Online Appendix

Fiscal Policy, Relative Prices and Net Exports in a Currency Union*

Luisa Lambertini
EPFL [†]

Christian Proebsting
EPFL [‡]

August 30, 2021

*Lambertini: Luisa.Lambertini@epfl.ch; Proebsting: Christian.Probsting@epfl.ch
[†]École Polytechnique Fédérale de Lausanne
[‡]École Polytechnique Fédérale de Lausanne

Contents

A Data **3**

A.1 Consumer Price Inflation Data 3

A.2 More Details on Import Shares by COICOP category 4

A.2.1 Concordance between Statistics Denmark Categories and Eurostat Categories 5

A.2.2 Adjusting the Input Coefficients 6

A.2.3 Constructing Import Shares of Inputs 8

A.2.4 Summary Statistics 8

A.3 Additional Results 9

B Model **10**

B.1 Notes on Labor Substitutability 10

B.2 Balassa-Samuelson Effect and Labor Substitutability 11

B.3 Pricing to Market 15

A Data

A.1 Consumer Price Inflation Data

Price inflation data is provided by Eurostat and covers all countries in the European Union. 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 $P_{n,t}$ be the HICP in country n at time t. It is defined as follows:

$$P^{ret}_{n,t} = \sum_j \nu_{j,n,t} P^{ret}_{j,n,t}$$

where $P^{ret}_{j,n,t} = P_{j,n,t}(1 + \tau^c_{j,n,t})$ is the retail price of good j in country n at time t relative to a base year, $\tau^c_{j,n,t}$ is the corresponding ad-valorem net tax rate relative to a base year tax rate and $\nu_{j,n,t}$ is the weight with $\sum_j \nu_{j,n,t} = 1$.

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

$$P_{n,t} = \sum_j \nu_{j,n,t} P_{j,n,t}.$$

Changes in the aggregate value added tax rate can then be computed as the difference in growth rates of the HICP and the HICP at constant tax rates:

$$\Delta\tau^c_{n,t} = \frac{P^{ret}_{n,t}}{P^{ret}_{n,t-1}} - \frac{P_{n,t}}{P_{n,t-1}}.$$

Imputation. This HICP at constant tax rates is provided by Eurostat at the overall level since 2003. For the period before 2003, we rely on 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.

A.2 More Details on Import Shares by COICOP category

We calculate import shares by COICOP category using data from input-output tables.

Up to a first-order approximation, overall consumption in country n at time t can be disaggregated as follows

$$\widetilde{C}_{n,t} = \sum_{j} \nu_{j,n} \tilde{c}^{j}_{n,t}$$

where $c^{j}_{n,t}$ is consumption of good j in country n at time t and $\nu_{j,n,t}$ is the weight of good j with $\sum_j \nu_{j,n,t} = 1$. $\tilde{x}_t$ refers to the percent deviation of variable x from its steady state. Consumption goods are classified into $J = 90$ categories such as 'Fish and seafood', 'Wine' and 'Maintenance and repair of personal transport equipment'. This corresponds to the level 4 division of Classification of individual consumption by purpose (COICOP).

We view these goods as being produced by combining inputs indexed by $s = 1, ..., S$, originating from countries $i = 1, ..., N$. 'Wine', for example, is produced by combining 'Wine from grape', potentially produced domestically and / or imported, with domestic 'Distribution services'. Denoting $y^{s,j,i}_{n,t}$ the amount of input s from country i in the production of good j in country n at time t, we can write consumption of good j in country n at time t as

$$\tilde{c}^{j}_{n,t} = \sum_{s=1}^{S} a^{s}_{j,n} \sum_{i=1}^{N} \omega^{s,i}_{n} \tilde{y}^{s,j,i}_{n,t} \tag{A.1}$$

Here, $a^{s}_{j,n}$ is the cost share of input s in the production of good j in country n. Notice that we allow this technology coefficient to be country-specific. Inputs are produced in potentially all countries with $\omega^{s,i}_{n}$ denoting country n's expenditure share on input s from country i with $\sum_{i=1}^{N} \omega^{s,i}_{n} = 1 \; \forall s, n$. The expenditure share on domestically produced inputs is $\omega^{s,n}_{n}$, while the share on imports is $1 - \omega^{s,n}_{n}$.

Consumption goods are commonly classified into tradables and non-tradables in an ad-hoc way or assigning them to industries and then classify them based on how tradable the inputs and outputs of these industries are (see e.g. Crucini et al., 2005; Berka et al., 2018). In contrast, we classify goods following equation (A.1), which takes into account that consumption goods might require inputs from various industries. In particular, for every consumption good j, we calculate the average import share, im_j, as a weighted average of the import shares of the underlying inputs, s, averaged across countries n:

$$im_j = \frac{1}{N} \sum_n \sum_s a^s_{j,n}(1 - \omega^{s,n}_n), \tag{A.2}$$

We allow import shares of inputs, $1 - \omega^{s,n}_n$, to be input- and country-specific.

Our main data sources are detailed use tables from Statistics Denmark for 2010, national use tables provided by Eurostat as well as the EU-inter country Supply, Use and Input-Output Tables (called FIGARO). Here we provide a few more details.

First, we calculate the input cost shares $a^s_{j,DNK}$ with $\sum_s a^s_{j,DNK} = 1$ for the 90 COICOP categories from the use tables provided by Statistics Denmark. We briefly discuss how we create a concordance between product classifications and consumption good classifications used by Statistics Denmark and Eurostat.

Second, we adjust these COICOP-specific input coefficients $a^s_{j,n}$ for each country n to be consistent with the aggregate consumption input coefficients derived from the official use tables.

Third, to calculate input-specific import shares, $\omega^{s,i}_n$, we rely on both national use tables and the FIGARO tables provided by Eurostat.

A.2.1 Concordance between Statistics Denmark Categories and Eurostat Categories

It is straightforward to match the products used by Statistics Denmark to those used by Eurostat because both rely on the same classification (CPA 2008). We simply aggregate up the Danish 4-digit level product categories to the 64 2-digit level product categories used by Eurostat.

In terms of consumption groups, Statistics Denmark uses a coarser classification than what is commonly used for reporting inflation data. Eurostat reports inflation data according to 4-digit level COICOP 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' encompasses 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 dwelling', 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 categories '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.2.2 Adjusting the Input Coefficients

Data provided by Statistics Denmark allows us to calculate COICOP-specific input coefficients, $a^s_{j,DNK}$ with $\sum_s a^s_{j,DNK} = 1$. Given information on the basket weight for each COICOP category, we can directly calculate the use of each CPA good in households' consumption.

