Impact of Some Tax Policies in a Currency Union: A DSGE analysis

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Abstract

Dealing with ageing and reducing the level of public deficit in most of the European countries will induce a increasing taxation rate and/or a shift in the type of taxation. The more recent experience is January 2007 3 points TVA increase in Germany.

Simple DSGE models show that, facing a VAT rate increase, the ability of firms to smooth the effects on prices and the design of monetary policy dramatically changes the pattern of consumption and output in the country. Simulation of in a two countries currency union model address spillovers effects of different tax policies.

1 Introduction

The analysis of tax policies has traditionally two pillars : the micro and the macro. From the micro perspective, taxation has large impact on allocation of resources and redistributive effects (for instance, Boeters et al. (2006) evaluates the long term impact of the last German tax reform) and a very large literature on optimal taxation deals with those issues. From the macro perspective, changing the fiscal stance affects the aggregate demand and supply, prices and output in the short run. There is now a growing 'policy oriented' literature aiming to close the gap between the two approaches. It is traditionally based on dynamic general equilibrium models including real and nominal rigidities to reproduce short run stylized facts. A recent contribution is Coenen et al. (2007) who focus on Euro Area wide consumption and labor tax reduction using the model NAWM.[1] In a similar vein, Roeger & in't Veld (2006) estimates the impact f shifting taxation from labor to consumption. Product and labor market reforms that may increase competition or decrease the NAIRU have been also analyzed with the same objective of closing the gap between short term and long term impacts.

The aim of this article is to evaluate the effect of two national fiscal policies : an increase of consumption tax rate (VAT) and an increase of labor taxation (social contributions). Those policies are conduct in order to decrease the public debt (fiscal stance is more restrictive) or two lower an other tax (tax shifting).[2] In a currency union, they may also affect other countries through trade channel (as domestic demand and relative prices are transitionary affected) and financial channel (common interest rate and exchange rate).

We will emphasize the role of differentiated price setting at the product level on the dynamic of the economy and the ability of the central bank to mitigate the short run impact of consumption tax increase. The extremely large literature on nominal price stickiness have not yet consider the case of the dynamic effect of changing the wedge between producer (excluding of taxes) price and consumer (including taxes) price. Macroeconomic dynamic may crudely depends on which of the two prices is sticky. There is little evidence that every industry chooses the same "price strategy": as a matter of fact, a share of goods is producer price sticky (PPS) and an other share consumer price sticky (CPS). We bring some evidence in favor of a producer price sticky share around 3/4 in the consumption bundle (i.e. the contemporaneous impact of VAT increase on consumer price is only 1/4).

[1] They estimate the impact of a large reduction of overall taxation in the Euro Area. This is not our benchmark forecast.

[2] The two measures may be packed in a "social VAT" (lowering social contribution compensate with a value added tax increase) as it has been projected in France.

The government withholds taxes (VAT identified as a consumption tax, social contributions and a lump-sum tax on households). VAT and social contribution rates are the tax policy instrument. The monetary policy set the interest rate according to a Taylor rule.

The first section presents the closed economy model populated by ricardian households and introduce the 'pricing-to-tax' framework and assess long-term effect of tax policies. The second part deals with the challenge faced by monetary authority after a consumption tax increase. The third section assess spillovers in the case of national tax policies in a common currency area and the last section conclude. The model extensions due to openness is left in appendix.

2 A closed ricardian economy model

The economy consists of infinite planning horizon households, PPS firms, CPS firms producing differentiated goods, a government that levies taxes on consumption (rate τ_{c}), wages (rate τ_{h} for the employees' share and rate τ_{f} for the employers' share) and purchases goods (public expenditures G) and a monetary authority setting the short term nominal interest rate following a 'simple rule'.

