FISCAL POLICY,
INFLATION AND TRADE*

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Abstract

How does inflation respond to fiscal policy? This paper empirically shows in a sample of 30 European countries over 1996 - 2017 that reductions in government spending are deflationary, whereas increases in consumption taxes are inflationary. The first effect is weaker for consumption categories with large import shares. Contractionary fiscal policy in a country’s trading partners, however, has no impact on domestic inflation. In a second step, we rationalize this asymmetric finding in a multi-product, multi-country DSGE models calibrated to match observed product-specific bilateral trade linkages. We show that pricing-to-market strategies can account for the asymmetric effects of fiscal policy on inflation.

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1 Introduction

The introduction of the euro reduced the volatility of bilateral real exchange rates. While the common currency was intended to foster economic ties across member countries, the dampened real exchange rate movements were considered a threat in the presence of asymmetric economic shocks, especially in the aftermath of the Great Recession and the ensuing period of fiscal austerity. Adjustments in real exchange rates are deemed necessary to equilibrate supply and demand of goods in open economies. In a currency union, these adjustments have to come from movements in inflation rates. In this paper, we document these movements in inflation rates and ask to what extent they are consistent with a workhorse open-economy DSGE model.

Two possible routes to follow:

1. Look at inflation response relative to $G$ shocks ($\tau$) shocks: Literature on cross-sectional multiplier, multipliers for different types of goods,...

2. Look at inflation response relative to output response: Phillips curve literature

Main finding: Countries seeing their unemployment rate rise by 10 percentage points after the crisis, saw their inflation rates fall by 1.9 percentage more than did countries with no change in their unemployment rate. Decomposing the inflation rate, we show that the fall in prices is almost twice as strong for non-traded goods than for traded goods. A notable exception are goods and services with 'administered' prices. Inflation of those goods and services tends to be positively correlated with changes in unemployment rate across countries.

1.1 Literature

- Cross-sectional multipliers: Chodorow-Reich, Nakamura and Steinsson (2014), Beraja et al. (2016); Open question: How do prices adjust to $G$ shocks? In Europe, the period of fiscal austerity saw changes in different types of fiscal policy, including labor / capital tax changes, VAT changes and administered price changes; typically these policies have very different effects on inflation, so one has to control for them.

- Fiscal devaluation (Farhi et al., 2013): To what extent did European countries implement the advice of fiscal devaluation?

- Schmitt-Grohé and Uribe (2016): Missing exchange rate adjustment to blame for large unemployment rate differentials across euro area
The literature on the relationship of inflation and unemployment in Europe after the financial crisis is surprisingly scarce. Blanchard et al. (2015) estimate time-series relationships for developed countries over the last 50 years. They conclude that this relationship has weakened over time and has only settled since the 1990s, with a 1 percent unemployment gap being associated with a 0.2 percentage lower inflation rate across euro area countries.\(^1\) A few empirical studies have looked at the cross-sectional variation in inflation and unemployment rates across Europe. Both Blanchard et al. (2016) and House and Proebsting (2016) point out that countries that implemented more “austere” fiscal policy experienced both less inflation and less economic activity. This relationship seems particularly strong among euro area countries.

One of the papers most closely related to our study is Beraja et al. (2016). They find a cross-sectional relationship between employment and nominal / real wage growth across US states during the Great Recession. They report very similar slopes for nominal and real wage growth regressions, slightly above 0.5. Although not reported, this indicates that a regression of employment on inflation would yield a very low coefficient around 0.1. Fitzgerald et al. (2014) study the relationship between unemployment rates and inflation at the MSA level for the US. They find that over the period of 1976-2010, a 10 percentage point increase in the local unemployment rate is associated with a 3 percentage point decline in the local annual inflation rate.

Papers on real exchange rates and law of one price.

- This paper is also related to the literature on real exchange rates. A good survey of the literature is provided in Burstein and Gopinath (2014). Several papers have used extensive micro data on retail prices to compare price levels across regions and countries. For example, Gopinath et al. (2011) report that differences in retail price changes across the US and Canada are mostly driven by differences in changes in wholesale prices, i.e. costs, especially at longer time horizons. These cost changes have a geographical component: Price changes in US stores relate to changes in both their own wholesale prices and wholesale prices in other US stores, but not wholesale prices in neighboring Canadian stores. The US-Canada border therefore

\(^1\)This is a simple average of the 11 euro area countries whose estimates are reported in Table 6, based on the second specification that uses average unemployment as a measure of the natural rate. The estimates for 3 out of 11 countries are statistically insignificant.
seems to almost perfectly segment markets, while within-country markets seem partially integrated. Our finding that prices of non-tradables are more cyclical than prices of tradables is complementary to the finding in Berka et al. (2014) that show, in the cross-section across European countries, price differences are larger for non-tradables than tradables. They trace back these cross-sectional differences to variations in TFP and unit labor costs. CITE ENGEL

- Papers on prices of non-tradables and real exchange rates (South America)

We begin by characterizing the relationship between inflation and unemployment both at the national and the subnational level. Data sources are discussed in the next section, followed by the empirical findings in Section 3.
2 Data

Here, we present the data sources for our analysis. We pay particular attention to the issue of obtaining inflation measures comparable across countries in the presence of governments affecting consumer prices either directly as price setters or indirectly through changes in tax policy.

Our country sample includes all 19 countries in the euro area as of 2015, plus Denmark whose currency is pegged to the euro. Unemployment rates and price data for these countries are provided by Eurostat. Unemployment rates are based on the labor force survey and follow the definition of the International Labor Organization. For price data, we use both the Harmonized Index of Consumer Prices (HICP) and GDP deflators at the industry level.

2.1 HICP

The HICP is the European counterpart of the US CPI and implements a common methodology in all European Union member states. The most commonly used measure of inflation captures changes in the overall HICP, $P_{i,t}$, which is defined for country $i$ at time $t$ as follows:

$$P_{i,t} = \sum_j p_{i,t}^j \tau_{i,t}^j \omega_{i,t}^j,$$

where $p_{i,t}^j$ is the pre-tax price of good $j$ in country $i$ at time $t$ relative to a base year, $\tau_{i,t}^j$ is the corresponding ad-valorem gross tax rate relative to a base year tax rate and $\omega_{i,t}^j$ is the weight of good $j$ with $\sum_j \omega_{i,t}^j = 1$. The HICP is divided into $J = 90$ categories such as ’Fish and seafood’ and ’Maintenance and repair of personal transport equipment’.

One drawback of this measure of inflation is that it does not only capture changes in underlying prices, but also changes in taxes. This is particularly worrisome for the post-crisis period because several countries substantially increased their value added tax rates to raise revenue. An alternative measure of changes of pre-tax prices, and the one used in this paper,
is the HICP at constant tax rates, which is defined as

$$P_{i,t}^c = \sum_j p_{i,t}^j \omega_{i,t}^j.$$  

This HICP at constant tax rates is provided by Eurostat at the overall level and for five main categories since 2003, and at the detailed level for most countries since 2006. To complement this data, we exploit the database in Benedek et al. (2015) on value-added tax changes by COICOP category and month and collect additional information on value-added tax changes from national statistical agencies.\(^4\) For some observations, we impute the index at the detailed level \((J = 90)\) by assuming that tax changes have been the same across all categories within a common main category.\(^5\)

**Classification of goods and services.** We construct separate price indices for tradable and non-tradable goods and services. As a general rule, we classify services as non-tradables, and goods as tradables. Exceptions are 'Passenger transport by air' (COICOP 07.33), 'Package holidays' (COICOP 09.6), 'Insurances' (COICOP 12.5) and 'Financial services' (COICOP 12.6), which we classify as tradables because a large share of these services are either consumed abroad or the services are not tight to a specific location. A complete list of categories and their classification is provided in the Appendix.

In constructing our price indices for tradables and non-tradable goods, we exclude categories whose prices are administered. In many European countries, certain goods and services are either directly provided by the government or the government influences to a significant extent their prices (e.g. 'Pharmaceutical products' (COICOP 06.11) and 'Water supply' (COICOP 04.41)). Again, as for changes in prices post taxes, inflation rates across countries for these categories are likely to reflect changes in government policies rather than changes in underlying costs or other market forces, especially over our sample period. Eurostat classifies all COICOP categories into 'Fully administered', 'Mainly administered' and 'Not administered'. This classification change both over time and across countries. To obtain a single classification, we first assign a '0' to all categories that are not administered, and a '1' otherwise. We then calculate an average value of this binary variable, \(admin_{i,t}^j\), for 2003 to 2014 for each country and category, and then take an average across all countries in our sample,

\(^4\)The HICP at constant tax rates mainly captures changes in value added taxes, but it includes for some products, especially in the energy sector, additional taxes.

\(^5\)See the Appendix for details.
with weights corresponding to the countries’ GDP:

\[ \text{Admin}^j = \sum_i \frac{GDP_i,2005}{\sum_n GDP_n,2005} \frac{1}{10} \left( \sum_{t=2003}^{2014} \text{admin}_i,t \right). \]

From the resulting list, we classify all categories as ’administered’ whose value \( \text{Admin}^j \) exceeds 0.5. We retain 15 COICOP categories with administered prices that we exclude from our calculation of the price indices for tradables and non-tradables.\(^6\)

### 2.2 GDP deflator

**Classification of industries.** We use input-output tables to classify industries into tradables and non-tradables. In total, we can distinguish 62 industries following the NACE classification.\(^7\) Using the information on exports and imports provided by the 2010 I-O tables, we calculate the trade share, defined as the sum of exports and imports divided by two, for each industry. We categorize all industries with a trade share larger than 20% to be tradable.

Again, the Appendix contains a complete list.