Although input coefficients are likely to be similar across our sample of (economically) rather homogenous countries, they might differ slightly. As a matter of fact, applying the Danish input coefficients to basket weights from a country other than Denmark, we obtain an implied use of each CPA good in that country's household consumption, which is inconsistent with data provided by national use tables. To be consistent with these national use tables, we therefore adjust the Danish input coefficients for each country separately. In doing so, we choose the input coefficients for country n, $a^s_{j,n}$, to be as "similar" as possible to the Danish input coefficients, $a^s_{j,DNK}$, while being consistent with country n's national use tables. In particular, we minimize

$$\min_{a^s_{j,n}} \sum_j \sum_s \frac{1}{2} \frac{\left(a^s_{j,DNK} - a^s_{j,n}\right)^2}{k + a^s_{j,DNK}}$$

subject to

$$\sum_{j}^{J} a^s_{j,n} \nu_{j,n} = a^s_{C,n} \qquad \forall s$$
$$\sum_{s} a^s_{j,n} = 1 \qquad \forall j = 1, ..., J$$
$$a^s_{j,n} \geq 0 \qquad \forall s, \quad \forall j = 1, ..., J$$
$$1 \geq a^s_{j,n} \qquad \forall s, \quad \forall j = 1, ..., J,$$

with $k > 0$.[1] Our loss function specifies our idea of "similarity" between the two matrices. The first constraint describes the constraint imposed by the data on input coefficients for overall consumption: When summing up the input coefficients $a^s_{j,n}$ for CPA good s across all consumption categories, j, weighted by their basket weights, $\nu_{j,n}$, we must obtain the input coefficient for overall household consumption, $a^s_{C,n}$. The second to fourth constraints are purely technical constraints on the parameters. In practice we set $k = 0.1$. This is a simple problem to solve. Let λ_s and λ_j denote the Lagrange multiplier on the first two constraints. We solve for these parameters using the two constraints and setting the preference weights to

$$a^s_{j,n} = min\left(1, max\left[0, a^s_{j,DNK} - (k + a^s_{j,DNK})\left(\lambda_j + \lambda_s \nu_{j,n}\right)\right]\right).$$

Two remarks:

- Real estate services: Use tables split up the CPA category 'L68' into 'L68A: Imputed rents of owner-occupied dwellings' and 'L68B: Real estate services excluding imputed rents'. Our consumption data only covers actual rentals (COICOP category CP041). Conceptually, we need to exclude imputed rents of owner-occupied dwellings from our list of CPA goods. For many countries, this means simply dropping category 'L68A' from the input-output tables. For some countries, the use tables do not distinguish between 'L68A' and 'L68B' (they report NaN for 'L68A'). Since the CPA category 'L68' is almost exclusively used for the consumption of category CP041, and category CP041 only requires CPA category 'L68' as an input, we directly adjust the share of category 'L68' in the use table for aggregate consumption to the basket weight of category CP041.

- Retail and wholesale services: Three countries (Roumania, Cyprus and Luxembourg)

[1] Notice that we require $k > 0$ because elements in $a^s_{j,DNK}$ might be equal to 0.

report that the CPA category 'G46: Wholesale trade services, except of motor vehicles and motorcycles' is not used for household consumption. It is, however used in other use categories (such as intermediate consumption). In these cases, we replace the input coefficient for household consumption $a^s_{C,n}$ by the input coefficient for total use, a^s_n. We proceed similarly for Luxembourg, which reports zero use of the CPA category 'G47: Retail trade services, except of motor vehicles and motorcycles'.

A.2.3 Constructing Import Shares of Inputs

National use tables on Eurostat report information on a product's origin—whether it is domestically produced or imported—conditional on its use.[2] These tables distinguish between 64 different products. We rely on the national use tables for the year 2010 because all countries in our sample provide data for that specific year. We complement this information with the FIGARO tables that themselves are based on the 2010 national use tables, but break down imports by country of origin. This allows us to calculate the import shares $\omega^{s,i}_n$ by partner country.

We face two main challenges when using these tables. First, the FIGARO tables report imports at FOB (free on board), whereas the national use tables report imports at CIF (cost, insurances and freight). Typically, for manufactured goods, imports valued at CIF exceed imports valued at FOB, whereas for services, the opposite is true. Second, the FIGARO tables do not report total imports, but only imports stemming from either of the 28 European Union countries. We therefore proceed as follows: If total imports (reported at FOB in the national use tables) is smaller than the sum of EU28 imports (reported at CIF in FIGARO), we adjust total imports up to match the sum of EU28 imports, and set non-EU28 imports to zero.

A.2.4 Summary Statistics

Table A1 shows the estimated import shares by COICOP categories, calculated as $\sum_s a^s_{j,n}(1-\omega^{s,n}_n)$. The table displays the median import share across countries as well as the 25% and 75% percentiles. The highest import shares of around 50% can be observed for high-value items such as motor vehicles and major household appliances. Food products typically have

[2]Practically, most statistical agencies apply the import proportionality assumption. This assumes that households consume imports of a product proportional to their total consumption of a product and in line with the economy-wide import share of that product. Statistical agencies apply the assumption at different levels of aggregation, with Denmark differentiating between more than 2'000 products.

medium import shares of about 15% to 30%. The low import share categories are typically classified as services.

A.3 Additional Results

For convenience, we reproduce the main regression specification to estimate the cumulative multiplier at horizon h:

$$\sum_{s=0}^{h}(\ln x_{i,t+s}-\ln x_{i,t-1}) = M_h \sum_{s=0}^{h}\frac{G_{i,t+s}-G_{i,t-1}}{Y_{i,t-1}} + \beta_{\mathbf{h}}\mathbf{z^h}_{i,t-1}+\varepsilon^{x}_{i+h,t}, \tag{A.3}$$

Estimates for aggregate consumption and investment. Figure A1 displays the estimated multipliers for GDP, private consumption, private investment and net exports. Consumption and investment are expressed in GDP, e.g. for consumption the left-hand-side variable in regression (A.3) is given by

$$\sum_{s=0}^{h}(\ln C_{i,t+s}-\ln C_{i,t-1})\,\frac{C_{i,t-1}}{Y_{i,t-1}}.$$

Both consumption and investment increase in response to a positive shock of government spending.

Estimated coefficient on interaction term. Figure A2 displays the estimated coefficient on the interaction term, m_h, for the regressions at the product level,

$$\sum_{s=0}^{h}\left(\log P^{j,ret}_{i,t+s}-\log P^{j,ret}_{i,t-1}\right) = (M_h + m_h \times im_j)\sum_{s=0}^{h}\frac{G_{i,t+s}-G_{i,t-1}}{Y_{i,t-1}} + \beta_{\mathbf{h}}\mathbf{z}^{j}_{i,t-1}+\varepsilon^{j}_{i,t+h}, \tag{A.4}$$

and the industry level,

$$\sum_{s=0}^{h}\left(\log P^{k}_{i,t+s}-\log P^{k}_{i,t-1}\right) = (M_h + m_h \times ex_{i,k})\sum_{s=0}^{h}\frac{G_{i,t+s}-G_{i,t-1}}{Y_{i,t-1}} + \beta_{\mathbf{h}}\mathbf{z}^{j}_{i,t-1}+\varepsilon^{k}_{i,t+h}, \tag{A.5}$$

together with 90% and 95% confidence intervals based on Driscoll-Kraay standard errors.

Estimates without tax controls. Figures A3 - A4 display our empirical results if we do not control for aggregate tax changes in our local projections. In that case, the response in retail prices is muted because positive spending shocks are associated with cuts in consumption taxes.