2.1 Households

At each period, the representative household sells labor service (hours h_t) and rent capital stock inherited from the previous period (K_{t-1}) to firms. He receives hours compensation $W_t^h\ h_t$, capital compensation $RK_t\ \mathrm{K}_{t-1}$ and dividends D_t from firms and unions. He consumes C_t, pays lump sum taxes Tax_t, invests I_t and accumulate short term bonds B_t. His budget constraint is given by[3]

$$CP_tC_t + IP_tI_t + \mathrm{B}_t = W_t^h h_t - \mathrm{Tax}_t + RK_tK_{t-1} + D_t + (1+i_{t-1})\mathrm{B}_{t-1} \tag{1}$$

The intertemporal utility of the representative household depends on his consumption and his hours supply. Utility exhibits external consumption habits (Catch-up with the Jones) which are driven by the parameter b.

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t - b\overline{C}_{t-1}, h_t) \qquad \text{where} \qquad U(C,h) = \left[\frac{C^{1-\rho}-1}{1-\rho} - \kappa\frac{h^{1+\zeta}}{1+\zeta}\right]$$

[3]The subscript always refers to the date the variable has been set.

Capital accumulation suffers adjustment costs when investment rate goes far away the stationary or the previous period investment rate.[4]

$$K_t = \Phi_t\left(\frac{I_t}{K_{t-1}}\right)K_{t-1} \quad \text{where} \quad \Phi_t(x) = 1-\delta+x-\frac{\varphi_1}{2}(x-\delta)^2-\frac{\varphi_2}{2}\left(x-\frac{I_{t-1}}{K_{t-2}}\right)^2$$

Let λ_t the marginal utility of current period consumption, mrs_t the marginal rate of substitution between consumption and leisure and q the Tobin's marginal q. Household's optimal behavior implies the following conditions:

$$\lambda_t = (C_t - bC_{t-1})^{-\sigma}$$

$$1 = \beta(1+i_t)\mathrm{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\frac{1}{1+\pi^c_{t+1}}\right\}$$

$$q_t = \beta\mathrm{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\left[\frac{RK_{t+1}}{CP_{t+1}}+q_{t+1}\left(\Phi_{t+1}\left(\frac{I_{t+1}}{K_t}\right)-\Phi'_{t+1}\left(\frac{I_{t+1}}{K_t}\right)\frac{I_{t+1}}{K_t}\right)\right]\right\}$$

$$\Phi'_t\left(\frac{I_t}{K_{t-1}}\right)q_t = \frac{IP_t}{CP_t}$$

$$\text{mrs}_t = \kappa\frac{{h_t}^\zeta}{\lambda_t}$$

2.2 Labor market, unions and wage stickiness

We assume that hours of different households are perfect substitute, but firms can't directly use it as an input of production. Unions aggregate households hours in labor service and sell it to firms. There is a continuum of unions ($u \in [0,1]$), $h(i,u)$ is the hours supplied by household i to union u. The quantity of labor supplied by union u to firms is $\ell(u) = \int h(i,u)di$ (one for one technology). Let $W(u)$ the price of labor service set by union u. The overall labor in economy, the aggregate price of labor and the demand for union u labor service have the traditional form:

[4] In the expression of Φ, the ratio investment to capital is common for all households and is not a control variable of the household.

$$L^{\frac{\theta_w-1}{\theta_w}} = \int \ell(u)^{\frac{\theta_w-1}{\theta_w}} du \qquad W^{1-\theta_w} = \int W(u)^{1-\theta_w} du \qquad \ell(u) = \left(\frac{W(u)}{W}\right)^{-\theta_w} L$$

Unions set wages in a Calvo framework where μ_w is probability not to re-optimize the wage. When it occurs, unions optimization targets the following profit :

$$\mathbb{E}_t \sum_{j=0}^{\infty} (\beta\mu_w)^j \lambda_{t+j} \left((1-\tau_{\mathrm{h}}) \frac{W_{t+j}(u)}{CP_{t+j}} - mrs_{t+j} \right) l_{t+j}(u)$$

Non re-optimising unions set wages by following a simple indexation rule on past wage inflation and consumer price inflation: $\left(1+\pi^w_{t-1}\right)^{\nu^1_w} \left(1+\pi^c_{t-1}\right)^{\nu^2_w}$ with $0 \leq \nu^1_w + \nu^2_w \leq 1$.