### 3 Empirical Findings

#### 3.1 Price movements in Europe

In order to evaluate the impact of austerity on inflation, we require some benchmark for inflation. Given such a benchmark we call a certain policy to be deflationary if actual inflation is below that benchmark. Our approach is to use inflation forecasts as such a benchmark. This builds on House and Proebsting (2016) and previous work by Blanchard and Leigh (2013). House and Proebsting (2016) create forecasts for several economic variables for the period 2010 through 2014 based on data prior to 2010. We adopt this approach to predict inflation rates over this time period. We then examine forecast errors in inflation and study their relationship to measures of austerity.

To come up with reasonable forecasts for inflation, we first document that both nominal

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\(^6\)See the Appendix for a complete list.  
\(^7\)We exclude the two industries 'L68A: Imputed rents of owner-occupied dwellings' and 'T: Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use'.

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exchange rate movements and initial differences in price levels across European countries can explain a large part of the variation in average inflation rates across countries observed between 1996 and 2009. To show this, we run the following regression

\[ \pi_{i,96-'09} = \beta_0 + \beta_1 \left( \ln(P_{i,96}^e) - \ln P_{EU15,96}^e \right) + \beta_2 \left( \tilde{S}_{i,96-'09} - \tilde{S}_{EU15,96-'09} \right) + \epsilon_{i,t}. \]  

(3.1)

We regress a country’s average annual (net) inflation rate between 1996 and 2009, \( \pi_{i,96-'09} \), on a constant, the log-difference in the country’s 1996 price level, \( P_{i,96}^e \), (measured in 1996 euros) relative to the EU15-wide price level, and the difference in growth rates of the country’s exchange rate, \( \tilde{S}_{i,96-'09} \), relative to the EU15’s exchange rate. The exchange rate, \( S \), is quoted in national currency per euro and the tilde refers to the annual (net) growth rate, averaged over 1996 - 2009. Data on the price level in euros stems from Eurostat’s survey on power purchasing parities. For every year, Eurostat reports a country’s price level relative to the EU15. Starting from the reported value for 2010, we use information on inflation rates and exchange rates to obtain a time series going back to 1996.\(^8\)

By looking at a country’s difference relative to the EU15, we can interpret \( \hat{\beta}_0 \) as the predicted average annual inflation rate of the EU15 countries over the time period.\(^9\) Our estimate of \( \beta_1 \) indicates the degree of convergence in price levels (quoted in a common currency), with a negative estimate indicating that countries with initially lower price levels experienced stronger inflation. We also posit that nominal exchange rate movements affect price levels in the medium- to long-run. If a country’s exchange rate depreciates relative to the EU15’s currency basket over the time period, the term \( \tilde{S}_{i,96-'09} - \tilde{S}_{EU15,96-'09} \) would be positive. An estimate of \( \beta_2 \) equal to 1 would indicate complete pass-through of exchange rate movements into prices.

Table 1 displays the regression results for three samples: all 28 countries, the subset of 18 countries that are part of the euro area (as of 2014) and a small subset of 7 countries with floating exchange rates.\(^{10}\) In all three samples, average inflation rates between 1996 and 2009 are well explained by initial price level differences and nominal exchange rate movements, as illustrated by the high \( R^2 \) (between 0.89 and 0.99). Our inflation prediction of a country starting from the EU15 average price level is about 2.2 percent per year. Our estimate of \( \beta_1 \) (0.036) indicates substantial price convergence: A country like Greece with an initial price

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\(^8\)Eurostat also reports PPP values for 1996, but data for some countries and subcategories are missing. The correlation between the reported PPP values for 1996 and our constructed values is 0.99.

\(^9\)All variables with an ‘EU15’ subscript are weighted averages across all member countries of the (former) EU15, with weights corresponding to average population figures over the time period.

\(^{10}\)These are Czech Republic, Hungary, Poland, Romania, Sweden, United Kingdom, Norway.
level 26 log points below the EU15 average is predicted to have an inflation rate about 1 percentage point higher, i.e. around 3.2 percent. Countries in Central and Eastern Europe typically had even lower price levels in 1996. For Latvia, the predicted inflation rate over 1996 - 2009 is 5.6 percent. Figure 1 illustrates these findings by plotting the average inflation rate from 1996 to 2009 against the log of the price level in euros in 1996 (relative to the EU15 price level) after controlling for exchange rate movements. The figure as well as the results from the two subsamples confirm that this relationship is not driven by any strong outliers.

We also find robust evidence that nominal exchange rate movements translate, on average, one-for-one into inflation movements. Our estimate of $\beta_2$ is $-0.982(0.032)$, which is very close to complete pass-through. Even for the 'euro' sample which, by construction, only has limited variation in exchange rate movements, the exchange rate pass-through is about 0.7.

We now exploit these tight relationships between initial price level difference and inflation rates to produce our forecasts for the period 2010-2014. In doing so, we make two assumptions: First, we forecast exchange rates not to move on average between 2010 - 2014 because nominal exchange rate movements are notoriously difficult to predict. Second, we assume that the cross-sectional relationship described in equation (3.1) also holds in the time dimension. Regression (3.1) estimates average inflation rates over a 13-year time window, but is silent over the exact time path of inflation over that time period. We believe it is reasonable to assume that the cross-sectional relationship also holds in the time series, i.e. we stipulate that countries with initially low price levels experience strong inflation that subsequently tappers off as the country’s price level approaches the price level in the EU15. Under this assumption, our estimate of $\beta_1$ indicates that it takes a country about 14 years ($= \frac{0.5}{0.036}$) to cut its price level difference relative to the EU15 in half. This relatively low number indicates that high inflation rates in Central and Eastern European countries observed in the late 1990s are unlikely to persistent throughout the early 2010s, simply because price levels in these countries had already substantially caught up to those observed in Western Europe by 2009. Our estimate of $\beta_1$ refers to the effect of initial price level differences on average inflation observed over 13 years (1996 - 2009). Given our assumption, these inflation rates were higher in the early period of the sample and then slowed down. We can easily derive a corresponding estimate for a 1-year window as $\beta_1' = 1 - (1 - 13\beta_1)^\frac{1}{13} = 0.043$. This means, a country whose price level was

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11 That means, it plots $\pi_i,96-09 - \hat{\beta}_2 (\bar{S}_{EU15,96-09} - \bar{S}_{i,96-09})$ vs. $\ln P_{EU15,96} - \ln(P_{i,96})$.

12 The euro was introduced in eleven countries in 1999. The remaining seven countries joined the euro till 2014.
10 log points below the EU average in year \( t - 1 \) experiences an inflation rate 0.43 percentage points higher than the EU average in \( t \) (or 0.36 percentage points higher on average over the next 13 years).\(^{13}\)

From this reasoning, we derive the following forecast specification of annual inflation starting in 2010:

\[
\hat{\pi}_{i,t} = \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{i,t-1}^e - \ln \hat{P}_{EU15,t-1}^e \right) \quad \text{for} \quad t \geq 2010,
\]

where we use actual values for \( P_{EU15,09}^e \) and \( P_{i,09}^e \) when predicting inflation in 2010.

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\(^{13}\)In regression (3.1), we estimate a relationship between average inflation over \( T \) years and initial price differences observed at \( t - 1 \) (ignoring exchange rate movements). We can write this relationship as

\[
\frac{1}{T} \sum_{s=0}^{T-1} \hat{\pi}_{i,t+s} = \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{EU15,t-1}^e - \ln P_{i,t-1} \right).
\]

Now, we stipulate that this cross-sectional relationship also holds in the time series, i.e.

\[
\hat{\pi}_{i,t} = \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{EU15,t-1}^e - \ln P_{i,t-1} \right).
\]

If both of these equations hold, we can solve for \( \hat{\beta}_0 \) and \( \hat{\beta}'_1 \) as functions of \( \hat{\beta}_0 \) and \( \hat{\beta}_1 \). In particular (using the approximation \( \ln P_{i,t} = \ln P_{i,t-1} + \pi_{i,t} \))

\[
\pi_{i,t+1} = \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{EU15,t}^e - \ln P_{i,t} \right) = \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{EU15,t-1}^e + \hat{\beta}_0 - \ln P_{i,t-1} - \pi_{i,t} \right) = \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{EU15,t-1}^e + \hat{\beta}_0 - \ln P_{i,t-1} - \hat{\beta}_1 \left[ \hat{\beta}_0 + \hat{\beta}'_1 \left( \ln \hat{P}_{EU15,t-1}^e - \ln P_{i,t-1} \right) \right] \right) = \hat{\beta}_0 + \hat{\beta}'_1 \left( 1 - \hat{\beta}_1 \right) \left[ \ln \hat{P}_{EU15,t-1}^e - \ln P_{i,t-1} \right] \quad \text{for} \quad t \geq 2010.
\]

\[
\frac{1}{T} \sum_{s=0}^{T-1} \hat{\pi}_{i,t+s} = \hat{\beta}_0 + \hat{\beta}'_1 \left( \sum_{s=0}^{T-1} \left[ 1 - \hat{\beta}_1 \right]^s \right) \left( \ln \hat{P}_{EU15,t-1}^e - \ln P_{i,t-1} \right).
\]

Then, we obtain \( \hat{\beta}_0 = \beta_0 \) and \( \hat{\beta}_1 \left( \sum_{s=0}^{T-1} \left[ 1 - \hat{\beta}_1 \right]^s \right) = \hat{\beta}_1 \). We can solve the later as \( \hat{\beta}_1 = 1 - (1 - T \hat{\beta}_1)^\frac{1}{T} \).
4 Model

This section presents a model to analyze the relationship between economic activity and inflation in a monetary union ("union") composed of several regions. We think of this union as representing either the euro area with countries as regions, or a single country composed of several subnational regions. We add several frictions to an otherwise neoclassical multi-region model. First, each country produces both a non-traded and a traded good. Second, both prices and wages are sticky, and potentially respond to both local and union-wide economic conditions.