B Model

B.1 Notes on Labor Substitutability

Horvath (2000) discusses the following utility function:

$$U(C,L) = \frac{C^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \kappa \frac{L^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}},$$

with

$$L_t = \left(L_{T,t}^{1+\xi} + L_{N,t}^{1+\xi} + L_{D,t}^{1+\xi} \right)^{\frac{1}{1+\xi}},$$

The derivative with respect to L_j:

$$\frac{\partial U}{\partial L_j} = \frac{\partial U}{\partial L}\frac{\partial L}{\partial L_j} = -\kappa L^{\frac{1}{\eta}} \times \left(\frac{L_j}{L} \right)^{\xi}.$$

This specification nests two canonical cases depending on the choice of ξ. If $\xi = 0$, labor across sectors are perfect substitutes and only aggregate labor enters the utility function:

$$U(C,L) = \frac{C^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \frac{\kappa}{1+\frac{1}{\eta}} \left(L_{T,t} + L_{N,t} + L_{D,t} \right)^{1+\frac{1}{\eta}}.$$

If $\xi = \frac{1}{\eta}$ (imperfect substitutes), labor enters separably in the utility function and labor supply in sector j does not depend on aggregate labor supply:

$$U(C,L) = \frac{C^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \frac{\kappa}{1+\frac{1}{\eta}} \left(L_{T,t}^{1+\frac{1}{\eta}} + L_{N,t}^{1+\frac{1}{\eta}} + L_{D,t}^{1+\frac{1}{\eta}} \right).$$

The response of relative employment to movements in relative wages is governed by ξ:

$$\left(\frac{L_T}{L_N} \right)^{\xi} = \frac{W_T}{W_N}.$$

Therefore, one way to estimate ξ is to look at how relative wages and relative employment respond to identified government spending shocks. Figure A5 shows the results. We observe that both relative wages and relative labor fall upon impact and they both fall by the same amount. More specifically, upon impact the point estimate of ξ is 1.00 and averaged over the first four semesters, it is 1.06. The figure also plots the response implied by our baseline model that imposes the value $\xi = 1$. The fit is remarkably good. A model with perfect labor substitutability $\xi = 0$ is unable to match the empirical relationship because it overestimates the relative employment response and underestimates the relative wage response.

B.2 Balassa-Samuelson Effect and Labor Substitutability

Berka et al. (2018) (BDE) find empirical evidence for a Balassa-Samuelson effect in the euro area. Using comparable price data across countries, BDE observe that an increase in productivity in the traded-good sector raises the overall price level. BDE rationalize this result by appealing to the standard Balassa-Samuelson logic: an increase in traded-good productivity raises wages in that sector and, with labor being perfectly substitutable across sectors, throughout the economy. This, in turn, pushes up the price level in the non-traded sector, and, consequently, the overall price level. BDE's explanation therefore relies on labor being mobile across sectors, which is at odds with our model where labor supplied to different sectors are imperfect substitutes. This raises the question of whether our model is consistent with the empirical evidence in BDE.

Here, we show that a model with imperfect labor substitutability is able to match the empirical findings in BDE. That is, perfect labor substitutability and wage equalization across sectors are not necessary to replicate the Balassa-Samuelson effect and the results in BDE.

To demonstrate this, Figure A6 shows the model response to a positive TFP shock in the traded sector. The figure distinguishes four model variations: Starting from a calibration dubbed 'BDE' that assumes that labor is perfectly substitutable across sectors ($\xi = 0$), that there are no hand-to-mouth consumers ($\chi = 0$) and that financial markets are complete, the following three calibrations add, one at a time, imperfect labor substitutability ($\xi = \frac{1}{\eta}$)), hand-to-mouth consumers ($\chi = 0.5$) and incomplete financial markets. The last model variation then corresponds to our benchmark calibration.

As seen in Figure A6, the 'BDE' model (blue line) generates an appreciation of the RER in line with the Balassa-Samuelson logic outlined above: an increase in traded-good productivity raises wages in that sector, but also in the sector producing the non-traded good because labor is perfectly substitutable across sectors. Since productivity has not increased in the non-traded sector, non-traded good prices go up, thereby raising the general retail price level and appreciating the real exchange rate.

The next model (red dashed line) shows that the Balassa-Samuelson logic breaks down if labor is assumed to be imperfectly substitutable across sectors (calibration (2) with $\chi = \frac{1}{\eta}$). The increase in wages in the traded-good sector does not directly spill over to the wage level in the non-traded good sector, putting less upward pressure on non-traded retail prices. The real exchange rate even depreciates as the price of the traded consumption good falls because consumers exhibit a home bias towards the domestically produced traded good that has become cheaper.[3] A model with complete markets, no hand-to-mouth consumers and imperfect labor substitutability across sectors therefore is unable to generate the real exchange rate appreciation in response to an increase in traded-good productivity.

Calibration (3) in Figure A6 (green, dotted line) adds hand-to-mouth consumers ($\chi = 0.5$), keeping labor across sectors imperfect substitutes. This modification is enough to generate a real appreciation. In contrast to the previous calibrations, the higher income generated in the traded-good sector leads to an increase in consumption (see panel 'Consumption' in Figure A6) that raises demand for non-traded goods, thereby raising wages and the price of non-traded goods.

Finally, our benchmark model (calibration (4), orange line with markers) adds incomplete markets. In this case, the benefits of the increase in traded-good productivity fully accrue to the small open economy and households will respond by raising their consumption even more. Non-traded-good prices increase even more and, as a result, the RER appreciation is more pronounced.

To sum up, a positive TFP shock in the traded-good sector leads to an appreciation if either labor is perfectlty substitutable across sectors and / or if financial frictions (restricting asset markets to non-contingent bonds and / or introducing hand-to-mouth consumers) are present. This implies that our benchmark model is fully consistent with the RER evidence in BDE; moreover, our model is consistent with the industry-level evidence on relative wage and relative labor.

[3] This 'terms-of-trade' effect is also present in our 'BDE' calibration and results from the fact that domestic and foreign traded goods are imperfect substitutes. In our model, we set the elasticity between domestic and foreign traded goods to $\psi = 2$, which is lower than the value of 8 in the original BDE paper. A lower value of that elasticity generates a stronger terms-of-trade response (i.e. the price of the traded good produced at Home falls) that mutes the response of the RER. This explains why the RER response of the model version (1) 'BDE' in Figure A6 is quantitatively somewhat weak compared to the original calibration in BDE.

A simple pencil-and-paper model. The result can also be derived in a simplified version of the model that can be solved with pencil and paper. It simplifies the benchmark model along the following dimensions: (i) prices are assumed to be fully flexible, (ii) production is linear in labor, (iii) there are no distribution costs, (iv) there is no government spending, and (v) the traded good produced in the SOE is identical to the traded good abroad.

