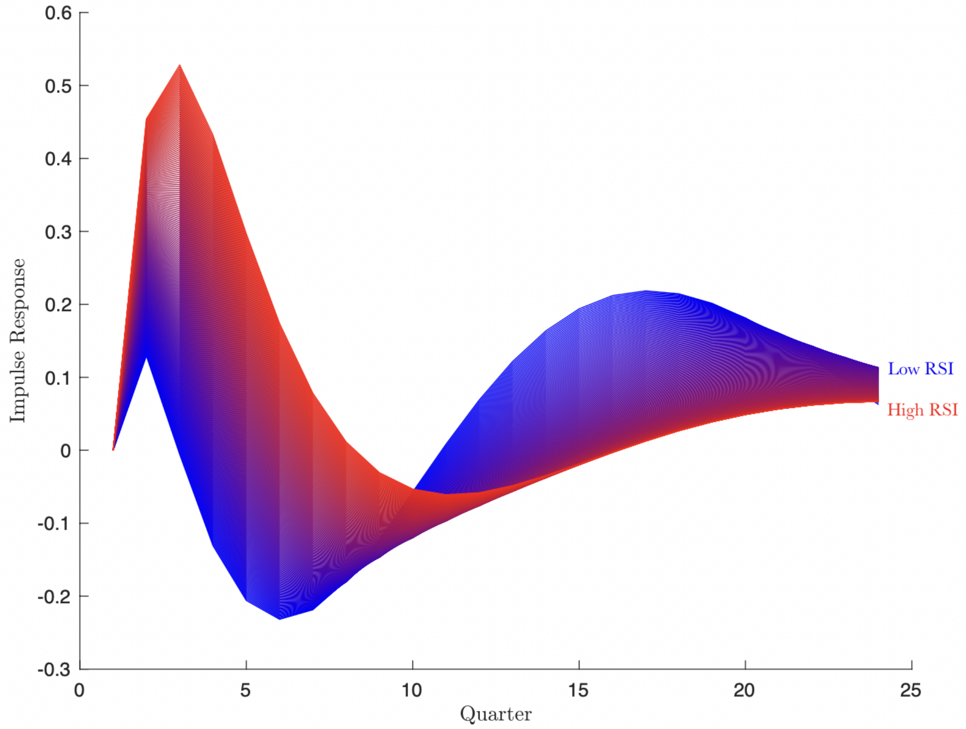
A potential problem for inference with the chosen model is that higher levels of government spending are likely to be associated with higher levels of progressivity as well as less contractionary effects from monetary policy tightening, as fiscal policy supports aggregate demand. All results are robust to including the government deficit as an endogenous variable in the country VAR and PCHVAR models, ordered before the interest rate. However, the mean R^2 for prices over the horizon period is slightly smaller. The results in Figure 16 show the countercyclical effects of fiscal policy: the budget balance is initially positive and larger in highly progressive settings, during which period output is relatively higher, and fiscal policy helps to smooth incomes, but shrinks towards deficit as the contractionary monetary policy effects begin to dominate, and output decreases.

Another potential issue could be that the model is not capturing the exchange rate channel of monetary policy transmission. Results are robust to including real effective exchange rates as an endogenous variable in the country VAR and PCHVAR models, ordered after the interest rate. However, the mean R^2 for prices over the horizon period is slightly smaller. The dynamics of the real effective exchange rate are shown in Figure 17. In the short run, the real effective exchange rate is shown to depreciate by more in more progressive settings, although after a year, much greater depreciation occurs in less progressive settings. The lower interest rates that occur in less progressive settings put greater downwards pressure on exchange rates.

I also consider that regressive value-added taxes, such as the Goods and Services Tax in Australia, are levied on businesses rather than households. This means that a government could decide to increase the size of a value-added tax, and decrease the level of progressivity in the economy, but this decrease would not be captured by the RSI, which only captures the differences in income inequality after *income* taxes and transfers. Results are robust when countries with value-added taxes are dropped from the model (see Appendix Figures 29 and 30).

Another issue could be that the model does not capture the effects of changes in

Figure 16: *Impulse Responses for the Budget Balance with Different RSI Values*

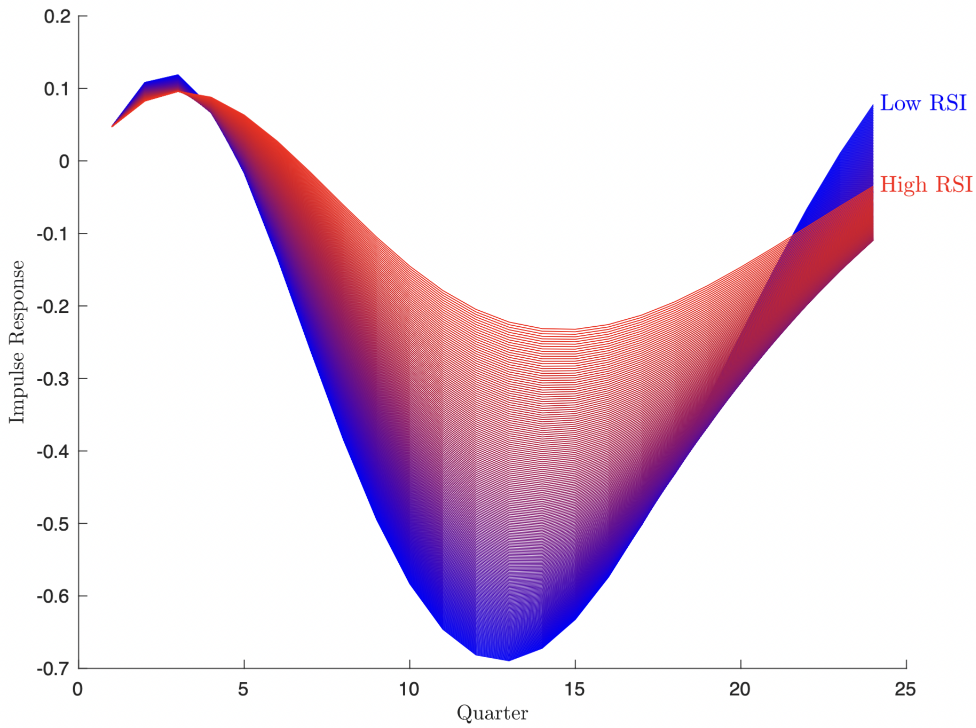


Note: Impulse responses of the budget balance shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. These responses are generated by including the budget balance as an additional endogenous variable in the PCHVAR model, ordered before the interest rate.

wealth, which would affect the proportion of wealthy hand-to-mouth households. To control for wealth in the models, I include house prices as an endogenous variable, ordered before the interest rate. Because these house price data are only available for a subset of my sample of countries, I restrict my sample for this identification. Results with house prices are different from baseline, but when restricting the baseline model to the smaller sample of countries, the results are the same (see Appendix Figure 31). This shows that results are robust to including house prices as a measure of wealth.

Monetary policy being constricted by the zero lower bound (ZLB) in some countries in the sample could contribute to the monetary policy shock being misidentified, as the interest rate is not allowed to freely respond to economic conditions. To mitigate this issue, I use a shadow interest rate where these data are available. I drop

Figure 17: *Impulse Responses for the Real Effective Exchange Rate with Different RSI Values**



Note: Impulse responses of the real effective exchange rate shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. These responses are generated by including real effective exchange rates as an additional endogenous variable in the PCHVAR model, ordered after the interest rate.

the remaining countries which experience monetary policy close to the ZLB, and find results to be robust to this restricted sample.

All results in this thesis are robust to using the overnight bank lending rate and the money supply (M3) in place of the short-term real interest rate in the model. Results are also robust to including the FRED Index of Global Real Economic Activity as an alternative control to the Real Commodity Prices index from Baumeister and Guérin (2021). Additionally, results are robust to including 1-year-ahead US inflation expectations and the 5-year-ahead US breakeven rate as endogenous variables in the model to control for inflation expectations. Including these variables slightly decreases the size of the price puzzles that occur in the PCHVAR impulse responses.

With respect to total labour hours, I have linearly interpolated across the annual data to achieve a quarterly frequency. For robustness, I also use cubic spline interpolation. While this has no noticeable effect on any of the other results, the impulse responses generated by the PCHVAR model do look substantially different for labour hours (see Appendix Figure 32). While in the baseline results, labour hours decrease by less in higher progressivity settings in the short run, in this identification the opposite is true. The cubic spline interpolation is creating a large amount of volatility, however, the conclusion that labour hours decrease by more in more progressive settings in the medium-to-long run still holds.

In the baseline specification, I use a lag order of 2 quarters for ease of computation. Increasing the lag order beyond 2 leads to very similar results, implying a lack of sensitivity to lag order.

Additionally, for Mexico and Hungary, only the pre-tax and transfer (not post-tax and transfer) Gini coefficients were available from the OECD. This means that the RSI for Mexico and Hungary is only computing the level of redistribution from transfers, not from taxes. This would be likely to overestimate the progressivity of Hungary, which has high levels of transfers, and underestimate the progressivity of Mexico, which has low levels of transfers. This may also be why Hungary has such a high RSI value on average. Results are robust to dropping both Mexico and Hungary from the sample to avoid this bias.

While my results are robust to the different specifications discussed above, they are sensitive to significant variation in the range of progressivity represented by countries in the sample. For example, removing most of the most or least progressive countries will significantly alter the results. However, dropping countries one or two at a time has a trivial impact. Splitting the sample into a "High Progressivity" group and a "Low Progressivity" group results in very different impulse responses for both (see Appendix Figure 33). Including countries with the widest range of progressivity values instead of restricting the sample will provide the most informative results. These results provide further evidence that the heterogeneity of responses is driven substantially by variation across countries, as discussed in Subsection 6.4.