4.1 Households

The number of households in any region is $N_n$, with $\sum_n N_n = 1$. In each period $t$ the economy experiences one event $s_t$ from a potentially infinite set of states. We denote by $s^t$ the history of events up to and including date $t$. The probability at date 0 of any particular history $s^t$ is given by $\pi(s^t)$.\footnote{\textsuperscript{14}The model is written in per capita terms. For example, $X_n$ denotes per capita investment in country $n$ and $N_n X_n$ is country $n$’s total consumption.}

Households consume a composite good $C_{n,t}$ at price $P_{n,t}$ and supply labor and capital to firms in the non-tradable sector, $K^N_{n,t}$, $L^N_{n,t}$, and in the tradable sector, $K^T_{n,t}$, $L^T_{n,t}$. Following Horvath (2000), labor is sector-specific and hence, wages are not generally equalized across the two sectors. Capital, however, is mobile across sectors, so that a common rental price, $R_{n,t}$ prevails across both sectors. The expected discounted sum of future period utilities for a household, as of date 0, is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_{n,t}^{1-\frac{1}{\sigma}} - \Lambda_{n,t}}{1 - \frac{1}{\sigma}} \right).$$  \hspace{1cm} (4.1)

Here $E_0$ is the expectation operator at time 0, $\beta$ is the discount factor, $\sigma$ is the intertemporal elasticity of substitution, and $\Lambda_{n,t}$ is the household’s disutility from supplying labor, defined in the next section.

In return for supplying labor to firms, households earn nominal sector-specific wages $W^j_{n,t} L^j_{n,t}$ in each sector. Total labor income is denoted $W_{n,t} L_{n,t}$, where $L_{n,t} = L^N_{n,t} + L^T_{n,t}$ denotes total employment, and $W_{n,t}$ is the (weighted) average wage. Similarly, households
also supply capital and earn nominal rents, \( R_{n,t} K_{n,t} \), where \( K_{n,t} = K^N_{n,t} + K^T_{n,t} \) is the economy-wide capital stock. Households own all domestic firms and receive their profits, \( \Pi_{n,t} \). In addition, households receive transfer payments from the central government. These transfer payments to region \( i \) are non-negative whenever primary income in \( i \) is below the union-wide average. Primary income is defined as \( PI_{n,t} = W_{n,t} L_{n,t} + R_{n,t} K_{n,t} + \Pi_{n,t} \). Transfers then correspond to \( \tau (PI_t - PI_{n,t}) \), with \( \tau \geq 0 \). In an economy without fiscal transfers, \( \tau = 0 \); complete insurance against regional fluctuation in primary income corresponds to \( \tau = 1 \). Note that fiscal transfers are self-financing.\(^{16}\)

In addition to direct factor incomes and transfer payments, the household may receive payments from state-noncontingent bonds. These bonds pay off in units of the union-wide currency, which we take to be the euro. They are in net zero supply and can be issued by households in any region. Let \( S^*_{n,t} \) be the quantity of these bonds purchased by the household in region \( n \) after history \( s^t \). The price of these bonds is \( \frac{1}{1+i^*_t} \). The nominal exchange rate to convert country \( n \)'s currency into the reserve currency is \( E_{n,t} \).\(^{17}\)

Households choose consumption \( C_{n,t} \), investment, \( X_{n,t} \) and bond holdings \( S^*_{n,t} \) for all \( s^t \) and for all \( t \geq 0 \) to maximize the expected discounted sum of future period utilities subject to the following sequence of budget constraints:

\[
P_{n,t}(C_{n,t} + X_{n,t}) + \frac{S^*_{n,t}}{(1 + i^*_t)E_{n,t}} = W_{n,t} L_{n,t} + R_{n,t} K_{n,t} + \Pi_{n,t} + \frac{S^*_{n,t-1}}{E_{n,t}} + \tau (PI_t - PI_{n,t}),
\]

and the law of motion for the economy-wide capital stock

\[K_{n,t+1} = X_{n,t} + (1 - \delta)K_{n,t}.\]

The labor supply decision is delegated to unions, as explained in the next section.

4.2 Wage Setting, Labor Supply and Unemployment

We present a variant of the staggered wage setting block based on Erceg et al. (2000). In this setup, labor supply decisions are delegated to unions that have some market power. Here, and in contrast to the standard approach, we assume that a fraction \( \gamma_w \) of labor markets are unionized at the national level, while the remaining fraction \( 1 - \gamma_w \) of labor markets\(^{16}\) Similar to the literature on external habit formation (see e.g Abel, 1990), we assume that the household takes union-wide labor income as exogenous.\(^{17}\) With all countries being in a currency union, we set \( E_{n,t} = 1 \) ∀\( n, t \).
are unionized at the regional level. We also introduce a notion of “unemployment” into our model, which is consistent with our empirical counterpart. We do so by assuming that labor is indivisible, following the lead of Galí et al. (2012).

The representative household’s members work either in the non-traded or the traded sector. The share of household members in sector \( j = N, T \) is denoted by \( \chi^j \). The household aggregates the disutilities from across the two sectors, \( \Lambda^j_{n,t} \), according to a population-weighted CES function:

\[
\Lambda_{n,t} = \left( \sum_{j=N,T} \left( \chi^j_n \right)^{\frac{1}{\psi_l}} \left( \Lambda^j_{n,t} \right)^{\frac{\psi_l-1}{\psi_l}} \right)^{\frac{\psi_l}{\psi_l-1}},
\]

where \( \psi_l \geq 0 \) is the elasticity of substitution of labor disutility across the two sectors. Even though we do not allow household members to move across sectors, we allow labor supply in each sector to vary over time. The elasticity \( \psi_l \) affects the degree to which these variations in labor supply comove across the two sectors.\(^{18}\)

Within each sector \( j \), household members are indexed by a pair \((z, \iota) \in [0, 1] \times [0, 1]\), representing the type of labor (e.g. carpenters, bakers,...), and a member’s disutility from work. This disutility is represented by \( \kappa_n \varphi_{n,t} \iota \frac{1}{\eta} \), where \( \eta \) is the Frisch elasticity of labor supply, \( \kappa_n \) an exogenous weight on the disutility of labor, and \( \varphi_{n,t} \) an endogenous weight, to be defined below. We assume that members are equally distributed across the two dimensions. When sending members to work, the household starts with those that are the least averse to working (i.e. those with a low \( \iota \)). Then, we can write the household’s sector-specific disutility of labor as

\[
\Lambda^j_{n,t} = \kappa_n \varphi_{n,t} \int_0^1 \int_0^{l^j_{n,t}(z)} \left( \frac{l^j_{n,t}(z)}{1 + \frac{1}{\eta}} \right)^{\frac{1}{\eta}} d\iota dz = \kappa_n \varphi_{n,t} \int_0^1 \frac{l^j_{n,t}(z)\left(1 + \frac{1}{\eta}\right)}{1 + \frac{1}{\eta}},
\]

where \( l^j_{n,t}(z) \) is the fraction of members specialized in type \( z \) labor who are employed in period \( t \). As in Galí et al. (2012), we let the endogenous weight on disutility follow

\[
\varphi_{n,t} = \left( \frac{\bar{C}_{n,t}^{\frac{1}{\eta}} \varphi_{n,t-1}^{\frac{1}{\eta}-1}}{\bar{C}_{n,t}^{\frac{1}{\eta}}} \right)^{1-\vartheta},
\]

where \( \vartheta \in [0, 1] \) governs the short-run wealth effect, and \( \bar{C}_{n,t} \) is aggregate consumption in

\(^{18}\)Our formulation of sector-specific labor slightly differs from the formulation commonly used in the literature, (see e.g. Horvath, 2000; Gorodnichenko et al., 2012), where the CES aggregator arguments are sectoral labor instead of sectoral disutilities. In our formulation, relative wages and employment can move in the same direction (if \( \psi_l > 1 + \eta \)), which is never the case in the traditional formulation.
region $n$ at time $t$, which the household takes as given.

Aggregation firms aggregate labor types $z$ using a CES function and then supply the labor aggregate to the firms at a nominal wage of $W^j_{n,t}$. Effective labor is given by

$$L^j_{n,t} = \left(\int_0^1 l^j_{n,t}(z) \frac{\psi_w^{-1}}{\psi_w} \, dz\right)^{\psi_w - 1},$$

where $L^j_{n,t}$ is the effective amount of labor supplied to the firms in sector $j$ of region $n$ at time $t$ and $\psi_w > 1$ governs the degree to which different labor types are substitutable. The labor aggregating firm behaves competitively and supplies effective labor to the firms at a nominal wage $W^j_{n,t}$, but hires labor by type according to the type-specific nominal wage $W^j_{n,t}(z)$. Demand for each labor type is

$$l^j_{n,t}(z) = L^j_{n,t} \left(\frac{W^j_{n,t}(z)}{W^j_{n,t}}\right)^{-\psi_w},$$

where $W^j_{n,t}$ is the wage index for effective labor in sector $j$ corresponding to (4.2).

Wages for each type of labor are set by trade unions. Regional unions set wages to maximize the utility of the household in their own region, $n$. National unions, in contrast, maximize the utility of a population-weighted average of households across all regions. When setting wages, unions behave monopolistically competitive and take the aggregate employment and wage levels of their sector, $L^j_{n,t}$ and $W^j_{n,t}$, as given. Then, unions desire a real wage $w^j_{n,t}(z) = W^j_{n,t}(z)/P_{n,t}$ in labor market ($z$), which is a constant markup, $\mu_w = \frac{\psi_w}{\psi_w - 1} > 1$, over the competitive wage.