Appendix A gives the first order condition for wage setting.

2.3 Firms

The production sector is traditional except for price setting. There is a continuum ($n \in [0,1]$) of firms producing $y(n)$ and divided in two sectors. Firms of the first sector ($n \in [0,N]$) set a sticky excluding of taxes price $P^e(n)$, firms of the second sector ($n \in (N,1]$) set a sticky including taxes price $P^i(n)$ (we will omit the e and i superscripts when no confusion is possible). The production and the price level of each sector are define by:

$$Y^{e\,\frac{\theta_p-1}{\theta_p}} = \int_0^N y(n)^{\frac{\theta_p-1}{\theta_p}} \mathrm{d}n \qquad Y^{i\,\frac{\theta_p-1}{\theta_p}} = \int_N^1 y(n)^{\frac{\theta_p-1}{\theta_p}} \mathrm{d}n$$

$$P^{e\,1-\theta_p} = \frac{1}{N} \int_0^N P(n)^{1-\theta_p} dn \qquad P^{i\,1-\theta_p} = \frac{1}{1-N} \int_N^1 P(n)^{1-\theta_p} dn$$

2.3.1 Production function and factor demand

Firm n employs capital $k(n)$ and labor $l(n)$ in a Cobb-Douglas production function with labor productivity common to all firms. Production and marginal costs are given by:

$$y(n) = (A\, l(n))^{\alpha} k(n)^{1-\alpha} \qquad MC = \left(\frac{1}{A\alpha}\right)^{\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left[W_t(1+\tau_{\mathrm{f}})\right]^{\alpha} RK_t^{1-\alpha}$$

Labor and capital demands are given by:

$$l(n) = \alpha \left(\frac{W(1+\tau_{\text{f}})}{MC} \right)^{-1} y(n) \qquad k(n) = (1-\alpha) \left(\frac{RK}{MC} \right)^{-1} Y(n)$$

2.3.2 Profits and price setting

Let D^e and D^i demand addressed to each sector. The demand for the good of a firm n is:

$$d(n) = \frac{1}{N} \left(\frac{P(n)}{P^e} \right)^{-\theta_p} D^e \text{ if } n \in [0, N] \qquad d(n) = \frac{1}{1-N} \left(\frac{P(n)}{P^i} \right)^{-\theta_p} D^i \text{ if } n \in (N, 1]$$

Profits of firm n is:

$$\Pi(n) = (P(n) - MC)\, d(n) \text{ if } n \in [0, N] \qquad \Pi(n) = \left(\frac{P(n)}{1+\tau_c} - MC \right) d(n) \text{ if } n \in (N, 1]$$

For both firm, we assume calvo-style sticky price setting where, each period, a share $1-\mu_p$ of firms re-optimize prices. Let π^{sect} the inflation rate of the sector specific price, non optimizing firms simply follow and indexation rule $(1+\pi^{sect})^{\nu_p}$with $0 \leq \nu_p \leq 1$. Re-optimizing firms choose $\tilde{P}_t(n)$ to maximize the following objective functions, depending on the sector the firm belongs to:

$$E_t \sum_{j=0}^{\infty} (\beta \mu_p)^j \lambda_{t+j} \frac{P_{t+j}(n) - MC_{t+j}}{CP_{t+j}} \left(\frac{P_{t+j}(n)}{P^e_{t+j}} \right)^{-\theta_p} D^e \quad \text{where} \quad P_{t+j}(n) = \tilde{P}_t(n) \left(\prod_{k=1}^{j} \pi^e_{t+k-1} \right)^{\nu_p}$$

$$E_t \sum_{j=0}^{\infty} (\beta \mu_p)^j \lambda_{t+j} \frac{\frac{P_{t+j}(n)}{1+\tau_c} - MC_{t+j}}{CP_{t+j}} \left(\frac{P_{t+j}(n)}{P^i_{t+j}} \right)^{-\theta_p} D^i \quad \text{where} \quad P_{t+j}(n) = \tilde{P}_t(n) \left(\prod_{k=1}^{j} \pi^i_{t+k-1} \right)^{\nu_p}$$

The first order conditions related to price setting for the two sectors are derived in appendix A.