Table 2: *Correlation Matrix of Relevant Variables*

Correlation	RSI	Pre Gini	Post Gini	PIT	CGT	Relief	VRM	GDP	Corp. Tax
RSI	1.000								
Pre Gini	0.053	1.000							
Post Gini	**-0.689**	**0.684**	1.000						
Top PIT	**0.571**	**-0.265**	**-0.600**	1.000					
CGT	**0.272**	**0.244**	-0.024	**0.370**	1.000				
Relief	0.085	**-0.118**	**-0.152**	**0.279**	**0.146**	1.000			
VRM	-0.026	**0.331**	**0.350**	**-0.276**	0.022	-0.015	1.000		
GDP	**0.331**	**-0.214**	**-0.413**	**0.508**	0.012	**0.254**	**-0.111**	1.000	
Corp. Tax	**-0.492**	**0.285**	**0.548**	**-0.387**	0.082	**0.422**	**-0.459**	**-0.134**	1.000

Note: Correlations higher than 0.1 are displayed in bold font. RSI = Reynolds-Smolensky index. Pre Gini = Pre-tax and transfer Gini coefficient. Post Gini = Post-tax and transfer Gini coefficient. PIT = average personal income tax rate for single person households earning 167% of average income. CGT = capital gains tax. Relief = mortgage interest relief policies (1 if yes, 0 if no). VRM = variable rate mortgage share. GDP = GDP per capita. Corp. Tax = effective average corporate tax rate.

7 Further Results

The PCHVAR framework outlined in Georgiadis (2014) and adopted in this thesis can be used to investigate the impacts of other conditioning variables on monetary policy effectiveness. Many of these auxiliary findings can shed more light on the baseline results. Table 2 displays a correlation matrix for the conditioning variables used, as well as other useful variables for comparison.

7.1 Inequality

Several studies have investigated the impact of inequality on the transmission of monetary policy. Notably, Pereira da Silva et al. (2022) conclude that low levels of inequality make monetary policy more effective. The measure of progressivity that I use, the Reynolds-Smolensky index, is constructed from two measures of inequality that can be used as individual conditioning variables to see if the results of the PCHVAR model support these claims. That is, I replace the RSI in the PCHVAR model with the pre-tax and transfer and post-tax and transfer income Gini coefficients, which represent income inequality before and after taxes and transfers, respectively. These results are also of interest to ensure that I am not just capturing effects from inequality in the baseline findings, but from progressivity itself.

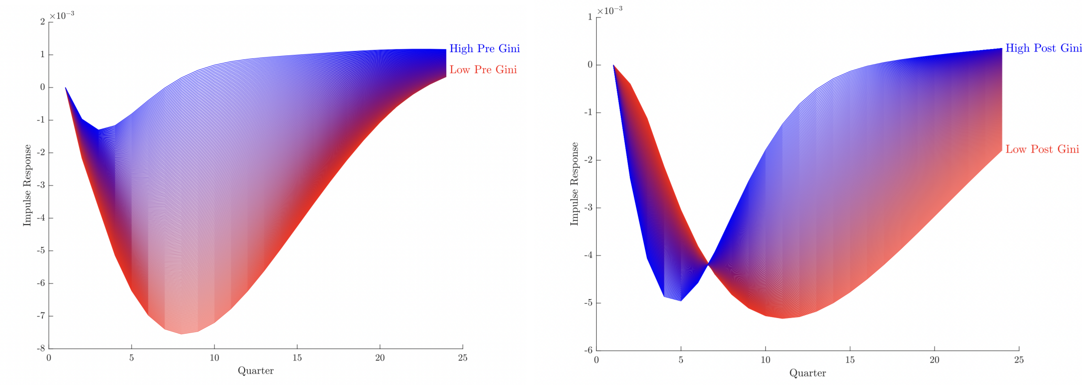
I firstly condition monetary policy transmission on the Gini coefficient of pre-tax and transfer income distribution. For each of the endogenous variables I consider in the model, I find that this measure of inequality is able to explain very little of cross-country heterogeneity in the impulse responses, and am unable to reject the null that it has no explanatory power.

Next, I consider the Gini coefficient of inequality after taxes and transfers. This conditioning variable can explain much more of cross-country heterogeneity in the impulse responses for output in the medium-to-long term, but not for prices (see Appendix Figures 34 and 35). The explanatory power for all variables is still around half that of the baseline results using the progressivity index.

These results imply that post-tax and transfer inequality is more significant for monetary policy transmission than pre-tax and transfer inequality. If only income distribution was important, and it was only these effects were being captured by looking at progressivity, the opposite effect should occur. Additionally, while the progressivity index is uncorrelated with the pre-tax and transfer Gini coefficient, it has a correlation of 0.6 with the post-tax and transfer Gini coefficient. Clearly, *redistribution* plays a significant role in these results. And importantly, while there is a moderate degree of correlation, not all countries with a very equal disposable income distribution are progressive, and vice versa. To the extent that inequality is important, I find progressivity to be much more important.

For both the pre and post-tax and transfer income Gini coefficients, the impulse responses for output and consumption are very similar to each other and to baseline. However, the right-hand panel of Figure 18 shows that in countries that are more equal after taxes and transfers, i.e. countries that are more likely to have higher levels of distribution, consumption remains higher than in less equal settings — as found in the baseline results. This effect does not occur when looking at pre-tax and transfer inequality, supporting the argument that the initial behavior consumption in the baseline impulse responses is supported by countercyclical government transfers. In the medium-to-long run, the results I find concur with empirical work in Pereira da Silva et al. (2022), who find that monetary policy has a greater impact on consumption when inequality is lower.

Figure 18: *Impulse Responses for Consumption Before and After Taxes and Transfers**



Note: Impulse responses of consumption shown are generated for 200 different values of the conditioning within the sample range, in response to a 1 percentage point contractionary monetary policy shock. The left-hand panel shows responses generated by using the pre-tax and transfer income Gini coefficient as a conditioning variable in the PCHVAR model instead of the RSI. The right-hand panel uses the post-tax and transfer income Gini coefficient.

Notably, when looking at both pre- and post-tax and transfer inequality, the impulse responses for prices and labour hours are very similar to each other, but very different to baseline. While monetary policy has more significant effects on output in more equal settings before and after taxes and transfers in the medium-to-long run, its effects on prices and labour hours are larger in less progressive settings. In more equal settings, labour hours may be less elastic in response to monetary policy shocks, leading to less of an effect on prices. I find opposite results for prices and output when using inequality, high-income tax rates, and capital gains taxes as conditioning variables. This points to there being a variable that affects the level of price stickiness that is more strongly correlated with these alternative conditioning variables than with progressivity. An (2022) finds that price stickiness increases with higher corporate taxes, and Carare et al. (2020) show that high-income countries have stickier prices. Looking at the mean effective corporate tax rate and GDP per capita shows that both variables are slightly more correlated with the level of post-tax and transfer inequality than the level of progressivity (Table 2). However, they are less correlated with pre-tax and transfer inequality. This means that it is unlikely that either of these variables would affect price stickiness differently when inequality was used as the conditioning variable, as opposed to progressivity.

Instead, it is possible that this result occurs because all of these variables interact both with prices, and possibly with the level of market power of firms. When firms have more market power, prices will be more rigid and will respond less to a monetary policy shock. When there is a lower level of inequality, or high income or capital gains taxes, market power could be higher if there is more state involvement in industry structures, such as more regulations supporting market power in such economies, meaning that prices are less responsive than otherwise. However, we might not expect redistribution to be correlated with the level of market power. Market power is difficult to measure, but future work could investigate its interaction with inequality and tax structure to find evidence for its effects on monetary policy transmission.

7.2 Income Taxes

Mattesini and Rossi (2012) show that, in a standard New Keynesian model, high income tax progressivity should make monetary policy *less* effective by acting as an automatic stabiliser. Does looking solely at taxation and not transfers, as in Mattesini and Rossi (2012), generate similar results from empirical analysis? I consider the average personal income tax rate for the high income earners as a more rudimentary measure of income tax redistribution. I use OECD data on average personal income tax rates for single-person households that earn 167% of average income, and then condition the PCHVAR impulse responses on this income tax measure.

The high-income tax measure has on average around half the explanatory power for output and prices as the progressivity index does (see Appendix Figures 36 and 37). Responses for output, the interest rate, consumption, and labour hours are all slightly different but generally consistent with the results from the baseline identification. While consumption is still higher in more progressive settings initially, it does not experience the jump that occurs in the baseline response. This is likely because the effects of government transfers, which initially support income and consumption after the monetary policy shock, are not being captured. However, prices follow an inverted response compared to baseline, which is not consistent with the rest of the results, and may be due to the interaction between income tax structure and level of market power of firms.

7.3 Measuring Hand-to-Mouth Share

Monetary policy can be more effective in a more progressive setting because redistribution reduces the number of hand-to-mouth households. Kaplan et al. (2014) approximate the share of hand-to-mouth households in the United States to be around 40%. Can we use a measure of hand-to-mouth households as a conditioning variable to determine how this effects monetary policy transmission?

I attempt to proxy for hand-to-mouth share by looking firstly at OECD data that contains the share of households with equivalent liquid financial wealth less than 25% of the poverty line. This measure should capture households with low levels of liquidity. According to this measure, the share of hand-to-mouth households in the United States would be 53.5% in 2016, around 12 percentage points larger than what Kaplan et al. (2014) find. Notably, there is very little correlation between this measure and the progressivity index, indicating that either this is not a good proxy for hand-to-mouth share, or the connection between hand-to-mouth share and progressivity is more tenuous than so far assumed. Using this measure of the hand-to-mouth share as a conditioning variable in the model, the impulse responses I retrieve from the PCH-VAR function are also very different to baseline. This discrepancy is likely more to do with the measurement of the variable — the arbitrary cut off point of 25% of the income poverty line is likely still capturing a large proportion of households that cannot be considered hand-to-mouth, and the true share in most countries should be lower. This measure is likely to be incompletely capturing the true pattern of variation in hand-to-mouth share.