Then, the real exchange rate is simply proportional to the price of the non-traded good (lower case letters denote log-linear deviations from steady state)

$$s = -(1-\gamma)p_N,$$

where, as a reminder, γ is the share of traded goods in the consumption basket. With fully flexible prices and output being linear in labor we have that the non-traded price fully reflects unit labor costs, $p_N = w_N - z_N$. Hence,

$$s = (1-\gamma)\left(z_N - w_N\right).$$

Similarly, $p_T = w_T - z_T = 0$, where the last equality follows from the assumption that traded goods produced in different countries are perfect substitutes such that the price of traded goods is determined at the world level and remains unchanged. Hence, $w_T = z_T$.

Classical Balassa-Samuelson effect with perfect labor substitutability Assume that labor is perfectly substitutable across sectors ($\xi = 0$) and there are no financial frictions, i.e. complete financial markets and no hand-to-mouth consumers ($\chi = 0$). With perfect labor substitutability, $w_N = w_T = w$. Then, $w = z_T$ and the real exchange rate is

$$s = (1-\gamma)\left(z_N - z_T\right).$$

This is the classical Balassa-Samuelson result: An increase in Home's traded-good productivity appreciates the real exchange rate (i.e. it raises the price level), and an increase in Home's non-traded-good productivity depreciates the real exchange rate (i.e. it lowers the price level).

Balassa-Samuelson effect with financial frictions Instead, now assume that labor is imperfectly substitutable ($\xi = \frac{1}{\eta}$) and a fraction χ of households are hand-to-mouth consumers as assumed in our benchmark model. Aggregate consumption is then composed of consumption by PIH consumers, c^{opt}, and consumption by hand-to-mouth consumers which is proportional to aggregate output:

$$c = (1-\chi)c^{opt} + \chi\left(\gamma(z_T + l_T) + (1-\gamma)(z_N + l_N)\right).$$

In this setup, one can solve for the real exchange rate s as a function of the productivity in the two sectors:[4]

$$\left[\frac{\gamma}{1-\gamma} + \frac{(1-\chi)(\sigma+\eta)}{1+\eta}\right] s = \left(1-\chi(1-\gamma)\right) z_N - \chi\gamma z_T.$$

Hence, in the absence of hand-to-mouth consumers, $\chi = 0$, (and with complete markets), TFP in the traded-good sector z_T has no effect on the RER because labor is imperfectly subsitutable across sectors: An increase in wages in the traded-good sector does not spill over to wage levels

---

[4]To see this, notice that the Backus-Smith condition requires that the real exchange rate is proportional to the marginal utility of consumption of the PIH consumers:

$$\sigma s = c^{opt} = \frac{1}{1-\chi}\left(c - \chi\left(\gamma(z_T + l_T) + (1-\gamma)(z_N + l_N)\right)\right).$$

We therefore need to solve for l_N, l_T and c as functions of z_T, z_N and s:

- For l_N: Since labor is imperfectly substitutable across sectors, optimal labor supply in sector N does not depend on labor supply in sector T. In particular, optimal labor supply is $w_N - p = \frac{1}{\eta}l_N + \frac{1}{\sigma}c^{opt} = \frac{1}{\eta}l_N + s$, where the second equality follows from the Backus-Smith condition. Since $p = -s$, this implies $w_N = \frac{1}{\eta}l_N$. Inserting this into the expression for the real exchange rate ($s = (1-\gamma)(z_N - w_N)$):

$$\frac{1}{\eta}l_N = z_N - \frac{1}{1-\gamma}s.$$

- For l_T: Since $l_T = \eta w_T$ and $w_T = z_T$, we have

$$l_T = \eta z_T.$$

- For c: The optimal choice of non-traded consumption requires $c = c_N + p_N - p$. Market clearing of the non-traded good implies $c_N = z_N + l_N$, prices in the non-traded sector obey $p_N = w_N - z_N$ and the price level is inversely related to the RER, $p = -s$. Hence, $c = w_N + l_N + s$. Hence,

$$c = s + \frac{1+\eta}{\eta}l_N = s + (1+\eta)\left(z_N - \frac{1}{1-\gamma}s\right).$$

Plugging in, we get

$$(1-\chi)\sigma s = s + (1+\eta)\left(z_N - \frac{1}{1-\gamma}s\right) - \chi\left(\gamma(1+\eta)z_T + (1-\gamma)((1+\eta)z_N - \frac{\eta}{1-\gamma}s)\right)$$
$$\left((1-\chi)\sigma - 1\right)s = (1+\eta)\left\{\left(1-\chi(1-\gamma)\right)z_N - \chi\gamma z_T\right\} - \frac{1+\eta}{1-\gamma}s + \chi\eta s.$$

Rewriting this equation yields the expression.

in the non-traded good sector, which keeps the price of non-traded goods constant. This shows that in the classical Balassa-Samuelson model with no financial frictions, labor substitutability is a necessary condition for the RER to appreciate in response to a positive TFP shock in the traded sector.

This is no longer true if we allow for hand-to-mouth consumers ($\chi > 0$). Then, an increase in z_T appreciates the RER even without labor substitutability. The reason for that is that when a fraction of consumers have no access to financial markets, then any increase in income raises their consumption one for one. Their increase in consumption raises their demand for non-traded goods and consequently their price. This demand effect is absent if $\chi = 0$ and financial markets are complete because complete financial markets imply that the benefits of the increase in traded-good productivity are fully shared with the RoW and consumption in the SOE does not respond to an increase in traded-good productivity.

As seen in Figure A6, restricting financial markets to the trade of non-contingent bonds has similar implications: in that case, the benefits of the increase in traded-good productivity fully accrue to the Home economy and households will respond by raising their consumption.

B.3 Pricing to Market

We discuss an extension of the model that allows for pricing to market.

Producers In contrast to the model discussed in the main body of the text, we assume that producers of traded goods are monopolistically competitive. They face non-CES demand à la Kimball (1995) for their traded good variety, which gives rise to variable markups and pricing to market. Each producer of traded goods is denoted by ι and produces output according to

$$Q_{T,t}(\iota) = \left(K_{T,t}(\iota)\right)^{\alpha} \left(L_{T,t}(\iota)\right)^{1-\alpha}.$$

Variety producers $[0, \omega]$ produce for the domestic market and variety producers $[\omega, 1]$ produce for the export market. Given their market power, these firms charge a markup for their products that will naturally depend on the demand curve they face. In particular, profit maximization gives rise to a simple pricing rule with a markup over marginal costs, (which is the same as the marginal cost for producers of non-traded goods, i.e. $P_{N,t}$), given by

$$\mathcal{M}_t(\iota) = \frac{\varepsilon_t(\iota)}{\varepsilon_t(\iota) - 1},$$

where $\varepsilon_t(\iota)$ is the elasticity of demand that the firm faces in its market.