2.4 Government

2.4.1 Tax and government consumption

The government collect taxes (consumption and labor tax and a lump-sum tax), purchase goods (there is no public sector with production). We assume a kind of inflation rule for the monetary policy (see the next section).

2.5 Equilibrium

The PPS firms supply for a share of consumer demand, for investment and for government purchase. CPS firms only supply a share of consumption. The consumption bundle is define over the two type of goods:

$$C = \left[{\eta_C}^{\frac{1}{\theta}} {C^e}^{\frac{\theta-1}{\theta}} + (1-\eta_C)^{\frac{1}{\theta}} {C^i}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

The consumption price index is define by:

$$CP^{1-\theta} = \eta_C \left[(1+\tau_c)P^e\right]^{1-\theta} + (1-\eta_C){P^i}^{1-\theta}$$

Demand addressed to each sector is:

$$\begin{cases} D^e = \eta_C \left(\frac{(1+\tau_c)P^e}{CP}\right)^{-\theta} C + I + G \\ D^i = \eta_C \left(\frac{P^i}{CP}\right)^{-\theta} C \end{cases}$$

2.6 The steady state

2.6.1 Value added decomposition

Let g the level of public spending (share of production). The level of investment is given by the modified golden rule (assume no growth) $\text{inv} = \frac{\theta_p - 1}{\theta_p} \frac{\delta}{\delta + 1/\beta - 1}(1-\alpha)$. The remainder is consumption at equilibrium.

The valued added (which is equal to production here) is divided according to :

Growth Domestic Product Decomposition

Labor income	net compensation	$\alpha\frac{\theta_p-1}{\theta_p}\frac{1-\tau_h}{1+\tau_f}$
	social contributions	$\alpha\frac{\theta_p-1}{\theta_p}\frac{\tau_f+\tau_h}{1+\tau_f}$
Capital income	profits	$\frac{\theta_p-1}{\theta_p}(1-\alpha)$
	rents	$\frac{1}{\theta_p}$
Taxes and subventions	VAT receipts	$\tau_c\,(1-g-\text{inv})$

2.6.2 The level of taxes and tax wedge

At the steady state, one can infer a relation between marginal rate of substitution and technological parameters and tax rates. Let $\tau_\text{s} = \frac{\tau_\text{h}+\tau_\text{f}}{1+\tau_\text{f}}$

$$\text{mrs} = \alpha A \left(\frac{1-\alpha}{\delta+1/\beta-1}\right)^{\frac{1-\alpha}{\alpha}} \frac{\theta_p-1}{\theta_p}\frac{\theta_w-1}{\theta_w}\frac{1-\tau_s}{1+\tau_c} \tag{2}$$

The revenue of the government is the sum of social contributions, VAT receipts and lump-sum taxes. At the steady state, one can evaluate the level of taxes (share of production) that allows the primary budget balance.

$$\text{tax} = g - \tau_\text{c}\,(1-g-\text{inv}) - \alpha\frac{\theta_p-1}{\theta_p}\tau_\text{s}$$

This allows us to evaluate the impact of fiscal policy (government purchases and tax rates) on the marginal rate of substitution:

$$\frac{1-\tau_s}{1+\tau_c} = \frac{1-g-\text{inv}}{\alpha\frac{\theta_p-1}{\theta_p}}\left[1-\frac{1-\text{inv}-\text{tax}-\alpha\frac{\theta_p-1}{\theta_p}}{1-\text{inv}-\text{tax}-\alpha\frac{\theta_p-1}{\theta_p}\tau_s}\right] \tag{3}$$

If public expenditure g increase and is financed by lump-sum taxes, consumption is reduced but real wage is maintained. The specification of the utility induces more labor supply.