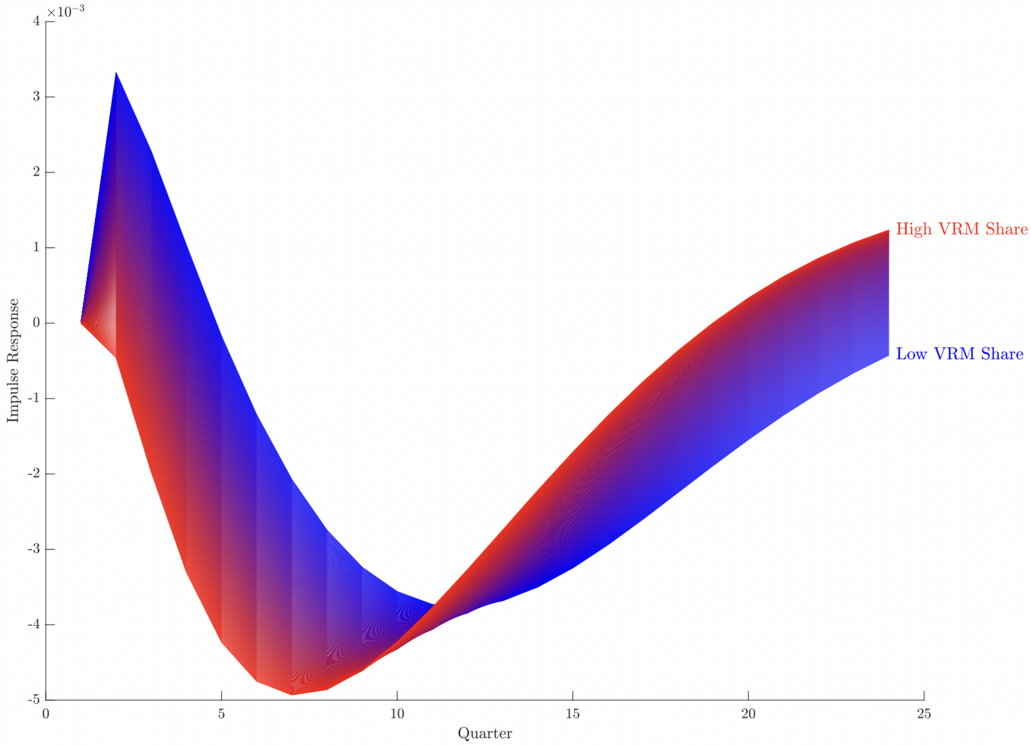
An possible alternative option to the previously mentioned measure is to look at rates of capital gains taxes (CGT) as a proxy for hand-to-mouth share. When CGT rates are higher, households are disincentivised from holding illiquid assets. Thus, the share of hand-to-mouth households should be inversely related to the size of CGT. I use constant CGT rates over the period as a conditioning variable, with a restricted sample of countries that have these taxes in place. Because the rate of CGT is constant over time, I do not capture any results from within-country variation. The impulse responses from the PCHVAR model look very similar to baseline when the progressivity index is used as the conditioning variable. However, the impulse responses for prices show the opposite of the baseline responses - prices fall further in *less* progressive settings. Again, this is likely due to interaction between high CGT rates and greater market power of firms.

7.4 Mortgage Policy

Several studies, including Rubio (2011) and Garriga et al. (2016) find that monetary policy transmission is more effective when a higher proportion of mortgages are set at variable (adjustable) rates as opposed to fixed rates. This is because the affordability of mortgage repayment becomes tied to interest rate changes, exposing households to greater interest rate risk. Given this theory, I use variable rate mortgage share as a conditioning variable to determine its effects on monetary policy effectiveness in the model. Given the restricted availability of these data to countries in the European Union, I use a restricted group of countries to examine these effects. The explanatory power of variable-rate mortgage share is much lower for output than when conditioning on the progressivity index, and never significant, but the explanatory power for prices is similar on average (see Appendix Figures 38 and 39). In Figure 20, prices decrease by more after the shock when the variable rate mortgage share is higher, agreeing with theory. However, output (Figure 19), consumption, and labour hours fall by more in the short-to-medium term with higher variable rate mortgage share.

Several countries in the sample have operated mortgage interest relief policies. These are potentially relevant because they increase the desirability of purchasing a house, an illiquid asset, and as such it is possible that countries with these policies would

Figure 19: *Impulse Responses for Output with Variable Rate Mortgage Shares*



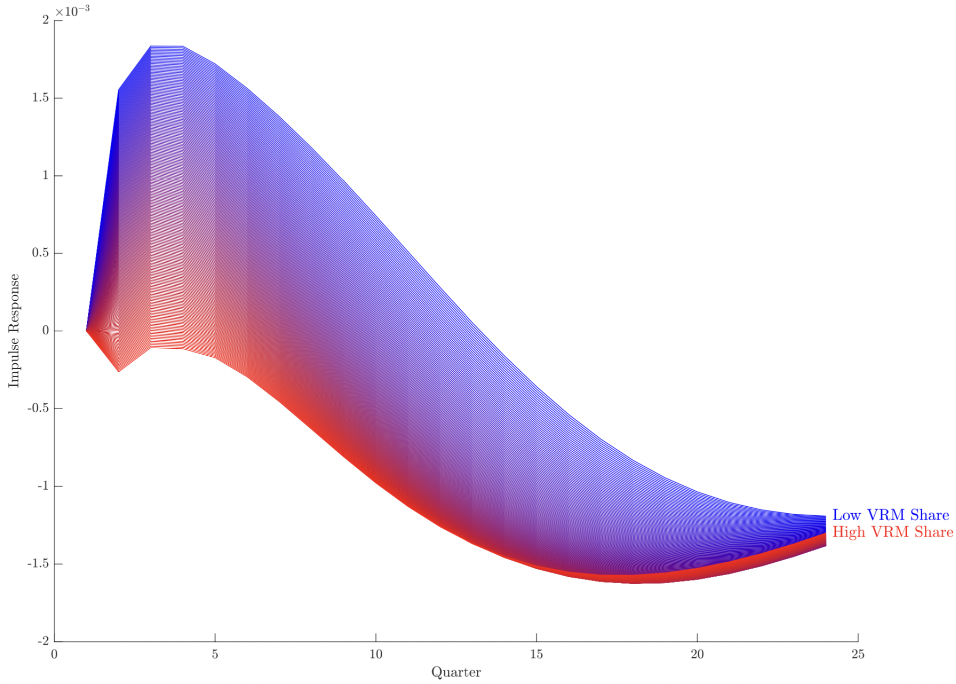
Note: Impulse responses of output shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. These responses are generated by using variable rate mortgage share as a conditioning variable in the PCHVAR model instead of the RSI.

have a higher proportion of wealthy hand-to-mouth households than those without. Splitting the sample into two groups — one for countries with relief, and one for countries without relief — yields different impulse response functions from the PCHVAR model. Notably, both groups are roughly evenly distributed in terms of progressivity. For the sample of countries with relief policies, shocks are more strongly identified, and there is less heterogeneity at high progressivity levels (Figure 21). For countries without mortgage interest relief, there are fewer hand-to-mouth households, which are more sensitive to income relative to interest rates.

7.5 Instrumenting Shocks in the Euro Area

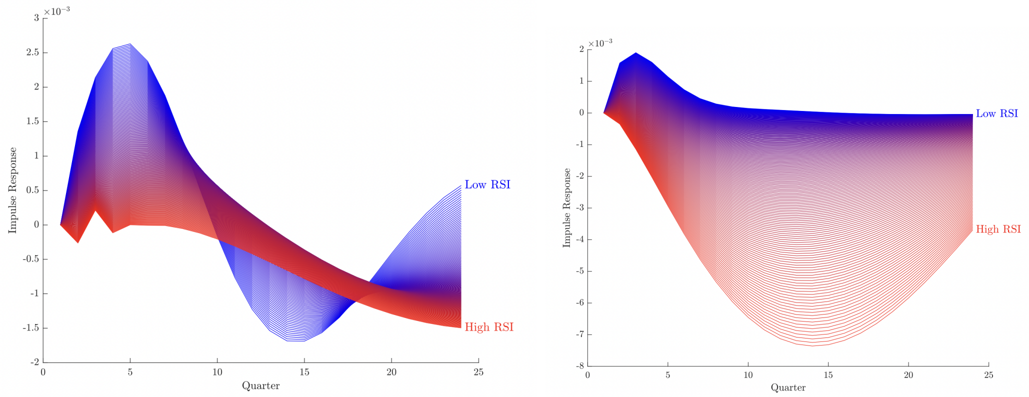
For most countries in the Euro Area, centralised monetary policy decisions made by the European Central Bank are generally not responding to domestic economic con-

Figure 20: *Impulse Responses for Prices with Different Variable Rate Mortgage Shares*



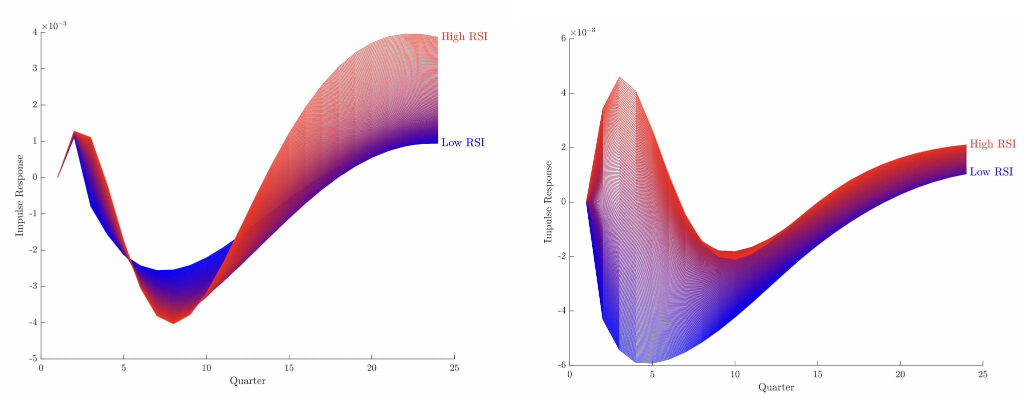
Note: Impulse responses of prices shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. These responses are generated by using variable rate mortgage share as a conditioning variable in the PCHVAR model instead of the RSI.

Figure 21: *Impulse Responses for Prices (Mortgage Interest Relief)*



Note: Impulse responses of prices shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. The responses in the left-hand panel are generated by only including data from the sample of countries with mortgage interest relief policies in the PCHVAR model. The responses in the right-hand panel are generated by excluding data from the sample of countries without mortgage interest relief policies.

Figure 22: *Impulse Responses for Prices and Consumption with Different RSI Values (Euro Area)*



Note: Impulse responses of prices (left-hand panel) and consumption (right-hand panel) shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. These responses are generated by only including data from countries within the sample that are also members of the Euro Area.

ditions, allowing for better identification of monetary policy 'shocks'. To exploit this exogeneity, I restrict my sample to Euro Area countries and control for Euro Area economic activity by including Euro Area GDP in the VAR models as an exogenous variable.

The explanatory power of the progressivity index in this identification is similar to baseline in the medium-to-long run, but significantly lower for prices. Additionally, unlike for the baseline results, the output results are never statistically significant. However, this is likely because the sample size is much smaller than for baseline, with fewer observations. The impulse responses generated by the PCHVAR model are generally very similar to baseline. A noticeable difference, however, is that output recovers from the shock much more quickly in high progressivity settings compared to low progressivity settings, relative to baseline (Figure 22). Additionally, consumption remains higher in high progressivity settings over the whole horizon — which indicates high levels of transfers supporting consumption. This is likely because the Euro Area subsample of countries include much higher transfers than the overall sample, so the countercyclical stabilisation effect is stronger for all of these countries compared to baseline.