Let $\theta_w$ be the probability that a union cannot reset the wage in labor market $z$ in a given period. When setting their wage, unions compare the marginal benefit of additional money at time $t + \tau$—the marginal utility of consumption—to the marginal disutility from supplying additional labor. Specifically, the maximization problem of a regional trade union in any
particular market $z$ is:\footnote{Note that the real wage a worker with a stuck nominal wage $W_{j,n,t}^j$ will charge in period $t + \tau$ is}

$$
\max_{w_{j,n,t}^*} \mathbb{E}_t \sum_{\tau=0}^{\infty} (\theta_w \beta)^\tau \left( \frac{(1 - \tau)w_{j,n,t}^i(z)}{\psi_w} \right) \left( \frac{\partial \Lambda_{n,t+\tau}}{\partial \Lambda_{n,t+\tau}} \kappa_n \varphi_{n,t} \pi_{n,t+\tau} (z) \right) + \frac{\partial \Lambda_{n,t+\tau}}{\partial \Lambda_{n,t+\tau}} \kappa_n \varphi_{n,t} \pi_{n,t+\tau} (z) \right)\right),
$$

where trade unions take into account that labor demand, $\pi_{n,t+\tau}$, depends on the chosen wage $w_{j,n,t}^i(z)$. Here, $\pi_{n,t+\tau}$ denotes the cumulative product of inflation in country $n$ between periods $t$ and $t + \tau$. The solution to this maximization problem gives the optimal reset wage for regional trade unions in region $n$ at time $t$:

$$
(w_{j,n,t}^i(z))^{1 - \psi_w} = \frac{\psi_w}{\psi_w - 1} \mathbb{E}_t \sum_{\tau=0}^{\infty} (\theta_w \beta)^\tau \left( \frac{\partial \Lambda_{n,t+\tau}}{\partial \Lambda_{n,t+\tau}} \kappa_n \varphi_{n,t} \left( L_{n,t+\tau}^i \right) \right) \left( \frac{\partial \Lambda_{n,t+\tau}}{\partial \Lambda_{n,t+\tau}} \kappa_n \varphi_{n,t} \pi_{n,t+\tau} (z) \right)\right),
$$

Note that it is the same across all labor markets $z$. Given (4.4), the real wage for effective labor evolves according to

$$
u_{n,t}^j(z) = \theta_w \left( \frac{w_{n,t-1}^j(z)}{\pi_{n,t}} \right)^{1 - \psi_w} + (1 - \theta_w) \nu_{n,t}^j(z)^{1 - \psi_w}.
$$

National unions maximize the utility of an average of all households across regions when resetting the wage. In particular, they maximize

$$
\max_{w_{j,n,t}^*} \mathbb{E}_t \sum_{\tau=0}^{\infty} (\theta_w \beta)^\tau \sum_n \mathbb{N}_n \left[ \left( \frac{(1 - \tau)w_{j,n,t}^i(z)}{\pi_{n,t+\tau}} \right) \left( \frac{\partial \Lambda_{n,t+\tau}}{\partial \Lambda_{n,t+\tau}} \kappa_n \varphi_{n,t} \pi_{n,t+\tau} (z) \right)\right]\right).
$$

The optimal reset wage and the nominal wage in region $n$ at time $t$ for national trade unions are then analogous to the expression for the regional trade unions, (4.4) and (4.5).

Then, the aggregate real wage in sector $j$ of region $n$ at time $t$ is obtained by integrating

$$
\frac{W_{j,n,t}^j}{P_{n,t+\tau}} = w_{n,t}^j \frac{P_{n,t}}{P_{n,t+\tau}} = w_{n,t}^{j-1} \pi_{n,t+\tau}.
$$
over all labor markets:

\[ w^j_{n,t} = \left( \int_0^{\gamma_w} \left( w^j_t(z) \frac{P_t}{P_{n,t}} \right)^{1-\psi_w} dz + \int_{\gamma_w}^{1} w^j_{n,t}(z)^{1-\psi_w} dz \right)^{\frac{1}{1-\psi_w}}. \]

### 4.2.1 Unemployment

Unemployment is defined as the share of the labor force that is not working. Following Galí et al. (2012), we define the labor force as all workers who find it optimal to participate in the labor market, that is any individual for which

\[ (1-\tau)w^j_{n,t}(z) \geq \frac{\partial \Lambda_{n,t}}{\partial \Lambda^j_{n,t}} \kappa_n \phi_n t \frac{i^j_{n,t}(t, z)}{C_{n,t}^{\frac{1}{\eta}}} \]

Let the marginal supplier of type \( z \) labor be denoted by \( \bar{l}^j_{n,t}(z) \). Then the unemployment rate in market \( z \) of sector \( j \) of region \( n \) at time \( t \) is

\[ u^j_{n,t}(z) = 1 - \frac{l^j_{n,t}(z)}{\bar{l}^j_{n,t}(z)}. \]

Notice that with flexible prices, \( \theta_w = 0 \), wages are a constant markup over the marginal rate of substitution.\(^{21}\) The corresponding unemployment rate is the natural rate of unemployment and is a simple function of both the labor supply and demand elasticities:

\[ u^{j,*}_{n,t}(z) = 1 - \left( \frac{\psi_w - 1}{\psi_w} \right)^{\frac{1}{\eta}}. \]

In this setup, fluctuations in the actual wage markup caused by sticky wages translate into fluctuations in unemployment.

### 4.3 Firms

The economy is populated by four types of firms: producers, importers, wholesalers and retailers. Producers are active in either the traded or the non-traded sector. They are perfectly

\(^{20}\)If the individual works in a national labor market, the relevant wage is \( w^j_t(z) \frac{P_t}{P_{n,t}} \) instead of \( w^j_{n,t}(z) \).

\(^{21}\)That is

\[ \left( l^j_{n,t}(z) \right)^{\frac{1}{\eta}} = \frac{\psi_t - 1}{\psi_t} \frac{(1-\tau)w^j_{n,t}(z)}{\frac{\partial \Lambda_{n,t}}{\partial \Lambda^j_{n,t}} \kappa_n \phi_n t} C_{n,t}^{\frac{-1}{\eta}} \quad \text{for} \quad \theta_w = 0. \]
competitive and employ labor and capital to produce a sector-specific intermediate good. Some of the traded goods are shipped overseas to foreign importers. Importers bundle these traded intermediate goods from different origins (including their own region) and then sell the bundle to wholesalers. Wholesalers, in addition to purchasing traded goods from their importers, also buy non-traded goods directly from the producers in the non-traded sector, and then combine these two goods to final goods. Wholesalers are monopolistically competitive and everyone of them creates its own variety of the final good. The prices of their varieties are potentially sticky. Retailers purchase the varieties of the final good from all the different wholesalers and assemble them to a final aggregate that is then either consumed or invested. In contrast to wholesalers, retailers are perfectly competitive.

We discuss this production chain in reverse order, starting with the retailers.

Possible simplifications:

- Unit elasticity between traded and non-traded
- Single traded good

4.3.1 Retailers

The perfectly competitive retailers in region \( n \) purchase from every wholesaler \( \xi \) in its region varieties \( y_{n,t}(\xi) \) at price \( P_{n,t}(\xi) \) to produce a final aggregate \( Y_{n,t} \) that is sold at price \( P_{n,t} \). They choose inputs to maximize profits

\[
\max_{y_{n,t}(\xi)} \left\{ P_{n,t}Y_{n,t} - \int_0^1 P_{n,t}(\xi) y_{n,t}(\xi) d\xi \right\}
\]

subject to the CES production function

\[
Y_{n,t} = \left[ \int_0^1 y_{n,t}(\xi) \frac{\psi_{p-1}}{\psi_p} d\xi \right]^{\frac{\psi_p}{\psi_p-1}},
\]

with \( \psi_p \) being the elasticity of substitution between final good varieties. It follows that the demand for each final good variety \( y_{n,t}(\xi) \) is

\[
y_{n,t}(\xi) = Y_{n,t} \left( \frac{P_{n,t}(\xi)}{P_{n,t}} \right)^{-\frac{\psi_p}{\psi_p-1}}. \tag{4.6}
\]
4.3.2 Wholesalers

Every wholesaler $\xi$ of region $n$ purchases traded and non-traded intermediate goods, $y_{n,t}^j(\xi)$, from importers and producers in their own region at price $P_{n,t}^j$ to assemble a variety of the final good. They seek to maximize profits taking the demand curve for their product (4.6) as given. These firms each have access to a CES production function

$$y_{n,t}(\xi) = \left( \sum_{j=N,T} (\nu_{n}^{j}) \frac{1}{\psi_y} (y_{n,t}^j(\xi)) \frac{\psi y - 1}{\psi y} \right)^{\frac{\psi y}{\psi y - 1}}.$$  

Here, $\psi_y$ denotes the elasticity of substitution between traded and non-traded goods. Because wholesalers are monopolistically competitive, they typically charge a markup for their products. The desired price naturally depends on the demand curve (4.6). Each type of wholesaler $\xi$ freely chooses its inputs each period but there is a chance that their nominal price $P_{n,t}(\xi)$ is fixed to some exogenous level. In this case, the wholesalers choose an input mix to minimize costs taking their date-$t$ output price $P_{n,t}(\xi)$ as given. Cost minimization implies that

$$P_{n,t}^j = MC_{n,t}(\xi) \left( \frac{\nu_{n}^{j}y_{n,t}(\xi)}{y_{n,t}^j(\xi)} \right)^{\frac{1}{\psi_y}} \quad (4.7)$$

where $MC_{n,t}(\xi)$ is the marginal cost of production and $P_{n,t}^j$ is the price of the intermediate good $j$. The share of traded goods in production is constant for all wholesalers, in particular

$$\frac{y_{n,t}^T(\xi)}{y_{n,t}^N(\xi)} = \nu_{n}^{T} \nu_{n}^{N} \left( \frac{P_{n,t}^N}{P_{n,t}^T} \right)^{\psi_y} = \frac{y_{n,t}^T}{y_{n,t}^N}.$$
Nominal marginal costs are then constant across wholesalers and can be expressed as

\[ MC_{n,t} = y_{n,t} \prod_j \left( \frac{y_{n,t}}{P_{n,t}} \right)^{\psi_j} \left( P_{n,t} \right)^{\psi_j}. \]

**Pricing** The nominal prices of the final good varieties are adjusted only infrequently according to the Calvo mechanism. As with wages, we assume that a share \( \gamma_p \) of firms in each region are union-wide wholesalers that can only set a single, union-wide price.\(^{23}\) The remaining fraction \( 1 - \gamma_p \) are region-specific wholesalers that set region-specific prices.