The pattern is different when expenditure increase is financed by consumption tax or wage tax. The marginal rate of substitution reduction lowers labor supply. But the two taxes are not equivalent. As long as the share of compensation in production is lower than $1-\text{inv}-\text{tax}$,

consumption tax is less distortionary than wage tax.[5] This result is easy to understand when $t = 0$ (only distortionary taxation) : contrary to social contribution, consumption tax holds also on monopoly rents and non re-invested profits.[6]

2.7 Calibration

Many parameters have to be calibrated or estimated in the model. Some are relevant for the steady state equilibrium: the part of capital in the production function $(1 - \alpha)$, the part of rents (the mark-up factor) in the economy $1/\theta_p$, the discounted factor β, the depreciation rate of capital δ, the tax rates τ_{vat}, τ_{fsc} and τ_{hsc}. Others are only relevant for the dynamic properties of the model: prices and wage rigidities, investment rigidities, the wage mark-up. We will choose conservative values for all these parameters and focus on the effects of two of them: the part of EoT and IT sticky price goods in the consumption bundle and the part of IT inflation in the monetary policy rule.

Production. The part of capital in production is set to 30%, the price mark-up is 14%, thus, the part of labor in the excluding of tax value added is 60%. The elasticity of substition between the two types of goods is set to 1,6. The depreciation rate of capital is 2,5% per quarter (which implies a share of investment in production of 18%).

Households. The discount factor is set to 0,99 and the habit parameters to 0,8. The intertemporal elasticity of substitution and the elasticity of labor supply are set to 1.35 and the inverse elasticity of labor supply is set to 2.

Government. The VAT rate is set to 15%, firms and households social contribution are set to 5%. The public purchase of goods is set to 15% of production, thus consumption is equivalent to 67% of production. All these parameters have values close to observed one.

2.7.1 How many firms set excluding of tax sticky prices

In the sticky price dynamic model, A key parameter is the share of firms setting excluding of tax prices and enable to re-optimize this price. The estimation of this share is not directly possible as shocks to broad based consumption tax rates are rare events. Carbonnier (2007) estimates that a sectoral VAT rate increase do not shift one for one in price increase in the long run: a positive share of VAT is paid by producers in mark-up reduction. The

[5] In national accounts, this condition is always verified.

[6] When tax = 0, the condition is equivalent to investment is smaller than the capital share in income or to dynamic efficiency.

experiment is not directly comparable to broad-based VAT increase as relative prices of goods are not remain constant in the long run.[7] This induces more likely margin contests in oligopolistic industries. But it offers a interpretation of CPS behavior in some industries: firm competition and industrial organization is probably connected to price behavior in the short run.

We calibrate the share of CPS in the consumption bundle using observed consumer price data at a disaggregated level during the January 2007 episode in Germany. Consumer price index is decomposed into 122 sub-index (see annex for item decomposition and weight in the overall price level index). One can rearrange those items in three categories:

- all products are taxed with the normal rate and see an increase of 3 points
- some products are taxed with the normal rate and some products are taxed with an other rate
- no product is taxed with the normal rate

Each sub-index is filtered to exclude seasonal component using TRAMO-SEAT (see appendix). Among the first category (that cover 46 % of the consummer price index), an item is said "excluding of tax sticky" if the price increase between December 2006 and January 2007 more than 1,5 % (the mechanical increase is 2.6%). This approach is clearly unsatisfactory as price index have trends related to sectoral productivity and cost of inputs and other shocks influencing the price dynamic. Our goal is to make a simple estimation of the EoT sticky price firm share in the consumption bundle, we supply some evidence of dual pricing behaviour in the appendix.