Of course, the block exogeneity assumption that is being made in this identification is violated when considering that Germany and France have substantial input into ECB monetary policy decisions, and so shocks may not be correctly identified for these countries. However, all results are very similar when dropping Germany and France from the sample.

8 Discussion

8.1 Relation to HANK Literature

I find that the progressivity index can explain more than 20% of heterogeneity in impulse responses across countries for output, and up to 8% for prices. The magnitude of the explanatory power of the progressivity index here is similar to magnitudes found for financial structure and labour market rigidities by Georgiadis (2014). Conditioning impulse responses on the progressivity index captures the effects on monetary policy from the automatic stabiliser effects of taxes and transfers, as well as their impact on the number of interest-rate-sensitive saver households. This implies that including progressivity in New Keynesian models could be important for capturing the heterogeneous effects of monetary policy. Additionally, the results provide support for looking at heterogeneous agents instead of a representative agent in these models, as done by Kaplan et al. (2018) and Debortoli and Galí (2021).

Kaplan et al. (2018) find that the indirect effects of monetary policy are much stronger than the direct effects when looking at the results of a heterogeneous-agent New Keynesian (HANK) model relative to a standard representative-agent New Keynesian (RANK) model. Empirically, there are a large number of hand-to-mouth households which are not captured in RANK models, and which are insensitive to interest rates relative to income. The higher the share of hand-to-mouth households, the less effective the direct effects of monetary policy will be, through encouraging intertemporal substitution by changing the interest rate. However, the indirect effects, that is, the aggregate demand effects, will be much higher because these households are more income sensitive, and will adjust their labour hours accordingly.

The results I find in this thesis fit well into the context of this literature. At higher levels of progressivity, where one may assume there will be the fewest hand-to-mouth households, I find the strongest direct effects of monetary policy after a lag. However, in the short run, these households are also much slower to adjust their consumption and labour hours after the shock, displaying a lack of sensitivity to changes in aggregate demand — the indirect effects of monetary policy. Conversely, at lower levels of progressivity, where there are likely to be the most hand-to-mouth households, the direct effects of monetary policy are smaller and less persistent, as more households are less sensitive to interest rates. However, in the short run, the indirect effects are stronger, with output, consumption, and labour hours falling more quickly because these households are sensitive to changes in income.

In my results, I am also capturing an added effect from progressivity — at high levels, household consumption may be smoothed further by increased transfers after the shock. This explains why consumption initially *increases* at these high levels following the shock, which is not implied by the work in Kaplan et al. (2018). Of course, I also encounter price puzzles, which make inference from my short-term results less reliable. However, my results can still provide empirical support for the consideration of heterogeneous agents in New Keynesian models.

8.2 In Context of Other Findings

It is worth taking some time to compare the findings in this thesis to those from two important related papers: Mattesini and Rossi (2012) and Pereira da Silva et al. (2022). While Mattesini and Rossi (2012) show that income tax progressivity makes monetary policy less effective, Pereira da Silva et al. (2022) show that decreased income inequality makes monetary policy more effective. Initially, these results seem to be in conflict — higher income tax progressivity decreases income inequality, but these results appear to have opposite effects on monetary policy transmission. The results of my thesis are consistent with the results of both of these works, and allow me to propose a more nuanced conclusion.

Firstly, Mattesini and Rossi (2012) incorporate income tax progressivity into a standard Representative Agent New Keynesian (RANK) model. They find that monetary policy is less potent with more progressive *income taxes*, as these act as an automatic stabiliser and mitigate the effect of the monetary policy shock. Notably, I look at transfer progressivity as well as tax progressivity, but I still find similar effects to Mattesini and Rossi (2012) in the short run, where the automatic stabiliser effect dominates. However, while all households will face similar liquidity constraints in a standard New Keynesian model, empirically, as Kaplan et al. (2018) argue, this will not be the case. The main effect that I find occurs from progressivity altering the level of liquidity of households, which in the medium-to-long run is able to offset the automatic stabiliser effect. This effect will not be captured when households are assumed to be homogenous. This explains why the conclusion I draw, more consistent with Kaplan et al. (2018), is not the same as in Mattesini and Rossi (2012).

Mattesini and Rossi (2012) also show empirically that as the progressivity of income taxes increases, volatility of output, hours worked, and inflation decreases. These results are in line with my short-term findings for output, consumption, and hours, which essentially determines their volatility.[5] As such, my empirical findings are consistent with those found in Mattesini and Rossi (2012).

Secondly, turning to Pereira da Silva et al. (2022), the authors find, using cross-country analysis, that monetary policy transmission to consumption is weaker when income inequality is higher. This analysis does not take into account differences between countries, which have been shown in the literature to respond differently to monetary policy shocks (Mateju, 2019). However, we might think that these results should imply that monetary policy transmission to consumption would also be weaker when progressivity is lower. Indeed, I find post-tax and transfer inequality to have a correlation of 0.6 with progressivity, showing a clear but imperfect relationship. In the medium-to-long-run, I also find that monetary policy has a stronger effect on con-

[5]Notably, my results for prices experience a puzzle in the short term, making inference for this period problematic.

sumption (as well as output, prices, and labour hours) at high levels of progressivity (Figure 13). Similarly to Pereira da Silva et al. (2022), I find high progressivity to have the strongest effects relative to low progressivity after around 2 years. However, I do find different short term effects. This makes sense, because these effects come from the role of taxes and transfers as automatic stabilisers, which we would not expect when looking just at inequality. This can be most clearly seen by the difference in short-term responses show in Figure 18. Notably, also, I find that progressivity has twice the explanatory power of post-tax and transfer inequality for consumption, as well as output and prices, in the medium-to-long run. I find opposite results for prices, potentially due to an unobserved relationship between inequality and market power. However, Pereira da Silva et al. (2022) does not investigate results for prices, only for consumption.

8.3 Policy Implications

The results of my thesis imply that progressivity could be relevant for central banks when considering if they should tighten or loosen monetary policy as much or more than other countries to achieve same effects. To illustrate, I focus on the example of Australia. Looking at Figure 2, Australia is very similar to the United States in terms of progressivity, but much less progressive than most European countries. As such, the impacts of progressivity on responses to a monetary policy shock would be similar for policy conducted by the Reserve Bank of Australia (RBA) and the Federal Reserve. In other words, differing levels of progressivity cannot be used as a justification for running a different monetary policy regime in Australia to in the United States. However, this argument could be made when comparing RBA policy to European Central Bank (ECB) policy. Australia is much less progressive in terms of taxes and transfers than most European countries. As such, the results of this thesis would imply that progressivity would dampen the effects of monetary policy transmission in the medium-to-long run in Australia relative to in, say, France or Germany.

In terms of magnitude, I find that progressivity has a comparable impact on heterogeneity of responses to financial structure and labour market rigidities (Georgiadis, 2014). Notably, I find that this impact is much larger than for inequality and variable rate mortgage share, two factors that are more frequently discussed in relation to their effect on monetary policy transmission. These results imply that progressivity is a factor that is worth considering along with other factors when central banks are thinking about policy.

8.4 Policy During the COVID-19 Pandemic

The results of this thesis have interesting implications for the period of the COVID-19 pandemic. During this period, many countries substantially increased transfer payments to low-income households to compensate for job loss necessitated by mobility restrictions and lockdowns. For example, the "Jobkeeper" payment in Australia, which operated as both a transfer and wage subsidy, and substantially increased government spending (Rose and Breunig, 2022). In the United States, this increase in progressivity was so visible and wide-reaching that it even had a significant positive impact on peoples' attitudes towards these progressive policies (Klemm and Mauro, 2021). This significant fiscal expansion in most countries coincided with loose monetary policy in order to stimulate demand in the economy. For many countries, policy was restricted by its proximity to the zero lower bound, and so limited movement of the policy rate was possible. As such, it was vital that small movements in the policy rate could have as great effects as possible.

The results of this thesis imply that substantial increases in progressivity during the pandemic may have contributed in dulling the effectiveness of monetary policy transmission for the first two years, due to the automatic stabiliser effect. While I find progressivity to support monetary policy transmission in the medium-to-long run, the turn around of the monetary policy stance of most central banks has already occurred in order to combat high inflation, so any benefit of the increase in progressivity in the medium-to-long run in terms of supporting transmission would have been unlikely to accrue.

8.5 Further Work

The work in this thesis motivates several directions for future work.

Firstly, while the benefit of the RSI as a progressivity measure is that it is easy to calculate and interpret with publicly available data, it does not capture the effects of value-added taxes, which are levied on businesses. A government may choose to increase value-added taxes, which are regressive, to boost tax revenue after increasing transfers to low income households, which would be progressive. This would mean that the Reynolds-Smolensky index would have appeared to have increased, while in actuality, the increase in progressivity from transfers has been cancelled out by the implementation of the value-added tax. While my results are robust to dropping countries with value-added taxes, it is easier to be more confident that the dynamics being displayed in the results are coming from the effects of redistribution, and not other characteristics, if the progressivity measure is accounting for all dimensions of progressivity. An index constructed from detailed micro data akin to those constructed by Sabirianova Peter et al. (2017) or Gerber et al. (2019), but capturing transfer policy as well as income taxes, may be more useful for inference.

Secondly, my model does not account for any structural breaks in the data. This is most noticeably a problem when considering the explosive behaviour of impulse responses from the specific country VARs for countries like Mexico and Costa Rica, which are likely occurring due to structural breaks in the time series data that are not being captured by the model. Using dummy variables in the country VAR and PCH-VAR models to incorporate structural breaks could mitigate the explosiveness of these impulse responses in future work. This approach could build on the work of Qu and Perron (2007), who outline a framework to deal with multiple structural breaks in a VAR model.

Finally, while I do look at a smaller sample of Euro Area countries and find very similar results to baseline, further work could take advantage of the exogeneity of ECB policy decisions for most Euro Area countries to try and identify monetary policy shocks. This could be done by constructing a Bayesian time varying parameter proxy

VAR, where the ECB decision can function as an instrument for a monetary policy shock. This work could expand on the model described in recent work by Mumtaz and Petrova (2022), which extends upon the proxy structural VAR model proposed by Stock (2008) and Mertens and Ravn (2013) to allow for time variation in the parameters of the model.