Wholesalers Wholesalers are perfectly competitive in both input and output markets. They purchase varieties of the traded good both at home and abroad to produce a wholesale good, V_t, according to

$$1 = \int_0^\omega \Upsilon\left(\frac{Q_{T,t}^{dom}(\iota)}{V_t}\right) d\iota + \int_\omega^1 \Upsilon\left(\frac{Q_{T,t}^{imp}(\iota)}{V_t}\right) d\iota. \tag{B.1}$$

Here, $Q_{T,t}^{dom}(\iota)$ denotes the quantity of the domestically produced variety ι, $Q_{T,t}^{imp}(\iota)$ is the quantity of the imported variety ι, ω is the share of domestic varieties, and Υ is a Kimball (1995) aggregator. In this setup, the demand for (domestic) variety ι is

$$Q_{T,t}^{dom}(\iota) = \Upsilon'^{-1}\left(Z_t \frac{P_{T,t}^{dom}(\iota)}{P_{V,t}}\right) V_t,$$

where $P_{T,t}^{dom}(\iota)$ is the price associated with $Q_{T,t}^{dom}(\iota)$, $P_{V,t}$ is the price of the final good produced by the wholesalers and Z_t is a term that is constant around a symmetric steady state up to a first-order approximation (see Burstein and Gopinath, 2014).

We follow Klenow and Willis (2006) and choose the specification of Υ such that

$$\Upsilon'^{-1}\left(Z_t \frac{P_{T,t}^{dom}(\iota)}{P_{V,t}}\right) = \left[1 - \theta \log\left(Z_t \frac{P_{T,t}^{dom}(\iota)}{P_{V,t}}\right)\right]^{\frac{\psi}{\theta}}.$$

In that case, the elasticity of demand for a specific variety is given by

$$\varepsilon_t(\iota) = -\frac{\partial \log Q_{T,t}^{dom}(\iota)}{\partial \log P_{T,t}^{dom}} = \frac{\psi}{1 - \theta \log\left(Z_t \frac{P_{T,t}^{dom}(\iota)}{P_{V,t}}\right)}.$$

This demand elasticity is constant and equal to ψ if $\theta \to 0$ (which corresponds to the CES case). In a symmetric steady state, where all variety producers charge the same price, ψ corresponds to the elasticity of substitution between varieties (and therefore has to be larger than 1). Notice that this elasticity also describes the elasticity of substitution between domestic and imported inputs. If $\theta > 0$, the demand elasticity is increasing in a variety's relative price $\frac{P_T^{dom}}{P_V}$. This implies that variety producers find it optimal to adjust their markup in response to price movements by their competitors. The elasticity of the markup to a relative price change is then (see Burstein and Gopinath, 2014):

$$\Gamma(\iota) = \frac{\theta}{\psi - 1 + \theta \log\left(Z_t \frac{P_{T,t}^{dom}(\iota)}{P_{V,t}}\right)}.$$

When competitors lower their price (i.e. a fall in $P_{V,t}$), the variety producer faces a higher elasticity of demand and responds by reducing their markup. The parameter θ controls how quickly the demand elasticity rises in this case and therefore controls the degree of strategic complementarities in pricing.

Exports We assume that wholesalers abroad import varieties from the SOE to assemble them with other varieties according to a production function similar to (B.1). Exporting variety producers therefore face a demand curve for their product given by

$$Q_{T,t}^{exp}(\iota) = \Upsilon'^{-1}\left(P_{X,t}(\iota)\right) V^*,$$

where $Q_{T,t}^{exp}(\iota)$ denote exports of variety ι, $P_{X,t}(\iota)$ is the corresponding price, and V^* is a constant demand shifter.

References

Benedek, Dora, Ruud A De Mooij, Michael Keen, and Philippe Wingender, "Estimating VAT Pass Through," *IMF Working Paper*, 2015.

Berka, Martin, Michael B. Devereux, and Charles Engel, "Real exchange rates and sectoral productivity in the eurozone," *American Economic Review*, 2018, *108* (6), 1543–1581.

Burstein, Ariel and Gita Gopinath, "International Prices and Exchange Rates," in "Handbook of International Economics," Vol. 4, Elsevier, 2014.

Crucini, Mario J, Chris I Telmer, and Marios Zachariadis, "Understanding European Real Exchange Rates," *American Economic Review*, 2005, *95* (3), 724–738.

Horvath, Michael, "Sectoral shocks and aggregate fluctuations," *Journal of Monetary Economics*, 2000, *45* (1), 69–106.

Kimball, Miles S, "The quantitative analytics of the basic neomonetarist model," Technical Report, National Bureau of Economic Research 1995.

Klenow, Peter J and Jonathan L Willis, "Real Rigidities and Nominal Price Changes," Technical Report 2006.