Both types of firms face a probability \( \theta_p \) that they cannot change their price that period. When a firm, indexed by \( \xi \), can reset its price it chooses an optimal reset price. For region-specific firms this optimal reset price is \( P^*_{n,t}(\xi) \). For union-wide firms, this price is denoted \( P^*_t(\xi) \). Firms choose their reset price to maximize the discounted value of their profits. Region-specific firms apply the stochastic discount factor of their own region’s household to all future income streams, whereas union-wide firms apply the discount factor of a population-weighted average of all households in the monetary union.

The maximization problem of a region-specific wholesaler that can reset its price at date \( t \) is

\[
\max_{P^*_{n,t}(\xi)} \sum_{\tau=0}^{\infty} \left( \theta_p \beta \right)^\tau \sum_{s^{t+\tau}} \pi(s^{t+\tau} | s^t) \frac{U_{1,n,t+\tau}}{P_{n,t+\tau}} \left( P^*_{n,t}(\xi) - MC_{n,t+\tau} \right) Y_{n,t+\tau} \left( P^*_{n,t}(\xi) \right)^{-\psi_p}.
\]

\(^{22}\)From equation (4.7), we have

\[
MC_{n,t} = y_{n,t} \prod_j \left( \frac{y_{n,t}}{P_{n,t}} \right)^{\psi_j} \left( P_{n,t} \right)^{\psi_j}
\]

for both \( j = N, T \). Then, noting that

\[ \prod_j MC^{\psi_j}_{n,t} = MC_{n,t} \]

yields the equation.

\(^{23}\)Wholesalers that operate in the entire union sell the “same” (non-tradable) good in every region, but this good will be produced using different inputs because non-traded inputs and, in the presence of home bias, also traded goods will differ across regions. As an example, we could think of a fast food chain that sells a burger under the same name at the same price in different regions, but purchases ingredients from local or closeby markets, as well as hires local labor and rents local buildings.
The solution to this optimization problem requires

$$P_{n,t}^*(\xi) = \frac{\psi_p}{\psi_p - 1} \frac{\sum_{\tau=0}^{\infty} (\theta_p \beta)^\tau \sum_{s^{t+\tau}} \pi(s^{t+\tau}|s^t) \frac{U_{1,n,t+\tau}}{P_{n,t+\tau}} P_{n,t+\tau}^\psi MC_{n,t+\tau} Y_{n,t+\tau}}{\sum_{\tau=0}^{\infty} (\theta_p \beta)^\tau \sum_{s^{t+\tau}} \pi(s^{t+\tau}|s^t) \frac{U_{1,n,t+\tau}}{P_{n,t+\tau}} P_{n,t+\tau}^\psi Y_{n,t+\tau}}.$$ 

Because firms adjust their prices infrequently, the nominal price of the final good is sticky. For region-specific wholesalers, this price evolves according to

$$P_{n,t}(\xi) = \left[\theta_p (P_{n,t-1}(\xi))^{1-\psi_p} + (1 - \theta_p) (P_{n,t}^*(\xi))^{1-\psi_p}\right]^{1-\psi_p}.$$

The maximization problem of union-wide firms is analogous:

$$\max_{P_t^*(\xi)} \sum_{\tau=0}^{\infty} (\theta_p \beta)^\tau \sum_{s^{t+\tau}} \pi(s^{t+\tau}|s^t) \sum_n N_n U_{1,n,t+\tau}^t (P_{n,t}^*(\xi) - MC_{n,t+\tau}) Y_{n,t+\tau} \left(\frac{P_{n,t}^*(\xi)}{P_{n,t+\tau}}\right)^{-\psi_p}.$$ 

Its solution is

$$P_t^*(\xi) = \frac{\psi_p}{\psi_p - 1} \frac{\sum_{\tau=0}^{\infty} (\theta_p \beta)^\tau \sum_{s^{t+\tau}} \pi(s^{t+\tau}|s^t) \sum_n N_n U_{1,n,t+\tau}^t P_{n,t+\tau}^\psi MC_{n,t+\tau} Y_{n,t+\tau}}{\sum_{\tau=0}^{\infty} (\theta_p \beta)^\tau \sum_{s^{t+\tau}} \pi(s^{t+\tau}|s^t) \sum_n N_n U_{1,n,t+\tau}^t P_{n,t+\tau}^\psi Y_{n,t+\tau}};$$

and the nominal output price for union-wide firms obeys:

$$P_t(\xi) = \left[\theta_p (P_{t-1}(\xi))^{1-\psi_p} + (1 - \theta_p) (P_t^*(\xi))^{1-\psi_p}\right]^{1-\psi_p}.$$

Then, the aggregate nominal price of the final aggregate in region $n$ at time $t$ is obtained by integrating over all wholesalers, both union- and region-wide ones:

$$P_{n,t} = \left(\int_0^{\gamma_p} P_t(\xi)^{1-\psi_p} d\xi + \int_{\gamma_p}^1 P_{n,t}(\xi)^{1-\psi_p} d\xi\right)^{1-\psi_p}.\)$$

### 4.3.3 Importers

Importers buy tradable intermediate goods from different regions to produce a single good $Y_{n,t}^T$ that is then sold to wholesalers of their own region at price $P_{n,t}^T$. Let $q_{i,n,t}$ denote the amount of the tradable good produced in region $i$ and exported to region $n$ at date $t$. Importers
purchase these goods at price $p^T_{i,t}$, converted into their own currency, and maximize profits,

$$\max_{y^T_{n,i,t}} \left\{ P^T_{n,t} Y^T_{n,t} - \sum_i \frac{E_{i,t}}{E_{n,t}} p^T_{i,t} q^T_{n,i,t} \right\},$$

subject to a CES production function:

$$Y^T_{n,t} = \left( \sum_i (\omega_{n,i})^{\frac{1}{\psi_T}} (q^T_{n,i,t})^{\frac{\psi_T - 1}{\psi_T}} \right)^{-\frac{1}{\psi_T - 1}}.$$  

Demand for each tradable good is then

$$q^T_{n,i,t} = Y^T_{n,t} \omega_{n,i} \left( \frac{E_{i,t}}{E_{n,t}} \frac{P^T_{i,t}}{P^T_{n,t}} \right)^{-\psi_T}$$

### 4.3.4 Producers

Producers of intermediate goods operate in either the traded $j = T$ or the non-traded $j = N$ sector. They are perfectly competitive in both input and output markets. Producers in the traded sector sell their output $Q^T_{n,t}$ to importers, whereas producers in the non-traded sector sell their output $Q^N_{n,t}$ directly to the wholesalers of their country. Production of the intermediate goods requires labor and capital. Their maximization problem is

$$\max_{K^j_{n,t}, L^j_{n,t}} \left\{ p^j_{n,t} Q^j_{n,t} - Z^j_{n,t} (K^j_{n,t})^{\alpha} (L^j_{n,t})^{1-\alpha} \right\}$$

The demand for labor and capital is then derived as:

$$W^j_{n,t} = p^j_{n,t} (1 - \alpha) Z^j_{n,t} (K^j_{n,t})^{\alpha} (L^j_{n,t})^{-\alpha}$$

$$R^j_{n,t} = p^j_{n,t} \alpha Z^j_{n,t} (K^j_{n,t})^{\alpha-1} (L^j_{n,t})^{1-\alpha}$$

Note that we assume perfect capital mobility across sectors within a region, so that $R^j_{n,t} = R_{n,t}$.

### 4.4 Monetary Policy

We assume a fixed exchange rate regime across all countries in the union, i.e. $E_{n,t} = E_{i,t}$.

The monetary authority of the union conducts open market operations to target a nominal
interest rate set by the following Taylor Rule:

\[ i_t = \frac{i_n}{1 - \phi_i} + \phi_i i_{t-1} + (1 - \phi_i) \left( \phi_{GDP} \hat{GDP}_t + \phi_{\pi} \pi_t \right), \]  

(4.8)

with \( \frac{\phi_{\pi}}{1 - \phi_i} > 1 \) to ensure local determinacy of the equilibrium (see e.g Woodford and Walsh, 2005). The Taylor Rule targets steady-state deviations of union-wide GDP, \( GDP_t \), and inflation, \( \pi_t \), which are population-weighted averages of memberstate-level GDP and inflation.