9 Conclusion

This thesis is motivated by the question, do differences in the structural characteristics of economies affect the transmission of monetary policy? In particular, I focus on differences in an economy's level of redistribution, or tax and transfer progressivity. I regress impulse response functions from traditional country monetary VAR models on those generated by the panel conditionally homogeneous VAR model. I find that the progressivity index can explain more than 20% of cross-country heterogeneity in impulse responses for output, and 8% for prices. These results are comparable to those found for other structural features of the economy in previous work by Georgiadis (2014), including financial structure and labour market rigidities. I further find that progressivity has much higher explanatory power than inequality or variable rate mortgage share when either of these variables are used to condition the PCHVAR model.

Looking at the impulse responses generated by the PCHVAR model, I find that monetary policy is more effective in more progressive settings in the medium-to-long run, when the RSI also has the most explanatory power for the heterogeneity in responses. This is likely because more redistribution increases the number of saver households which are more sensitive to interest rates, so the direct effects of monetary policy are stronger. However, these effects are delayed due to the monetary policy lag. In the short run, I find opposite effects for output, consumption, and labour hours. This is likely because higher progressivity means that households can better smooth their consumption to changes in pre-tax income, so monetary policy has less effect. However, it is more difficult to make inference about the short term because of the price puzzles which indicate some omitted variable. In other words, the automatic stabiliser effect dominates in the short term, and the effect from having more interest-rate sensitive households dominates in the medium-to-long term.

The results that I find have implications for policy conducted by central banks. I find that including progressivity in New Keynesian models could be important for capturing the heterogeneous effects of monetary policy. Additionally, the results provide support for looking at heterogeneous agents instead of a representative agent in these models, as done by Kaplan et al. (2018), because they are driven by different households behaving differently. These results also imply that progressivity could be relevant when considering if Australia has to tighten or loosen monetary policy as much or more than other countries for the same effects. Notably here, Australia is very similar to the US in terms of progressivity, but much lower-ranked than most European countries. This implies that progressivity will have a similar impact on responses to monetary policy conducted by the Fed as to the RBA, but the impact may be different for ECB policy.

The work in this thesis motivates several directions for extension in the future. Further work could construct a more detailed progressivity index for taxes and transfers using micro data, account for structural breaks in the data in the model, and take advantage of the exogeneity of ECB policy decisions for most Euro Area countries to try and identify monetary policy shocks by constructing a Bayesian time varying parameter proxy VAR.

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A Appendix

A.1 Data Sources and Definitions

Table 3: *Baseline Data Definitions and Sources*

Variable	Definition	Frequency	Source
Pre-Tax and Transfer Gini Coefficient	Gini - disposable income, pre taxes and transfers, working age population (18-65)	Annual	OECD.Stat
Post-Tax and Transfer Gini Coefficient	Gini - disposable income, post taxes and transfers, working age population (18-65)	Annual	OECD.Stat
Output	GDP - expenditure approach, US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted	Quarterly	OECD.Stat
Prices	CPI - index, seasonally adjusted	Quarterly	OECD.Stat
Consumption	Private final consumption expenditure - constant prices, seasonally adjusted, growth previous period	Quarterly	OECD.Stat
Hours Worked	Average annual hours actually worked per worker - hours	Annual	OECD.Stat
Interest Rate	Short-term interest rates (percentage)	Quarterly	OECD.Stat
Shadow Interest Rate	US shadow fed funds rate, Euro Area shadow rate, UK shadow rate	Monthly	Wu and Xia (2016, 2017, 2020)
Shadow Interest Rate	Shadow rates for Australia, Canada, Switzerland, Japan, and New Zealand	Monthly	LJK Macro Finance Analysis
Real Commodity Prices	Real commodity price factor	Monthly	Baumeister and Guérin (2021)

Table 4: *Robustness Data Definitions and Sources*

Variable	Definition	Frequency	Source
Exchange Rates	Real effective exchange rate index (2010 = 100)	Annual	DataBank (World Bank)
House Prices	Real house prices, revised 2023 Q2	Quarterly	Mack and Martínez-García (2011)
Interbank Rate	Interbank rate (percentage)	Quarterly	OECD.Stat
M3	Broad money index, index, 2015 = 100, seasonally adjusted	Quarterly	OECD.Stat
IGREA	Index of Global Real Economic Activity, index, not seasonally adjusted	Monthly	FRED
Euro Area Output	GDP, Euro Area (19 countries) - expenditure approach, US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted	Quarterly	OECD.Stat
Global Financial Cycle Index	Global factor in risky asset prices	Monthly	Miranda-Agrippino and Rey (2020)
US Inflation Expectations	1-year expected inflation, not seasonally adjusted (percentage)	Quarterly	FRED
US Breakeven Rate	5-year breakeven inflation rate, not seasonally adjusted (percentage)	Quarterly	FRED
Value Added Tax Rate	Standard value added tax rate as on 1 January 2022 (percentage)	Cross-section	OECD (2022)
Mortgage Interest Relief	Countries with national-level mortgage interest relief policies	Cross-section	OECD Affordable Housing Database
Variable Rate Mortgage Share	Share of new loans to households for house purchase with a floating rate or an initial rate fixation period of up to one year in total new loans from MFIs to households, EUR (percentage)	Monthly	ECB Statistical Data Warehouse
Capital Gains Tax Rate	Top marginal capital gains tax rate as at 2023 (percentage)	Cross-section	Tax Foundation
Top Income Bracket Tax Rate	Average income tax rate (percentage of gross wage earnings) for a single person at 167% of average earnings, without child	Annual	OECD.Stat
Illiquid Households	Share of individuals with equivalent liquid financial wealth <25% of the income poverty line (percentage)	Annual	OECD.Stat
GDP Per Capita	GDP - expenditure approach, per head, US dollars, volume estimates, fixed PPPs, OECD reference year, seasonally adjusted	Quarterly	OECD.Stat
Effective Average Corporate Tax Rate	Composite Effective Average Tax Rate (EATR) - synthetic tax policy indicator reflecting the average tax contribution a firm makes on an investment project earning above-zero economic profits, constructed as a weighted average across finance- and asset-specific EATRs, 2019 (percentage)	Cross-section	OECD.Stat

A.2 Reynolds Smolensky Index Data

Table 5: OECD Countries Ranked By Average RSI Over 2000-2021.

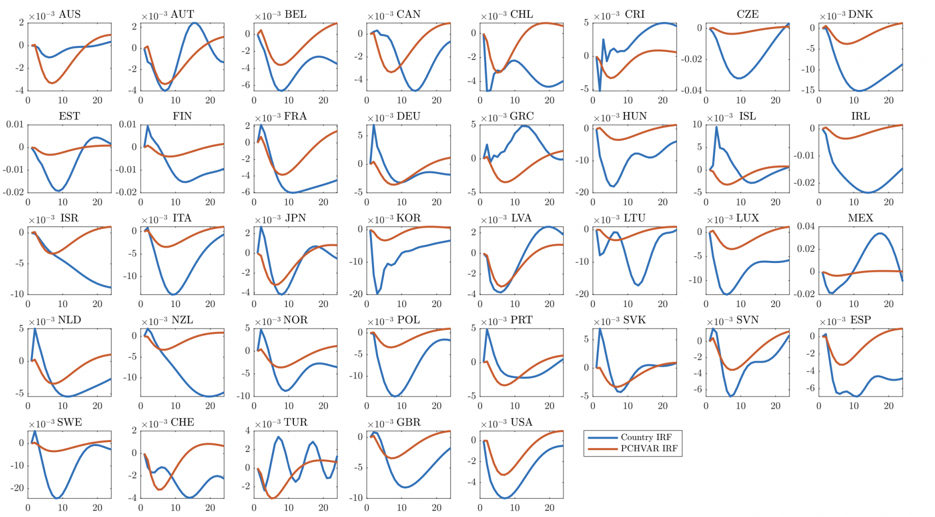
Country	Average RSI
Mexico	0.011
Chile	0.024
South Korea	0.029
Costa Rica	0.036
Switzerland	0.044
Turkiye	0.047
Japan	0.066
Iceland	0.073
Latvia	0.081
New Zealand	0.083
United States	0.088
Canada	0.090
Estonia	0.091
Lithuania	0.092
Australia	0.104
Israel	0.104
Netherlands	0.105
Sweden	0.106
United Kingdom	0.107
Slovak Republic	0.110
Italy	0.110
Norway	0.113
Spain	0.114
Germany	0.117
Portugal	0.121
Poland	0.122
Greece	0.128
Czech Republic	0.128
Luxembourg	0.138
Denmark	0.141
France	0.142
Austria	0.145
Slovenia	0.150
Hungary	0.155
Belgium	0.156
Finland	0.159
Ireland	0.191