Table A1: LIST OF COICOP CATEGORIES AND IMPORT SHARES

			Import Share		
Code	Name	Weight	50%	25%	75%
CP0712_0714	Motor cycles, bicycles and animal drawn vehicles	3‰	53.7%	33.1%	63.5%
CP0911	Equipment for the reception, recording and reproduction of sound and picture	6‰	50.2%	47.1%	53.1%
CP0531_0532	Major household appliances whether electric or not and small electric household appliances	10‰	49.6%	43.6%	57.1%
CP0711	Motor cars	40‰	49.5%	41.4%	54.9%
CP0912	Photographic and cinematographic equipment and optical instruments	2‰	47.6%	44.5%	50.3%
CP0512	Carpets and other floor coverings	2‰	46.1%	37.4%	48.1%
CP0611	Pharmaceutical products	17‰	45.5%	40.1%	51.9%
CP032	Footwear	14‰	41.6%	34.4%	43.7%
CP0431	Materials for the maintenance and repair of the dwelling	11‰	38.1%	26.6%	44.9%
CP0312	Garments	44‰	35.2%	29.2%	36.9%
CP0931	Games, toys and hobbies	5‰	35.0%	32.1%	42.3%
CP0453	Liquid fuels	5‰	34.8%	28.5%	49.8%
CP0733	Passenger transport by air	6‰	32.8%	11.6%	66.2%
CP0313	Other articles of clothing and clothing accessories	2‰	31.6%	26.1%	33.1%
CP0115	Oils and fats	6‰	31.5%	17.7%	42.3%
CP0722	Fuels and lubricants for personal transport equipment	48‰	31.4%	23.8%	48.8%
CP0511	Furniture and furnishings	20‰	30.8%	26.6%	35.2%
CP0111	Bread and cereals	30‰	29.5%	16.6%	39.8%
CP0452	Gas	13‰	29.5%	12.7%	71.6%
CP1232	Other personal effects	4‰	28.7%	23.9%	31.2%
CP1212_1213	Electrical appliances for personal care; other appliances, articles and products for personal care	19‰	28.0%	22.2%	31.8%
CP1231	Jewellery, clocks and watches	4‰	27.4%	25.5%	28.6%
CP052	Household textiles	5‰	26.3%	22.7%	28.8%
CP0112	Meat	40‰	25.8%	14.7%	34.7%
CP054	Glassware, tableware and household utensils	5‰	25.6%	15.5%	30.7%
CP0612_0613	Other medical products, therapeutic appliances and equipment	5‰	25.6%	22.7%	31.5%
CP0122	Mineral waters, soft drinks, fruit and vegetable juices	10‰	24.7%	14.0%	33.3%
CP022	Tobacco	29‰	24.4%	20.4%	31.9%
CP0561	Non-durable household goods	11‰	23.5%	19.6%	28.3%
CP0721	Spare parts and accessories for personal transport equipment	7‰	23.3%	18.5%	26.6%
CP0114	Milk, cheese and eggs	27‰	22.9%	13.3%	29.6%
CP0932	Equipment for sport, camping and open-air recreation	3‰	22.0%	19.9%	27.7%
CP0118	Sugar, jam, honey, chocolate and confectionery	12‰	22.0%	12.6%	29.3%
CP0119	Food products n.e.c.	6‰	21.9%	13.9%	29.9%
CP055	Tools and equipment for house and garden	5‰	21.9%	18.7%	28.0%
CP0921_0922	Major durables for indoor and outdoor recreation including musical instruments	3‰	21.3%	18.6%	24.5%
CP0311	Clothing materials	0‰	21.3%	18.4%	22.4%
CP0116	Fruit	12‰	20.6%	15.2%	32.5%
CP0213	Beer	9‰	20.1%	11.5%	27.1%
CP0212	Wine	8‰	20.1%	11.6%	27.1%
CP0211	Spirits	7‰	19.7%	11.4%	26.5%
CP0913	Information processing equipment	5‰	19.4%	15.5%	25.8%
CP0117	Vegetables	16‰	18.2%	13.5%	28.5%
CP0951	Books	5‰	18.1%	8.9%	28.4%
CP0121	Coffee, tea and cocoa	5‰	18.0%	11.0%	21.8%
CP0933	Gardens, plants and flowers	6‰	17.7%	12.9%	27.9%
CP0952	Newspapers and periodicals	8‰	16.6%	8.2%	26.4%
CP082_083	Telephone and telefax equipment and services	35‰	16.6%	14.9%	22.6%
CP0953_0954	Miscellaneous printed matter; stationery and drawing materials	3‰	16.4%	11.4%	19.7%
CP0934_0935	Pets and related products; veterinary and other services for pets	5‰	14.6%	10.9%	22.3%
CP0923	Maintenance and repair of other major durables for recreation and culture	0‰	13.5%	0.1%	26.3%
CP0113	Fish and seafood	8‰	11.9%	8.3%	14.6%
CP0914	Recording media	3‰	9.2%	4.9%	12.1%
CP0454	Solid fuels	5‰	6.1%	2.0%	18.3%
CP0513	Repair of furniture, furnishings and floor coverings	0‰	5.3%	0.7%	8.8%
CP0734	Passenger transport by sea and inland waterway	1‰	5.1%	0.5%	26.4%
CP0942	Cultural services	16‰	5.0%	2.2%	10.4%
CP0941	Recreational and sporting services	9‰	4.8%	3.6%	5.5%
CP126	Financial services n.e.c.	9‰	4.8%	0.3%	6.7%
CP081	Postal services	1‰	2.5%	0.0%	6.4%
CP0455	Heat energy	11‰	2.4%	0.2%	7.5%
CP127	Other services n.e.c.	8‰	2.3%	1.3%	3.7%
CP0736	Other purchased transport services	0‰	1.7%	1.3%	6.3%
CP125	Insurance	13‰	1.3%	0.0%	5.0%
CP0915	Repair of audio-visual, photographic and information processing equipment	1‰	1.3%	1.2%	1.6%
CP0724	Other services in respect of personal transport equipment	7‰	1.2%	0.0%	13.5%
CP0731	Passenger transport by railway	4‰	1.2%	0.3%	5.9%
CP0451	Electricity	28‰	1.1%	0.0%	6.1%
CP0314	Cleaning, repair and hire of clothing	1‰	1.0%	0.2%	3.9%
CP0732	Passenger transport by road	10‰	1.0%	0.2%	4.5%
CP0735	Combined passenger transport	3‰	1.0%	0.3%	3.1%
CP0562	Domestic services and household services	6‰	0.9%	0.0%	3.6%
CP0443	Sewerage collection	4‰	0.7%	0.0%	9.8%
CP0442	Refuse collection	4‰	0.6%	0.0%	9.5%
CP1211	Hairdressing salons and personal grooming establishments	11‰	0.3%	0.0%	3.8%
CP0533	Repair of household appliances	1‰	0.2%	0.0%	1.2%
CP0723	Maintenance and repair of personal transport equipment	17‰	0.2%	0.0%	0.5%
CP0621_0623	Medical services and paramedical services	10‰	0.2%	0.0%	1.3%
CP063	Hospital services	7‰	0.1%	0.0%	0.7%
CP0622	Dental services	8‰	0.1%	0.0%	0.7%
CP0432	Services for the maintenance and repair of the dwelling	8‰	0.0%	0.0%	0.8%
CP0444	Other services relating to the dwelling n.e.c.	7‰	0.0%	0.0%	3.0%
CP112	Accommodation services	17‰	0.0%	0.0%	3.8%
CP1111	Restaurants, cafés and the like	68‰	0.0%	0.0%	3.8%
CP1112	Canteens	9‰	0.0%	0.0%	3.8%
CP10	Education	13‰	0.0%	0.0%	0.9%
CP0441	Water supply	6‰	0.0%	0.0%	0.2%
CP124	Social protection	10‰	0.0%	0.0%	0.1%
CP041	Actual rentals for housing	38‰	0.0%	0.0%	0.0%
CP096	Package holidays	16‰	0.0%	0.0%	0.5%

Notes: Table displays the list of COICOP categories including their codes and description. We classify COICOP categories with an import share above 10% as high-import share COICOP categories (those above the horizontal line). Weight is the average consumption basket weight (across countries and time) in promils.The 25%, 50% and 75% quantiles across countries of the import share are given as well.Categories classified as administered are marked with an asterisk.