### 4.5 Aggregation and Market Clearing

For each country \( n \), aggregate production of the intermediate goods \( j = N, T \) is given by

\[ Q^j_{n,t} = Z^j_{n,t} (K^j_{n,t})^{\alpha} (L^j_{n,t})^{1-\alpha}. \]

The market clearing for the intermediate good in the tradable sector produced by country \( n \) is

\[ Q^T_{n,t} = \sum_{i=1}^{N} \frac{N_i}{N_n} q^T_{i,n,t}. \]

For the non-traded intermediate good, we have \( Q^N_{n,t} = Y^N_{n,t} \). Production of the final good by retailers is given by (up to a first-order approximation)

\[ Y_{n,t} = \left( \sum_{j=N,T} \left( \nu^i_n \right)^{1\over \psi_y} \left( Y^j_{n,t} \right)^{\psi_y-1 \over \psi_y} \right)^{\psi_y \over \psi_y - 1}. \]

and its market clearing condition is

\[ Y_{n,t} = C_{n,t} + X_{n,t}. \]

The labor market clearing condition is

\[ L_{n,t} = L^N_{n,t} + L^T_{n,t}. \]

Finally, the bond market clearing conditions require

\[ \sum_{n=1}^{N} N_n B_n(s^t, s_{t+1}) = 0 \quad \forall s_{t+1}. \]
**Definitions.** For each country $n$, define nominal net exports as

$$ P_{n,t} N X_{n,t} = p_{n,t}^T Q_{n,t}^T - \sum_{i=1}^{n} \frac{E_{i,t}}{E_{n,t}} p_{n,t}^T y_{n,i,t} = p_{n,t}^T Q_{n,t}^T - P_{n,t}^T Y_{n,t}^T, $$

where the second equality follows from the zero profit condition for the producers of the final good composed of tradables. We can use this expression to write nominal GDP as

$$ NGDP_{n,t} = \sum_{j=N,T} p_{n,t}^j Q_{n,t}^j = P_{n,t}^N Y_{n,t}^N + P_{n,t}^T Y_{n,t}^T + P_{n,t} N X_{n,t} = P_{n,t} (Y_{n,t} + N X_{n,t}). $$

Real GDP is calculated at steady-state prices, that is $RGDP_{n,t} = \sum_{j=N,T} p_{n,t}^j Q_{n,t}^j$. Finally, aggregate inflation is the geometric average of sectoral inflation:

$$ \pi_{n,t} = \prod_{j=N,T} (\pi_{n,t}^j) \nu_n^j. $$
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**Notes:** Table displays the regression coefficient of a multivariate regression. Various samples.
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<tr>
<td><strong>Price and Wage Rigidity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sticky price probability</td>
<td>$\theta_p$</td>
<td>0.80</td>
<td>Alvarez et al. (2006)</td>
</tr>
<tr>
<td>Sticky wage probability</td>
<td>$\theta_w$</td>
<td>0.80</td>
<td>Barattieri et al. (2014)</td>
</tr>
<tr>
<td>Price centralization</td>
<td>$\gamma_p$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Wage centralization</td>
<td>$\gamma_w$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Fiscal and Monetary Policy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gov’t purchases over final demand</td>
<td>$\frac{G_n}{Y_n}$</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Persistence of shocks</td>
<td>$\rho$</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Transfers</td>
<td>$\tau$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Taylor rule persistence</td>
<td>$\phi_i$</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Taylor rule GDP coefficient</td>
<td>$\phi_{GDP}$</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Taylor rule inflation coefficient</td>
<td>$\phi_{\pi}$</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

*Notes:*
Figure 1: Inflation 1996 - 2009

Note: Figure displays average inflation rates over 1996 - 2009 after controlling for exchange rate movements vs. the log of the price levels in euros in 1996. Controlling for exchange rate movements is based on regression (3.1).
Figure 2: Cross-Country Phillips Curve Coefficient by COICOP

Note: Figure displays the coefficient $\beta_1$ of regression (??) for countries in the euro area by COICOP subgroup. The values for the band are $\hat{\beta}_1 \pm 2\text{std}(\hat{\beta}_1)$. COICOP categories are classified as tradables, non-tradables or subject to administered prices.
A Data

A.1 Price Inflation Data

Price inflation data is provided by Eurostat and covers all 19 countries in the euro area, plus Denmark. Eurostat publishes two price indices, the Harmonized Index of Consumer Prices (HICP) and the HICP at constant tax rates. The HICP is the European counterpart of the CPI (calculated by the BLS) and implements a common methodology in all European Union memberstates. The HICP is a Laspeyres index with weights being updated at an annual frequency. The HICP is divided into $J = 90$ categories (COICOP level 4). Let $P_{i,t}$ be the HICP in country $i$ at time $t$. It is defined as follows:

$$P_{i,t} = \sum_j p_{i,t}^j \tau_{i,t}^j \omega_{i,t}^j,$$

where $p_{i,t}^j$ is the pre-tax price of good $j$ in country $i$ at time $t$ relative to a base year, $\tau_{i,t}^j$ is the corresponding ad-valorem gross tax rate relative to a base year tax rate and $\omega_{i,t}^j$ is the weight with $\sum_j \omega_{i,t}^j = 1$.

The HICP at constant tax rates subtracts any changes in consumption tax rates from the HICP:

$$P_{i,t}^{ct} = \sum_j p_{i,t}^j \omega_{i,t}^j.$$

We prefer the HICP at constant tax rates as our measure of 'market-driven' inflation for our cross-sectional analysis because it is not contaminated by country-specific tax changes. A caveat to keep in mind is that the HICP at constant tax rates might differ from the counterfactual price index if tax changes hadn’t taken place. This is particularly true for industries with strong market power, where firms absorb, at least in the short run, tax changes in their markup rather than their prices. For example, a strong increase in the tobacco tax in Spain in 2006 left the HICP almost unchanged, whereas the HICP at constant tax rates dropped by 20 points.\footnote{Tobacco turns out to be an outlier in our Phillips curve regression: Tobacco prices increased in countries with increasing unemployment rates. This result is strongly influenced by Spain where price inflation for tobacco (measured at constant tax rates) returned to 'normal' levels in the post-crisis periods after the strong price decrease in 2006.}
**Imputation.** This HICP at constant tax rates is provided by Eurostat at the overall level and for five main categories since 2003, and at the detailed level for most countries since 2006.\(^{25}\) We impute missing values in two different ways: First, we use data on value-added tax changes by country, month and COICOP categories collected by Benedek et al. (2015), as well as data collected by ourselves based on information provided by the statistical agencies. Second, if some data is still missing, we impute the index at the detailed level by assuming that tax changes have been the same across all categories within a common main category.

**ALTERNATIVE:** We scale the detailed data on value-added tax changes so that our data matches the tax changes at the aggregate level reported by Eurostat.

Let \( j^p \) index the main category that good \( j \) belongs to. Further suppose that the price index for good \( j \) is available at time \( t \), but only the price index for the main category \( j^p \) is available at time \( s \). Then, we calculate the tax rate of good \( j \) at time \( s \) as follows:

\[
\tau_{i,s}^j = \tau_{i,t}^j \frac{\tau_{i,s}}{\tau_{i,t}^{j^p}},
\]

and the price index at constant tax rates is simply the ratio of the price index (including taxes) and the tax rate: \( p_{i,s} = \frac{p_{i,s}^j \tau_{i,s}^j}{\tau_{i,s}^j} \).

**Aggregate indices.** To calculate price indices for tradable and non-tradable goods, we have to aggregate price indices across several goods categories. Time series for these aggregate indices are chain-linked. That is, the aggregate price index in month \( m \) of year \( t \) is

\[
P_{m,t} = P_{Dec,t-1} \frac{\sum_j \frac{p_{m,t}^j \omega_t^j}{p_{Dec,t-1}^j}}{\sum_j \omega_t^j}.
\]

All indices are normalized so that

\[
\frac{1}{12} \sum_m p_{m,2015}^j = 100.
\]

**A.2 Wage Inflation Data**

Eurostat also publishes wage inflation data. The counterpart to the HICP is the Harmonized Labor Cost Index (HLCI), published since 1996. Among its various subindices, we choose

\(^{25}\)These five main categories are 'Processed food including alcohol and tobacco’, 'Unprocessed food’, 'Non-energy industrial goods’, 'Energy’, 'Services’
'total labor costs per effective hour of work’ as our main measure of wages. Total labor costs comprise the total costs incurred by an employer for using the factor labor over a certain time period, after deducting any subsidies and including non-wage payments such as obligatory social security contributions.

The HLCI is calculated for the economy as a whole and by economic activity (NACE). **MISSING: HOW MANY INDUSTRIES?** Every four years, member states conduct a large labor cost survey to record actual hourly labor costs. Smaller quarterly surveys and other sources are then used to monitor changes in those hourly labor costs.

The HLCI is a chain-linked Laspeyres index (similar to the HICP): [TO DOUBLE CHECK]

\[
W_{q,t} = W_{t-1} - \sum_k \frac{w_{q,t}^k \omega_t^k}{\sum_j \omega_t^j},
\]

where \(W_{q,t}\) is the wage index in quarter \(q\) of year \(t\), \(W_{t-1}\) is the annual wage index of year \(t-1\), \(w_{q,t}^k\) is the hourly labor cost in industry \(k\) in quarter \(q\) of year \(t\), and \(\omega_t^k\) is the weight of industry \(k\) at time \(t\). This weight is calculated as industry \(k\)’s share in overall labor costs.

Similar to the time-varying consumption basket of the HICP, the HLCI allows for a changing industry composition over time. These changes in the industry composition only affect the HLCI if wages grow at different rates across industries. In that respect, the HLCI is less prone to a composition bias inherent to other measures of wages, such as unit labor costs. Unit labor costs, roughly measured as total compensation of employees divided by real GDP, go down if the share of a low-paying industry goes up, even if wages remain constant within each industry.

### A.3 Linking Industries Inputs to COICOP

Input and output tables detail how an economy’s supply of goods and services is used for intermediate consumption and final demand. On the input side, these tables distinguish between various industries and whether inputs are sourced from domestic industries or foreign industries. On the output side, they break up intermediate consumption by the same industries and final demand mainly by household consumption, government consumption, investment and exports. These tables typically do not provide the necessary detail to link the inputs provided by a certain industry, e.g. ‘A01 Crop and animal production’ to a specific COICOP category of final household consumption, such as ‘CP0121 Coffee, tea and cocoa’. An exception
are the I-O tables for Denmark published by Statistics Denmark. These tables distinguish between 117 industries based on the NACE classification and 72 consumption groups based on COICOP. We can therefore calculate the import share of each consumption group. E.g. the import share for the good ‘CP0121: Coffee, tea and cocoa’ was about 22% on average between 2000 and 2014, rising from 16% to 28% over time. This number might seem low because Denmark is not cultivating any coffee, tea nor cocoa. But the table reveals that almost 60% of the final product purchased by consumers is derived from services provided by the wholesale and retail industry. These services are all produced domestically. In addition to these detailed I-O tables, Statistics Denmark has also granted us access to a use table for 2014 detailing which consumption categories use which products from which source (domestic or imported). This table distinguishes almost 500 product categories (based on the CPA 2008 4-digit classification).