Table 6: Sample Data for Reynolds-Smolensky Index

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Australia	0.119	0.118	0.116	0.115	0.113	0.108	0.104	0.099	0.094	0.095	0.096	0.098	0.099	0.103	0.107	0.103	0.099	0.102	0.104	0.099
Austria	-	-	-	-	-	-	-	0.14	0.145	0.152	0.151	0.146	0.149	0.142	0.142	0.145	0.143	0.142	0.143	0.144
Belgium	-	0.158	0.154	0.157	0.139	0.147	0.149	0.156	0.158	0.157	0.164	0.163	0.162	0.162	0.161	0.160	0.151	-	-	-
Canada	0.090	0.093	0.092	0.091	0.089	0.087	0.085	0.086	0.083	0.090	0.093	0.088	0.084	0.083	0.083	0.085	0.09	0.092	0.089	0.084
Chile	-	-	-	-	-	-	-	0.022	0.023	0.023	0.024	0.024	0.024	0.0245	0.025	0.024	0.023	0.024	0.025	-
Costa Rica	-	-	-	-	-	-	-	-	-	-	0.025	0.028	0.027	0.029	0.028	0.033	0.038	0.037	0.039	0.039
Czech Republic	-	-	0.144	0.1455	0.147	0.147	0.143	0.136	0.124	0.132	0.131	0.134	0.133	0.129	0.126	0.123	0.116	0.104	0.101	0.097
Denmark	0.150	0.149	0.148	0.148	0.147	0.146	0.138	0.131	0.126	0.132	0.14	0.144	0.147	0.146	0.145	0.145	0.142	0.137	0.134	0.13
Estonia	-	-	-	0.103	0.092	0.088	0.081	0.086	0.104	0.103	0.098	0.097	0.094	0.084	0.080	0.081	0.077	0.077	0.104	
Finland	0.186	0.164	0.163	0.159	0.156	0.158	0.159	0.145	0.145	0.155	0.156	0.155	0.158	0.160	0.162	0.169	0.168	0.161	0.154	0.151
France	0.104	0.113	0.124	0.131	0.137	0.142	0.140	0.139	0.139	0.149	0.148	0.15	0.153	0.151	0.155	0.155	0.156	0.155	0.151	0.148
Germany	-	-	0.128	0.110	0.119	0.111	0.120	0.118	0.118	0.125	0.119	0.120	0.116	0.118	0.114	0.114	0.111	0.104	-	-
Greece	-	-	-	0.084	0.077	0.116	0.116	0.116	0.119	0.134	0.158	0.162	0.135	0.154	0.138	0.131	0.136	-	-	-
Hungary	-	-	-	-	0.192	0.203	0.198	0.201	0.172	0.169	0.157	0.162	0.137	0.132	0.123	0.111	0.104	0.105	-	-
Iceland	-	-	-	0.060	0.057	0.052	0.05	0.046	0.077	0.103	0.103	0.092	0.092	0.088	0.075	0.064	0.068	-	-	-
Ireland	-	-	-	-	0.141	0.140	0.153	0.172	0.196	0.219	0.234	0.221	0.23	0.214	0.207	0.198	0.183	0.186	0.172	
Israel	0.137	0.1326	0.128	0.124	0.119	0.115	0.112	0.109	0.106	0.100	0.101	0.104	0.098	0.083	0.084	0.083	0.086	0.086	0.086	0.094
Italy	0.103	0.107	0.11	0.114	0.117	0.116	0.110	0.109	0.108	0.111	0.117	0.113	0.113	0.114	0.109	0.113	0.110	0.101	0.100	-
Japan	0.051	0.0543	0.057	0.061	0.064	0.067	0.069	0.072	0.074	0.077	0.070	0.063	0.056	0.062	0.069	0.075	0.073	0.070	0.068	-
Korea	-	-	-	-	-	-	0.019	0.022	0.024	0.023	0.024	0.021	0.019	0.020	0.024	0.030	0.033	0.036	0.041	0.045
Latvia	-	-	-	0.085	0.073	0.071	0.06	0.066	0.097	0.110	0.101	0.098	0.087	0.081	0.076	0.073	0.074	0.076	0.075	-
Lithuania	-	-	-	0.109	0.105	0.092	0.083	0.083	0.095	0.130	0.118	0.111	0.091	0.083	0.074	0.073	0.074	0.074	0.072	-
Luxembourg	-	-	-	0.143	0.126	0.130	0.124	0.146	0.153	0.151	0.158	0.158	0.149	0.134	0.119	0.133	0.123	0.124	0.140	-
Mexico	-	-	-	-	-	-	-	-	-	-	-	-	0.011	0.0125	0.014	0.013	0.012	0.011	0.009	0.010
Netherlands	0.096	0.099	0.101	0.104	0.106	0.109	0.106	0.097	0.093	0.096	0.100	0.097	0.103	0.115	0.117	0.117	0.116	0.114	0.107	0.101
New Zealand	0.100	0.097	0.093	0.09	0.089	0.087	0.086	0.083	0.082	0.073	0.069	0.077	0.071	0.065	0.067	0.083	0.085	0.084	0.084	0.085
Norway	0.117	0.115	0.112	0.1095	0.107	0.108	0.109	0.110	0.111	0.114	0.118	0.117	0.113	0.115	0.112	0.112	0.116	0.116	0.114	0.112
Poland	-	-	0.154	0.139	0.127	0.121	0.120	0.118	0.117	0.120	0.117	0.117	0.110	0.118	0.113	0.112	-	-	-	-
Portugal	-	-	-	0.073	0.075	0.111	0.106	0.110	0.122	0.121	0.137	0.140	0.151	0.143	0.138	0.137	0.129	0.123	0.126	-
Slovak Republic	-	-	-	0.145	0.121	0.125	0.120	0.107	0.117	0.118	0.106	0.111	0.101	0.096	0.098	0.104	0.103	0.091	0.099	-
Slovenia	-	-	-	0.161	0.156	0.155	0.144	0.139	0.152	0.154	0.162	0.166	0.161	0.154	0.152	0.147	0.138	0.131	0.133	-
Spain	-	-	-	-	-	0.088	0.093	0.109	0.121	0.116	0.125	0.127	0.127	0.123	0.118	0.115	0.114	0.111		
Sweden	-	-	-	0.133	0.127	0.121	0.115	0.109	0.115	0.115	0.103	0.101	0.098	0.098	0.096	0.095	0.092	0.094	0.092	-
Switzerland	-	-	-	-	-	-	0.032	0.030	0.033	0.037	0.043	0.043	0.047	0.053	0.049	0.055	0.053	0.050	0.045	0.048
Turkiye	-	-	-	-	-	-	-	-	-	0.061	0.019	0.018	0.021	0.020	0.020	0.0535	0.087	0.088	0.08	-
United Kingdom	0.107	0.109	0.101	0.103	0.103	0.100	0.097	0.098	0.102	0.112	0.121	0.122	0.122	0.118	0.114	0.110	0.106	0.100	0.098	0.090
United States	0.093	0.090	0.075	0.082	0.098	0.079	0.076	0.086	0.083	0.093	0.093	0.091	0.090	0.086	0.084	0.085	0.084	0.085	0.083	0.080

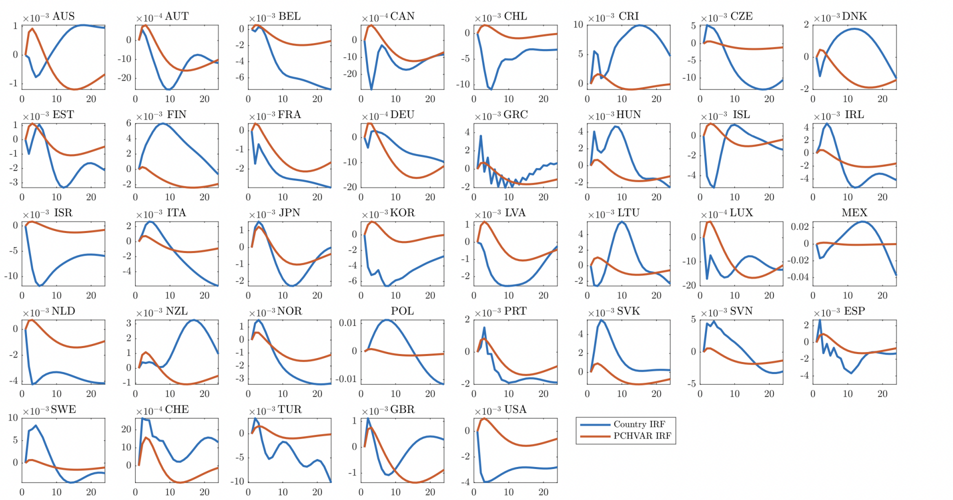
A.3 Figures

Figure 23: Country VAR and PCHVAR Impulse Responses for Output



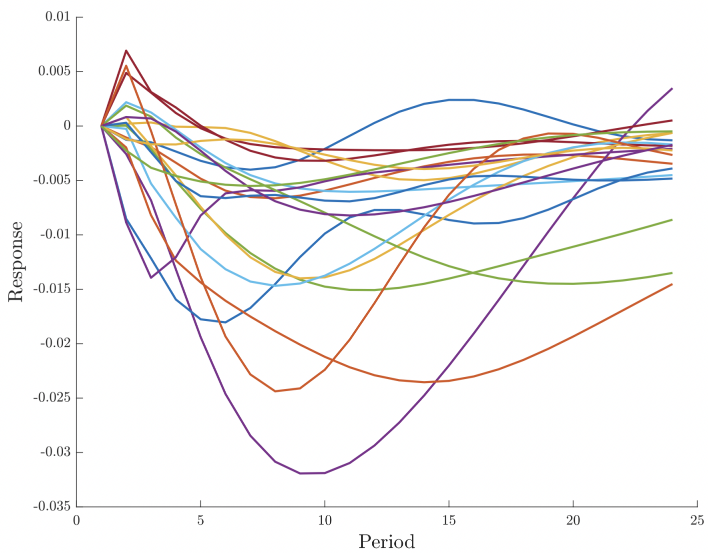
Note: Impulse response functions for output are shown in response to a 1 percentage point contractionary monetary policy shock. Country IRFs are estimated from the individual country VAR models, while PCHVAR IRFs are estimated from the PCHVAR model.

Figure 24: Country VAR and PCHVAR Impulse Responses for Prices



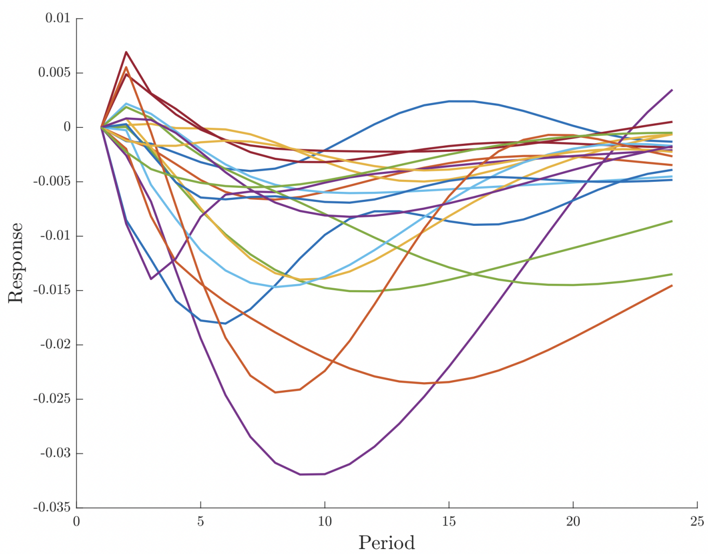
Note: Impulse response functions for output are shown in response to a 1 percentage point contractionary monetary policy shock. Country IRFs are estimated from the individual country VAR models, while PCHVAR IRFs are estimated from the PCHVAR model.