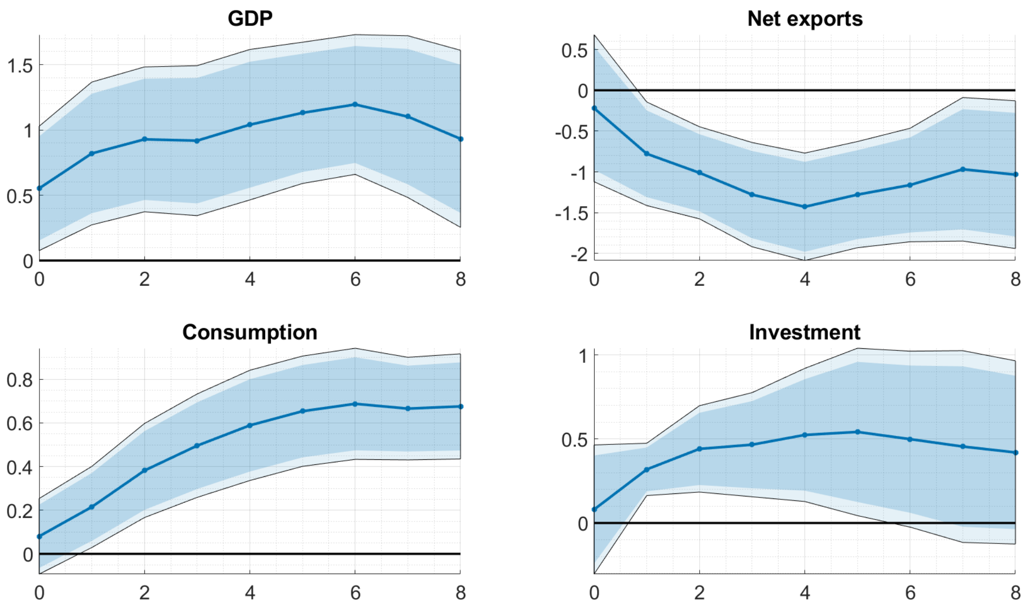
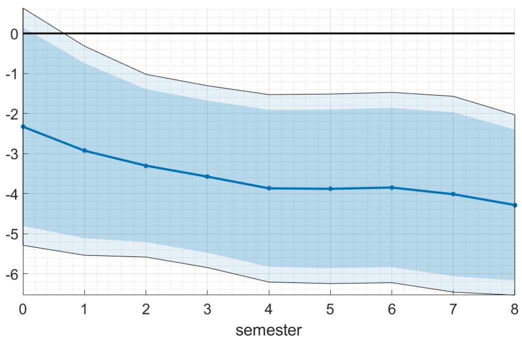
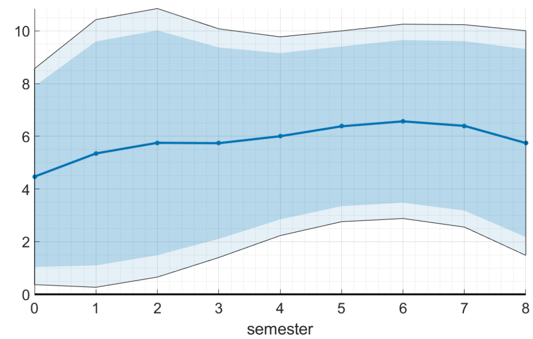


Figure A1: Empirical Government Spending Multipliers: Demand Components

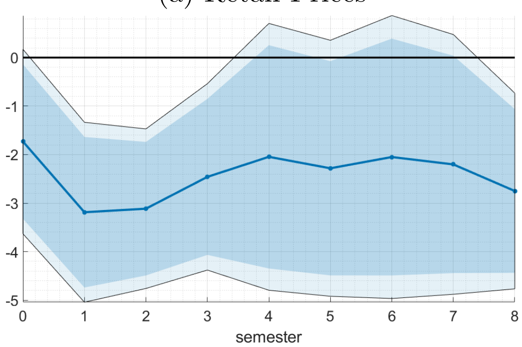
Note: Estimates for GDP, consumption, investment and net exports. See Figure 5 in main article for more details.



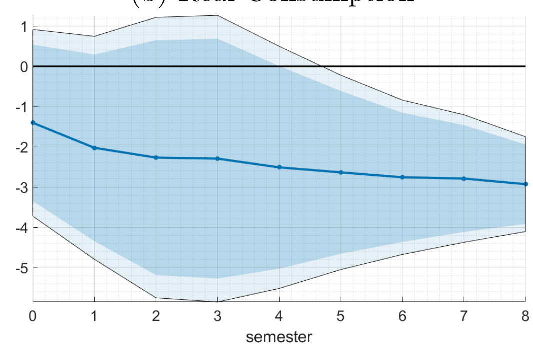
(a) Retail Prices



(b) Real Consumption



(c) GVA deflator



(d) Nominal wages

Figure A2: Empirical Estimated Coefficient on Interaction Term

Note: Figures depict the interaction term coefficient, $\hat{m}_h$, for four different regressions: (a) product-level regression of retail prices, (b) product-level regression of real consumption, (c) industry-level regression of GVA deflators and (d) industry-level regression of nominal wages. The regression for (a) and (b) is specified in (A.4) and the regression for (c) and (d) is specified in (A.5). 90 percent and 95 percent confidence intervals are displayed, based on Driscoll-Kraay standard errors clustered at the country and time level.

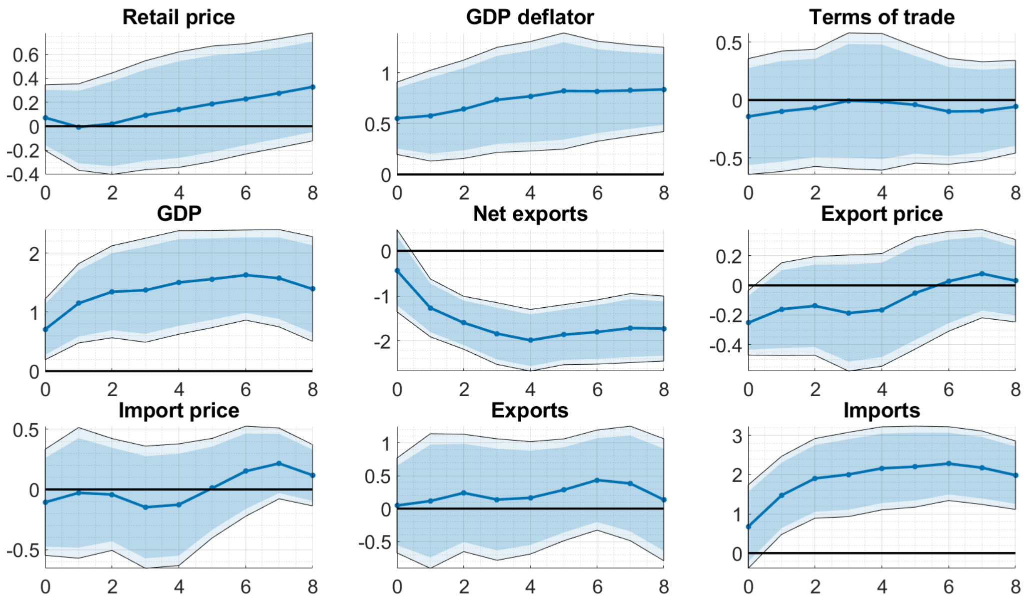
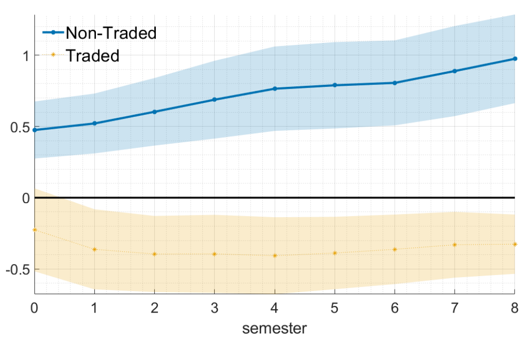
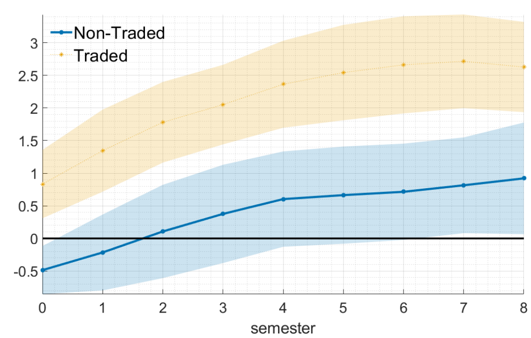


Figure A3: Empirical Government Spending Multipliers: Not Controling for Consumption Taxes

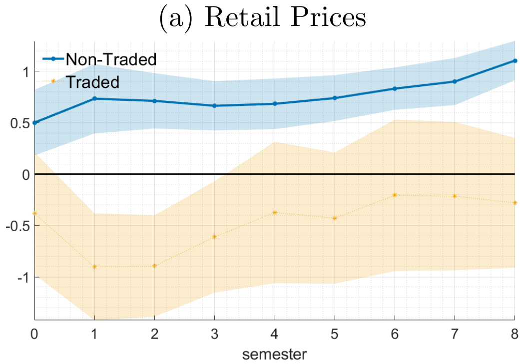
Note: Estimates without controling for consumption tax rate. See Figure 5 in main article for more details.