Our analysis englobes many countries in the European Union, not only Denmark. Before applying these import shares and production structures to these other countries, we have to discuss two issues:

1. We have to match the Danish industry and consumption good classification to the classification used by Eurostat. In particular, we aggregate up the 117 industries to the 64 NACE industries used in our analysis, and match the 72 consumption categories to the 90 COICOP categories.

2. We expect import shares to differ across countries. For instance, while Denmark imports basically all of its wine, we expect France to have a much lower import share thanks to its domestic production.

We discuss each of these issues one step at a time.

A.3.1 Concordance between Statistics Denmark Categories and Eurostat Categories

On the supply side, it is straightforward to match the industries used by Statistics Denmark to those used by Eurostat because both statistical agencies use the same classification (NACE Rev.2) and Statistics Denmark’s 117 industries can be directly aggregated up into the 64 industries used by Eurostat.

On the use side, Statistics Denmark provides less detailed information than our inflation data from Eurostat (72 vs. 90 different groups). Statistics Denmark’s classification of
consumption groups is based on Eurostat’s COICOP, but sometimes uses more aggregated
groups (e.g. the Danish category 'Regular maintenance and repair of the dwelling’ encom-
passes Eurostat’s categories ‘CP0431: Materials for maintenance and repair of the dwelling’,
and ‘CP0432: Services for maintenance and repair of the dwelling’.) In certain cases, we
disaggregate the information into the underlying Eurostat categories by exploiting the details
offered on the supply side. For instance, for 'Regular maintenance and repair of the dwel-
ling’, we assign all supplies provided by the industries 'Professional repair and maintenance
of buildings' and 'Own-account repair and maintenance of buildins’ (both forming part of the
sector 'Construction’) to the category 'CP0432: Services for maintenance and repair of the
dwelling’. All supplies provided by the remaining industries (which all form part of the sectors
'Manufacturing’ or ‘Wholesale and retail trade’) are classified under 'CP0431: Materials for
maintenance and repair of the dwelling’. In some cases, we cannot distinguish between the
underlying Eurostat categories. For instance, Statistics Denmark aggregates up the two ca-
tegories ‘CP0211: Spirits’ and ‘CP0212: Wine’ into a single category. Both products rely on
inputs from the beverage industry and from the retail sector. The tables are not disaggregated
enough to distinguish between the supplies for 'Spirits’ as opposed to the supplies for 'Wine’.
In that case, we assume that the input mix and import share are the same across 'Spirits’ and
'Wine’.

A.3.2 Adjusting the Import Shares of Inputs

The Eurostat input-output tables provide us with information on the import share of supplies
for 64 industries, e.g. the import share of products produced by the industry 'A01: Crop
and animal production’ for France in 2010 is almost 20%. The detailed use tables provided
by Statistics Denmark indicate that within these industries, some goods have substantially
larger import shares than others. For instance, coffee is exclusively imported, whereas milk
has a much smaller import share. More importantly, we expect these import shares to be
different across European countries, e.g. the import share of wine should be lower in Southern
European countries that produce wine themselves. We correct for these differences by using
import data at the CPA 2008 4-digit level provided by Eurostat. Our procedure involves the
following steps, described at the example of 'Wine’

1. For every COICOP category, we determine the input coefficients of CPA inputs from
Statistics Denmark data. We assume that these input coefficients are the same for all
2. Calculate total imports for every CPA in the mix

3. Calculate a first indicator of the import share of each CPA by comparing the imports of each CPA with the amount of that CPA required for final consumption\textsuperscript{26}

4. The obtained import share requires adjustments. First, import data is before taxes whereas consumption data includes VAT and product taxes. This typically underestimates the import shares. Second, import data covers all uses of a CPA good, not just its use as a consumption good. Some CPA are primarily used as inputs for industries (e.g. some types of fuels). Most of the imports are not destined to households and our import shares calculated in the previous step are substantially larger than 100 percent. We therefore do two adjustments:

(a) Adjust the CPA import share for every country (except Denmark) by multiplying it by the ratio of the Danish CPA import share from the use table to the Danish CPA import share from the trade data. This tackles the second issue and relies on the approximation that the ratio of consumption use to total use of a CPA is about the same in every country.

(b) Adjust the CPA import share so that industry-level import shares correspond to those reported by the country. While countries do not report import shares for '1105 Wine from grapes', they report import shares for goods used for consumption and produced by the industry 'C10-C12 Manufacture of food products; beverages and tobacco products'. We proportionately adjust our import shares of all goods belonging to that industry to match that import share. In this step, we also restrict the import shares to be smaller or equal to 1.

5. We end up with an estimated import share for every CPA. Based on these import shares and the input coefficients we can calculate import shares for every COICOP. Note: The CPA import shares do not differ across COICOP. But data for Denmark reveals that most CPA are only used for a single COICOP.

\textsuperscript{26}For instance, 1089 is an input for several COICOP categories; calculate the weight of 1089 for each COICOP (e.g. 01190 consists of 20% of 1089, 01110 consists of 1% of 1089); then calculate the final consumption as 20%*basket weight of 01190 + 1% * basket weight of 01110 + ...;
B  Phillips Curve Regressions

We run regressions of the following type:

\[ w_i \Pi_i = \beta_0 w_i + \beta_1 w_i X_i + \epsilon_i, \]  

(B.1)

where \( \Pi_i \) is a measure of inflation in region \( i \), \( X_i \) a measure of economic performance in region \( i \), and \( w_i \) are weights (nominal GDP as of 2005).

\( x_{i,t} \) is a measure of economic performance in country \( i \) at time \( t \), \( T \) denotes the time period of length \( T \) that we average over,

We consider three ways of calculating our measure of inflation and our measure of economic performance:

1. Average inflation rate

\[ \Pi_i^1 = \left( \prod_{t \in T} \pi_{i,t} \right)^{\frac{1}{T}} \]

2. Average inflation rate relative to benchmark

\[ \Pi_i^2 = \left( \prod_{t \in T} \pi_{i,t} \right)^{\frac{1}{T}} - \left( \prod_{t \in T_{ref}} \pi_{i,t} \right)^{\frac{1}{T_{ref}}} \]

3. Change in inflation rate

\[ \Pi_i^3 = \pi_{T} - \pi_{T_0} \]

Here, \( \pi_{i,t} = \frac{P_{i,t}}{P_{i,t-1}} \) is a measure of (gross) inflation in country \( i \) at time \( t \). Our benchmark uses the second measure, and we choose \( T \) to encompass 2008Q2 - 2014Q4, and the reference period \( T_{ref} \) is 2003Q1:2007Q4.

We run the regression for 3 samples:

1. Euro area countries: Countries in our sample include all 19 countries in the euro area as of 2015, plus Denmark whose currency is pegged to the euro.\(^{27}\)

2. Regions in Spain (autonomos comunidades): 19

\(^{27}\)Countries in the euro area as of 2015 are Belgium, Germany, Estonia, Ireland, Spain, Greece, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Austria, Portugal, Slovenia, Slovakia and Finland.
3. NUTS level 2 regions in Europe (CPI is only available for Spain, Portugal, Germany and Poland). For this regression, we include country fixed effects.

We run the regression for various inflation measures

1. the HICP encompassing all goods and services ($\pi$)
2. the core HICP which excludes food and oil ($\pi^{core}$)
3. the HICP at constant tax rates $\pi^{ct}$
4. the HICP at constant tax rates of tradables $\pi^{trad}$
5. the HICP at constant tax rates of non-tradables $\pi^{ntrad}$
6. the GDP deflator.

and various measures of economic performance ($x_{i,t}$)

1. a measure of the output gap, $x_{i,t} = \frac{y_{i,t} - y_{i,t}^{pot}}{y_{i,t}^{pot}}$, where $y$ denotes real GDP per capita and $y^{pot}$ is a measure of potential real GDP per capita\(^{28}\)
2. the annualized gross growth rate of real GDP per capita
3. the unemployment rate
4. the gross migration rate, where a positive number indicates immigration and a negative number emigration

\(^{28}\)We use a measure of potential GDP published by AMECO, Table 6.5.
### Table A1: List of COICOP Categories and Tradability