Figure 25: *Individual Country VAR Impulse Responses for Output (Georgiadis (2014) Sample)*



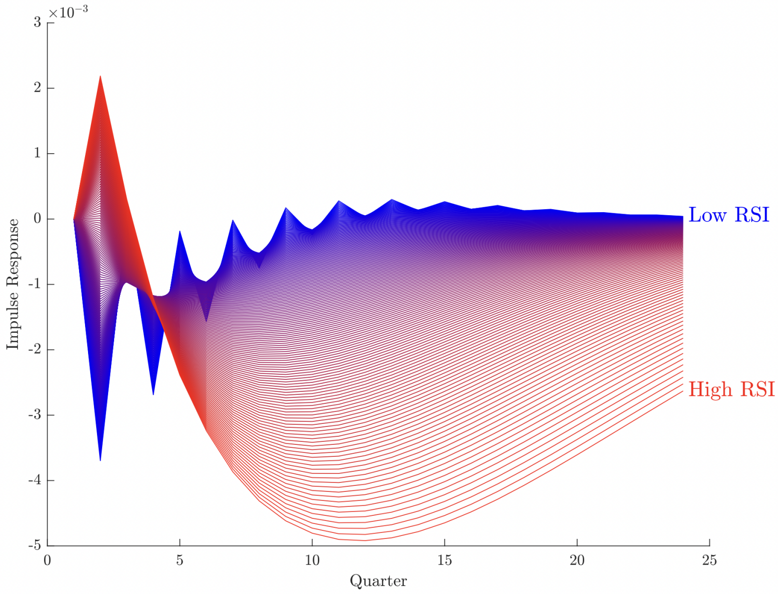
Note: Output responses for the same sample of countries used in Georgiadis (2014) are shown in response to a 1 percentage point contractionary monetary policy shock, i.e. a 1 unit increase in the interest rate.

Figure 26: *Individual Country VAR Impulse Responses for Prices (Georgiadis (2014) Sample)*



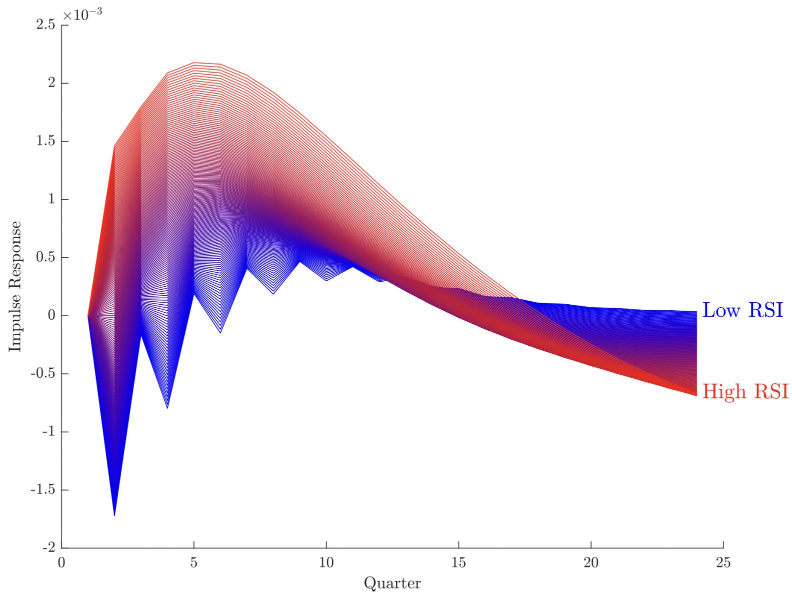
Note: Prices responses for the same sample of countries used in Georgiadis (2014) are shown in response to a 1 percentage point contractionary monetary policy shock, i.e. a 1 unit increase in the interest rate.

Figure 27: *Impulse Responses for Output with Different RSI Values (Using End-of-Sample RSI)*



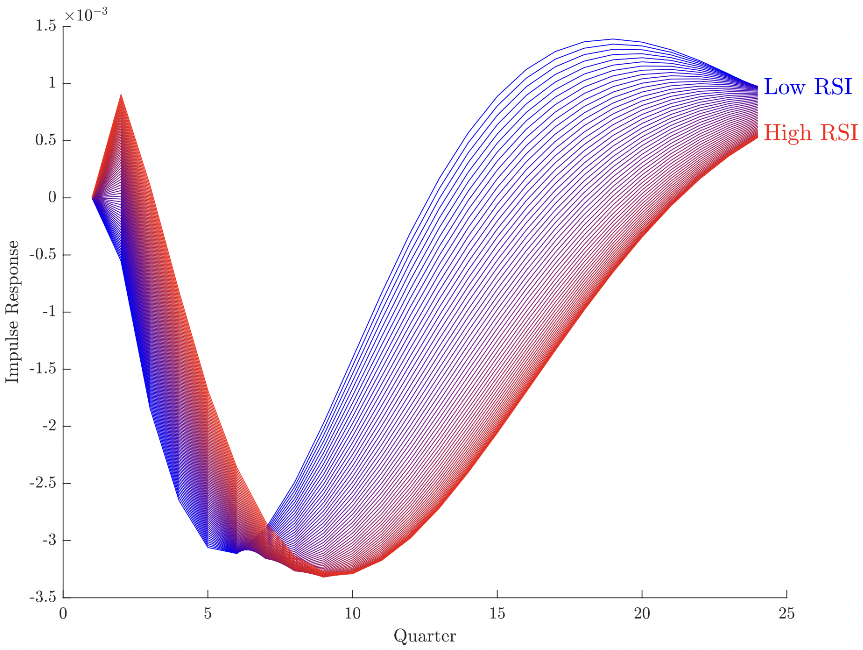
Note: Impulse responses of output shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. Only end-of-sample RSI values are used.

Figure 28: *Impulse Responses for Prices with Different RSI Values (Using End-of-Sample RSI)*



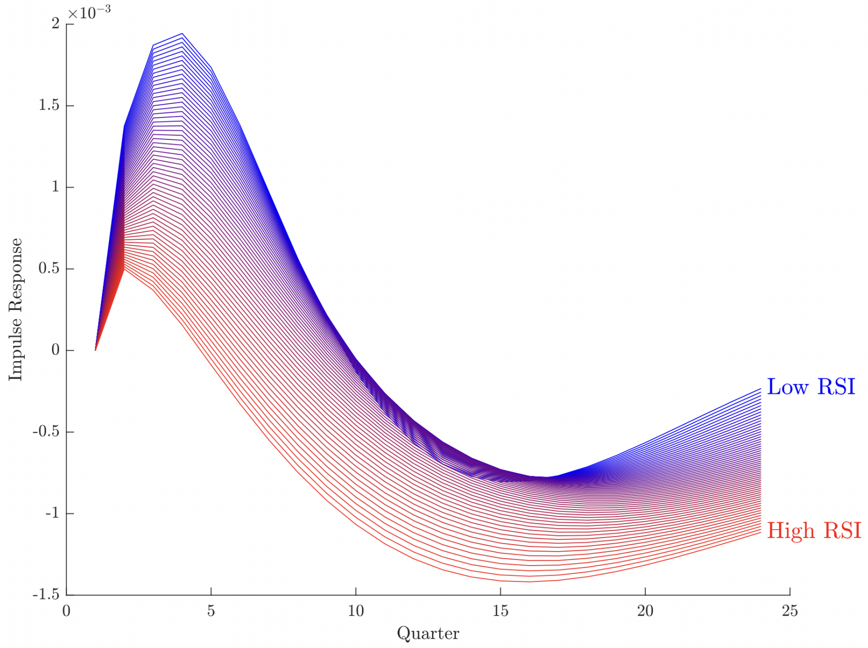
Note: Impulse responses of prices shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. Only end-of-sample RSI values are used.

Figure 29: *Impulse Responses for Output with Different RSI Values (No VAT Countries)*



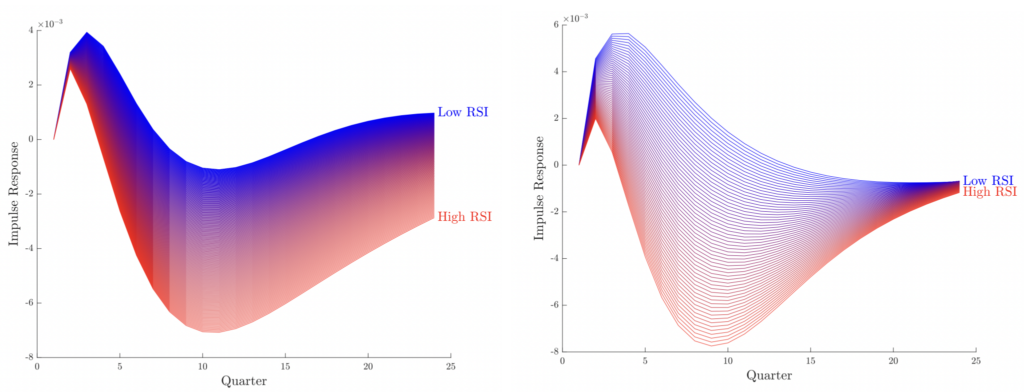
Note: Impulse responses of output shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. Countries with value-added taxes are omitted from the sample.

Figure 30: *Impulse Responses for Prices with Different RSI Values (Using End-of-Sample RSI)*



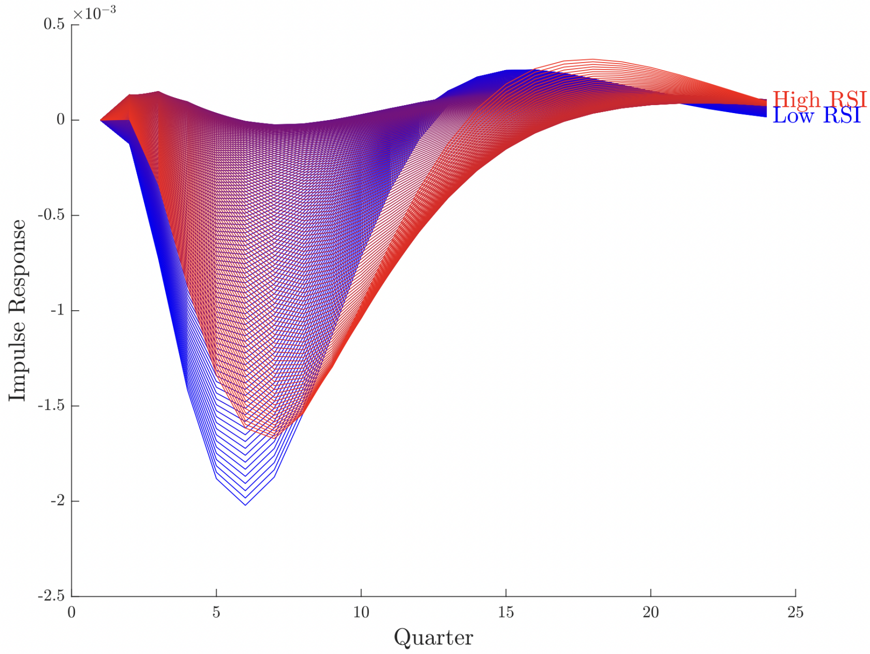
Note: Impulse responses of prices shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. Countries with value-added taxes are omitted from the sample.