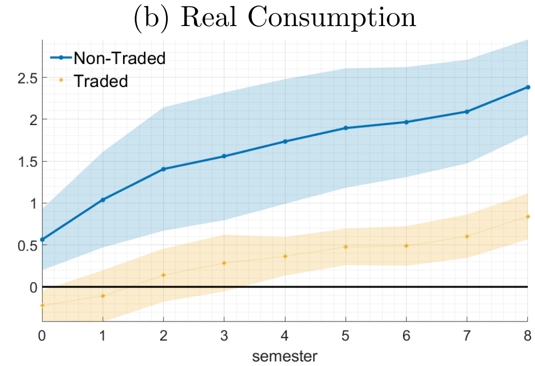
(a) Retail Prices



(b) Real Consumption



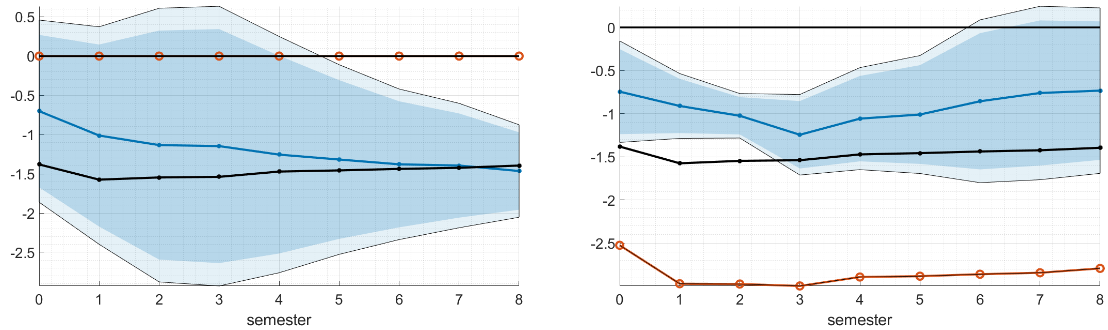
(c) GVA Deflator



(d) Nominal Wage per Employee

Figure A4: Empirical Multipliers at the Product and Industry Level: Not Controling for Consumption Taxes

Note: Estimates without controling for consumption tax rate. See Figures 6 and 7 in main article for more details.



(a) Relative Wage (b) Relative Labor

Figure A5: Multipliers at the Industry Level: Relative Wage and Labor Response

Note: Response of relative wages and relative labor to a government spending shock. Panels display the estimated coefficient for a non-traded good ($\widehat{M}_h$) and a good with an export share of 50% (calculated as the linear combination of the estimated coefficients $\widehat{M}_h + 0.5 \times \widehat{m}_h$). The figure also displays the implied response by the baseline model (black line) and a model variant with perfect labor mobility (red line with circles). The model response is calculated as the response of the wage (labor) in the traded sector relative to the response of the wage (labor) in the non-traded and distribution sector.

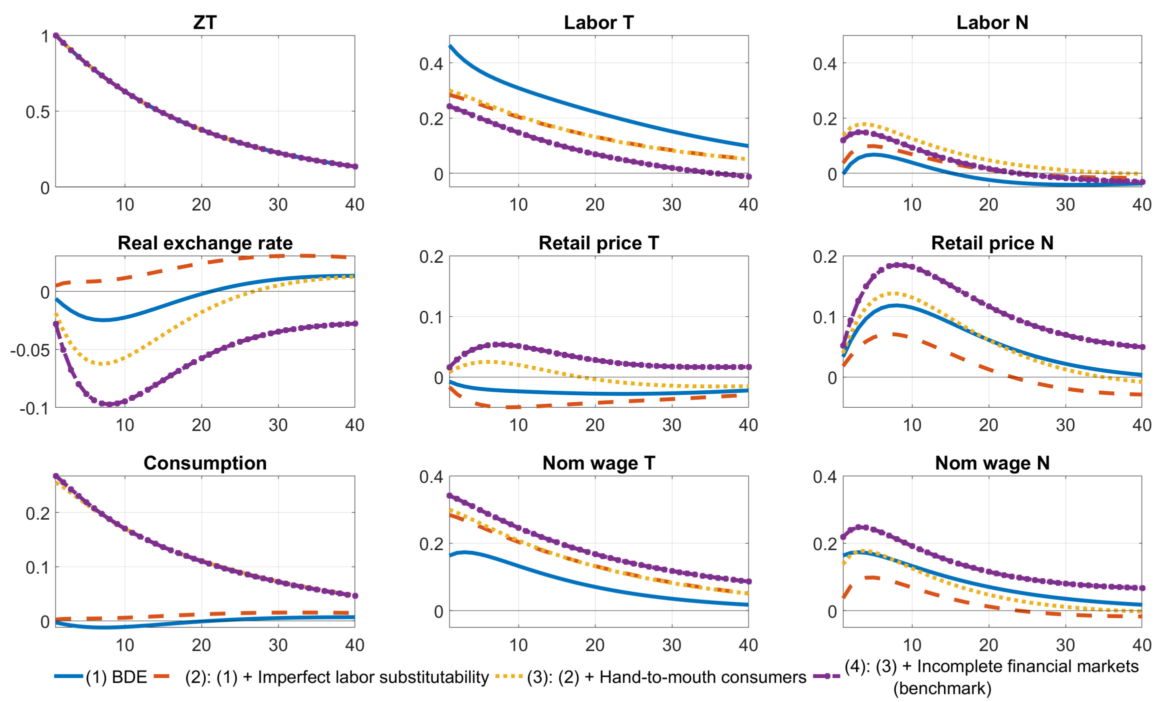


Figure A6: IRF to Shock in Traded-Good TFP

Note: The figure displays impulse response to a 1 percent increase in traded-good TFP (z_T). The first calibration (1), dubbed 'BDE', assumes that labor is perfectly substitutable across sectors ($\xi = 0$), that there are no hand-to-mouth consumers ($\chi = 0$) and that financial markets are complete. The following three calibrations add, one at a time, imperfect labor substitutability ($\xi = \frac{1}{\eta}$)), hand-to-mouth consumers ($\xi = 0.5$) and incomplete financial markets. The last model variation (4) corresponds to our benchmark calibration.