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Code</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP0111</td>
<td>Bread and cereals</td>
<td>CP0622</td>
<td>Dental services</td>
</tr>
<tr>
<td>CP0112</td>
<td>Meat</td>
<td>CP063</td>
<td>Hospital services</td>
</tr>
<tr>
<td>CP0113</td>
<td>Fish and seafood</td>
<td>CP0711</td>
<td>Motor cars</td>
</tr>
<tr>
<td>CP0114</td>
<td>Milk, cheese and eggs</td>
<td>CP0712</td>
<td>Fuels and lubricants for personal transport equipment</td>
</tr>
<tr>
<td>CP0115</td>
<td>Oil and fats</td>
<td>CP0714</td>
<td>Motor cycles, bicycles and animal drawn vehicles</td>
</tr>
<tr>
<td>CP0116</td>
<td>Fruit</td>
<td>CP0721</td>
<td>Spare parts and accessories for personal transport equipment</td>
</tr>
<tr>
<td>CP0117</td>
<td>Vegetables</td>
<td>CP0722</td>
<td>Fuels and lubricants for personal transport equipment</td>
</tr>
<tr>
<td>CP0118</td>
<td>Sugar, jam, honey, chocolate and confectionary</td>
<td>CP0723</td>
<td>Maintenance and repair of personal transport equipment</td>
</tr>
<tr>
<td>CP0119</td>
<td>Food products n.e.c.</td>
<td>CP0724</td>
<td>Other services in respect of personal transport equipment</td>
</tr>
<tr>
<td>CP0121</td>
<td>Coffee, tea and cocoa</td>
<td>CP0731</td>
<td>Passenger transport by railway</td>
</tr>
<tr>
<td>CP0122</td>
<td>Mineral waters, soft drinks, fruit and vegetable juices</td>
<td>CP0732</td>
<td>Passenger transport by road</td>
</tr>
<tr>
<td>CP0211</td>
<td>Spirits</td>
<td>CP0733</td>
<td>Passenger transport by air</td>
</tr>
<tr>
<td>CP0212</td>
<td>Wine</td>
<td>CP0734</td>
<td>Passenger transport by sea and inland waterway</td>
</tr>
<tr>
<td>CP0213</td>
<td>Beet</td>
<td>CP0735</td>
<td>Combined passenger transport</td>
</tr>
<tr>
<td>CP0214</td>
<td>Tobacco</td>
<td>CP0736</td>
<td>Other purchased transport services</td>
</tr>
<tr>
<td>CP0311</td>
<td>Clothing materials</td>
<td>CP0737</td>
<td>Postal services</td>
</tr>
<tr>
<td>CP0312</td>
<td>Garments</td>
<td>CP0738</td>
<td>Fuels and lubricants for personal transport equipment</td>
</tr>
<tr>
<td>CP0313</td>
<td>Other articles of clothing and clothing accesso-</td>
<td>CP0739</td>
<td>Maintenance and repair of personal transport equipment</td>
</tr>
<tr>
<td></td>
<td>ries</td>
<td>CP0740</td>
<td>Other durables for recreation and culture</td>
</tr>
<tr>
<td>CP0314</td>
<td>Cleaning, repair and hire of clothing</td>
<td>CP0911</td>
<td>Equipment for the reception, recording and reproduction of sound and picture</td>
</tr>
<tr>
<td>CP032</td>
<td>Footwear incl repair</td>
<td>CP0912</td>
<td>Photographic and cinematographic equipment</td>
</tr>
<tr>
<td>CP041</td>
<td>Rentals of housing</td>
<td>CP0913</td>
<td>Information processing equipment</td>
</tr>
<tr>
<td>CP042</td>
<td>Service for maintenance and repair of dwelling</td>
<td>CP0914</td>
<td>Recording media</td>
</tr>
<tr>
<td>CP043</td>
<td>Materials for maintenance and repair of dwelling</td>
<td>CP0915</td>
<td>Repair of audio-visual, photographic and informa-</td>
</tr>
<tr>
<td></td>
<td>Services for maintenance and repair of dwelling</td>
<td>CP0921</td>
<td>tion processing equipment</td>
</tr>
<tr>
<td>CP044</td>
<td>Water supply</td>
<td>CP0922</td>
<td>Major durables for indoor and outdoor recrea-</td>
</tr>
<tr>
<td>CP0443</td>
<td>Sewerage collection</td>
<td>CP0923</td>
<td>tion including musical instruments</td>
</tr>
<tr>
<td>CP0444</td>
<td>Other services relating to the dwelling</td>
<td>CP0924</td>
<td>Maintenance and repair of other major durables</td>
</tr>
<tr>
<td>CP0451</td>
<td>Electricity</td>
<td>CP0925</td>
<td>for recreation and culture</td>
</tr>
<tr>
<td>CP0452</td>
<td>Gas</td>
<td>CP0926</td>
<td>Miscellaneous printed matter; stationery and drawing materials</td>
</tr>
<tr>
<td>CP0453</td>
<td>Liquid fuels</td>
<td>CP093</td>
<td>Gardens, plants and flowers</td>
</tr>
<tr>
<td>CP0454</td>
<td>Solid fuels</td>
<td>CP0935</td>
<td>Pets and related products; veterinary and other services for pets</td>
</tr>
<tr>
<td>CP0455</td>
<td>Heat energy</td>
<td>CP094</td>
<td>Other personal care</td>
</tr>
<tr>
<td>CP0511</td>
<td>Furniture and furnishings</td>
<td>CP095</td>
<td>Food processing</td>
</tr>
<tr>
<td>CP0512</td>
<td>Carpets and other floor coverings</td>
<td>CP096</td>
<td>Holiday packages</td>
</tr>
<tr>
<td>CP0513</td>
<td>Repair of furniture, furnishings and floor coverings</td>
<td>CP097</td>
<td>Education</td>
</tr>
<tr>
<td>CP052</td>
<td>Household textiles</td>
<td>CP098</td>
<td>Restaurants, cafes and the like</td>
</tr>
<tr>
<td>CP053</td>
<td>Major household appliances whether electric or</td>
<td>CP099</td>
<td>Canteens</td>
</tr>
<tr>
<td></td>
<td>and smoke electric household appliances</td>
<td>CP100</td>
<td>Hotels and other accomodations</td>
</tr>
<tr>
<td>CP0533</td>
<td>Repair of household appliances</td>
<td>CP101</td>
<td>Hairdressing salons and personal grooming estab-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CP102</td>
<td>lishments</td>
</tr>
<tr>
<td>CP054</td>
<td>Kitchen and household utensils</td>
<td>CP121</td>
<td>Electrical appliances for personal care; other appliances, articles and products for personal care</td>
</tr>
<tr>
<td>CP055</td>
<td>Tools and accessories for house and garden</td>
<td>CP1212</td>
<td>Jewellery, clocks and watches</td>
</tr>
<tr>
<td>CP056</td>
<td>Non-durable household goods</td>
<td>CP1213</td>
<td>Other personal effects</td>
</tr>
<tr>
<td>CP0562</td>
<td>Domestic services and household services</td>
<td>CP122</td>
<td>Social protection services</td>
</tr>
<tr>
<td>CP061</td>
<td>Pharmaceutical products</td>
<td>CP123</td>
<td>Insurances</td>
</tr>
<tr>
<td>CP0612</td>
<td>Other medical products, therapeutic appliances</td>
<td>CP124</td>
<td>Financial services</td>
</tr>
<tr>
<td></td>
<td>and equipment</td>
<td>CP125</td>
<td>Other services</td>
</tr>
</tbody>
</table>

Notes: Table displays the list of COICOP categories including their codes and description. Categories classified as tradable are in italic.
## Table A2: LIST OF CATEGORIES WITH ADMINISTERED PRICES

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Admin&lt;sup&gt;j&lt;/sup&gt;</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP0735</td>
<td>Combined passenger transport</td>
<td>0.98</td>
<td>5.01</td>
</tr>
<tr>
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<tr>
<td>CP0731</td>
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<td>Tobacco</td>
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<td>CP0734</td>
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<td>Canteens</td>
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<td>Books</td>
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<td>CP0562</td>
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<td>CP0432</td>
<td>Services for maintenance and repair of dwelling</td>
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</table>

*Notes:* Table displays the variable Admin<sup>j</sup> for each COICOP category that has a positive value for Admin<sup>j</sup>. We classify goods with Admin<sup>j</sup> > 0.50 as administered categories (those above the horizontal line). The weight corresponds to the average weight in the consumer basket across countries and time periods (out of 1'000).
<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Trade</th>
<th>Code</th>
<th>Name</th>
<th>Trade</th>
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<tr>
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<td>Mining and quarrying</td>
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<td>Postal and courier activities</td>
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<td>C10_C12</td>
<td>Manufacture of food products, beverages and tobacco products</td>
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<td>I</td>
<td>Accommodation and food service activities</td>
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<td>C13_C15</td>
<td>Manufacture of textiles, wearing apparel, leather and related products</td>
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<td>Publishing activities</td>
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<td>Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials</td>
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<td>Motion picture, video, television programme production; programming and broadcasting activities</td>
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<td>Telecommunications</td>
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<td>C18</td>
<td>Printing and reproduction of recorded media</td>
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<td>J62, J63</td>
<td>Computer programming, consultancy, and information service activities</td>
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<tr>
<td>C19</td>
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<td>K64</td>
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<tr>
<td>C20</td>
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<td>Insurance, reinsurance and pension funding, except compulsory social security</td>
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<tr>
<td>C21</td>
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<td>K66</td>
<td>Activities auxiliary to financial services and insurance activities</td>
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<tr>
<td>C22</td>
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<tr>
<td>C23</td>
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<td>M69, M70</td>
<td>Legal and accounting activities; activities of head offices; management consultancy activities</td>
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<tr>
<td>C24</td>
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<tr>
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<td>M73</td>
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<tr>
<td>C27</td>
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<td>Other professional, scientific and technical activities; veterinary activities</td>
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<tr>
<td>C28</td>
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<tr>
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<tr>
<td>C30</td>
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<td>C31_C32</td>
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<td>N80, N82</td>
<td>Security and investigation, service and landscape, office administrative and support activities</td>
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<tr>
<td>C33</td>
<td>Repair and installation of machinery and equipment</td>
<td>0.17</td>
<td>O</td>
<td>Public administration and defence; compulsory social security</td>
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<tr>
<td>D</td>
<td>Electricity, gas, steam and air conditioning supply</td>
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<td>E36</td>
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<td>Q87, Q88</td>
<td>Residential care activities and social work activities without accommodation</td>
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<td>Construction</td>
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<td>R90, R92</td>
<td>Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities</td>
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<tr>
<td>G45</td>
<td>Wholesale and retail trade and repair of motor vehicles and motorcycles</td>
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<td>R93</td>
<td>Sports activities and amusement and recreation activities</td>
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<tr>
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<td>S96</td>
<td>Other personal service activities</td>
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</tbody>
</table>

Notes: Table displays the list of NACE categories including their codes and description. Categories classified as tradables are in italic.
References