Figure 31: *Impulse Responses for Output with House Price Sample*



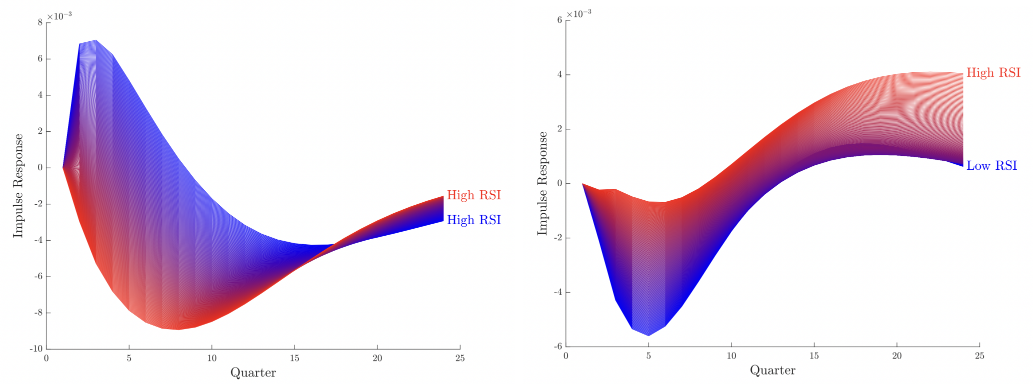
Note: Impulse responses of output shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. The left-hand panel displays the IRFs from the model without house prices, while the right-hand panel displays the IRFs from the model including house prices as an endogenous variable

Figure 32: *Impulse Responses for Labour Hours with Different RSI Values (Cubic Spline Interpolation)*



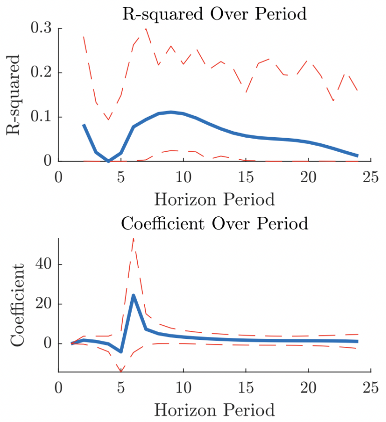
Note: Impulse responses of prices shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. Labour hours data are interpolated using a cubic spline.

Figure 33: *Impulse Responses for Output (Low and High Progressivity Samples)*



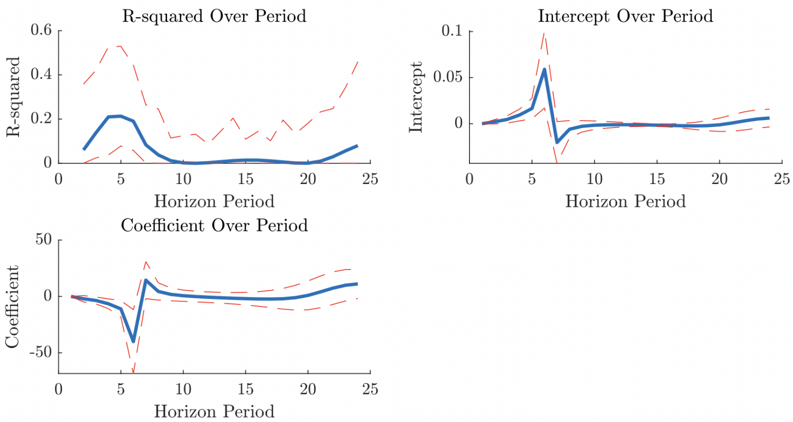
Note: Impulse responses of output shown are generated for 200 different values of the RSI within the sample range, in response to a 1 percentage point contractionary monetary policy shock. The left-hand panel displays the IRFs for the Low Progressivity sample, while the right-hand panel displays the IRFs for the High Progressivity sample.

Figure 34: *Regressing PCHVAR IRFs on Country IRFs for Output (Post-Tax and Transfer Inequality)*



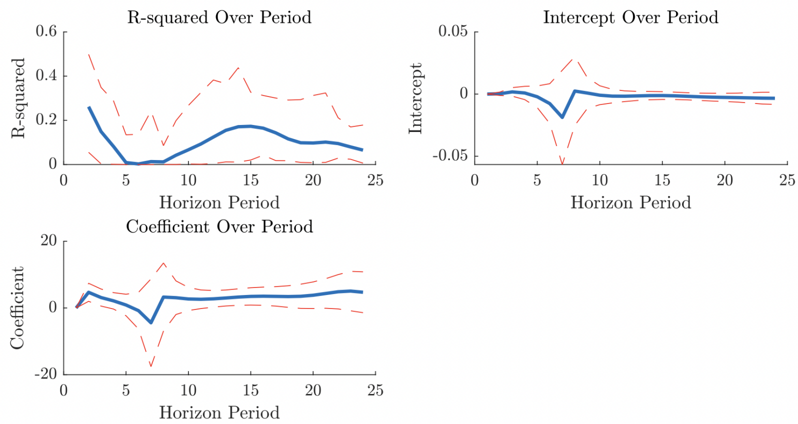
Note: Red dashed lines indicate bootstrapped 95% confidence intervals. PCHVAR IRFs are conditioned on the post-tax and transfer Gini coefficient instead of the RSI.

Figure 35: *Regressing PCHVAR IRFs on Country IRFs for Prices (Post-Tax and Transfer Inequality)*



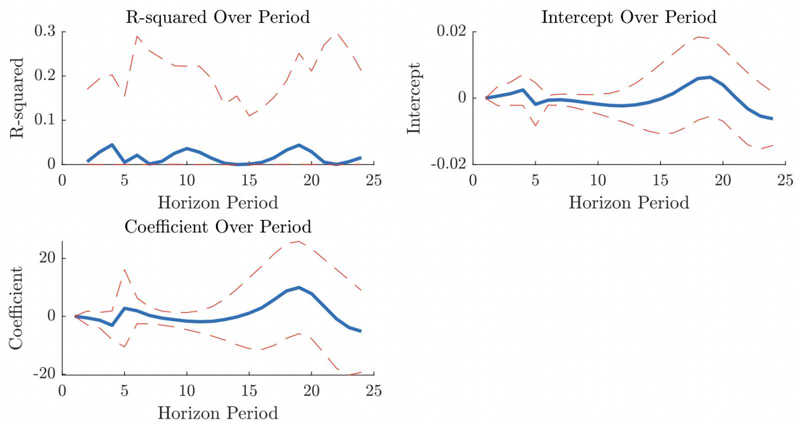
Note: Red dashed lines indicate bootstrapped 95% confidence intervals. PCHVAR IRFs are conditioned on the post-tax and transfer Gini coefficient instead of the RSI.

Figure 36: *Regressing PCHVAR IRFs on Country IRFs for Output (High-Income Tax Rate)*



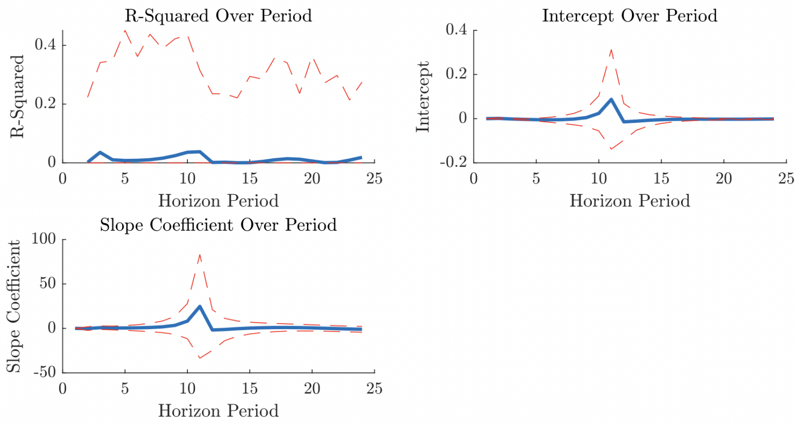
Note: Red dashed lines indicate bootstrapped 95% confidence intervals. PCHVAR IRFs are conditioned on the high-income tax rate.

Figure 37: *Regressing PCHVAR IRFs on Country IRFs for Prices (High-Income Tax Rate)*



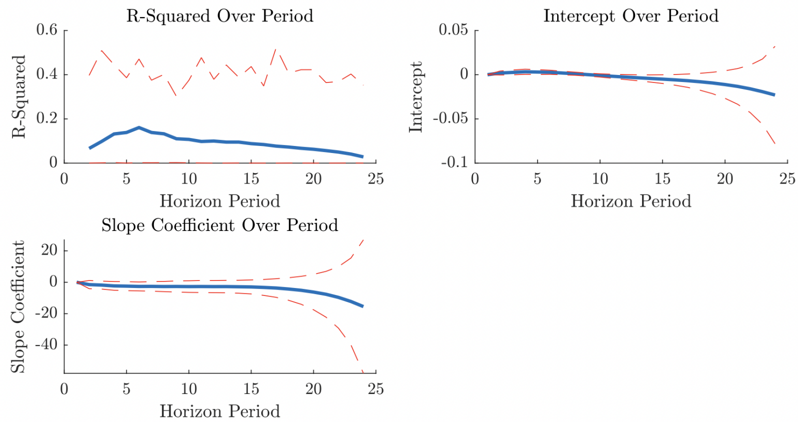
Note: Red dashed lines indicate bootstrapped 95% confidence intervals. PCHVAR IRFs are conditioned on the high-income tax rate.

Figure 38: *Regressing PCHVAR IRFs on Country IRFs for Output (Variable Rate Mortgage Share)*



Note: Red dashed lines indicate bootstrapped 95% confidence intervals. PCHVAR IRFs are conditioned on the variable rate mortgage share.

Figure 39: *Regressing PCHVAR IRFs on Country IRFs for Prices (Variable Rate Mortgage Share)*



Note: Red dashed lines indicate bootstrapped 95% confidence intervals. PCHVAR IRFs are conditioned on the variable rate mortgage share.