Using this definition, only 15 % of firms are excluding of tax sticky. As the model is quarterly, We extend the definition to items where index increase is over 1.5 % between 2006Q4 and 2007Q1. With this new definition, the share of excluding of tax sticky price firms is 25 %. In the rest of the paper, we keep the 1/4 share as the central share but will make some robustness analysis.

[7] Firms may invest in cost reduction or modify the quality of the product to maintain relative prices.

3 Tax policy and monetary policy

3.1 Introduction

In most countries, the tax system is a rigid institution. VAT rate shifts are rare events : two increases in 15 years in Germany. Social contribution rates are also not frequently modified. Comparing to other kind of shocks occurring more frequently (productivity, demand, etc.), tax shocks are far from the normal law. Thus, computing an optimal monetary policy in a time-less perspective[8] with a large structure of shocks seems not really relevant. This section is looking at simple monetary policy rules able to reproduce, as far as it is possible, the fully flexible wage and price dynamic following a permanent increase of VAT rate.

A consumption tax increase modifies relative prices in the economy. As long as nominal rigidities constraint the dynamic, firms and households face inefficient mark-up and relative price evolutions. In our framework, four types of inefficiencies appear: the level of the real interest rate, the level of real wage, the relative price of EoT and IT products and the dispersion of wages and prices due to the inflation dynamic in the Calvo framework. The distortion in the relative price between the two types of firms can not be addressed by the monetary policy : as she operates on marginal cost (and price setting) of every firm in the same way, the central bank can not influence this relative price. As a matter of fact, from the monetary policy point of view, the real interest rate distortion prevails among inefficiencies induced by nominal rigidities.

The central bank is, by assumption, unable to know which price is sticky at the product (or firm) level: she can't observe π^i and π^e. Therefore, we restraint the choice of the central bank to simple rules based on headline inflation (including tax consumption price inflation) and producer price inflation (excluding of tax consumption price inflation); the two series differ only the period of tax increase. The central bank has to wonder only about the size of the interest rate increase the first period and follows her business-as-usual rule other periods.

3.2 Looking for (near) optimal monetary policy

As ricardian equivalence holds, the debt of government plays no role and one can assume that the government budget is balanced each period (which is obtained by the lump-sum tax). In the long run, a consumption tax increase weights on the real wage: production is lowered due to labor supply effects of increasing the distortion of the tax system. Two opposite factors

[8] See Woodford (2003) for the definition and Juillard & Pelgrin (2007) for computational of those policies.

drive the consumption in the short run when prices and wages are fully flexible. On the one hand, households expect a lower production in the long run, a lower permanent income and decrease their consumption. On the other hand, the real interest rate decreases and enhances consumption in short run. Without any consumption habits, the real interest rate channel dominates and the consumption increases in the short run. The presence of habits make the consumption smoothly decrease to his new long term value (see dot line in figure 1).

Including price and wage rigidities modify the dynamic effect of a VAT increase on real rates and consumption. Main mechanisms will appear more clearly if we make extreme assumption on the share of EoT sticky price firms in the economy.

If all the consumption lies on IT sticky price goods ($\eta_C = 0$), the consumption price level increases smoothly after a consumption tax rate upswing (between 6 and 8 quarters in the simulation). The consumption dynamic will depends on the share of producer price inflation in the monetary policy rule. If this share is high, the nominal interest rate decreases at period 1, stimulating consumption. For intermediate level of this share, consumption decreases the first period but less than in the fully flexible wage and price benchmark (see figure 1).

If all the consumption lies on excluding of tax sticky price goods ($\eta_C = 1$), the consumption price level has a one shot increase the first period. If the monetary policy reacts to (including of tax) consumer price inflation, nominal interest rates rises suddenly and consumption decreases deeply in the short run. If the monetary policy reacts to (excluding of price) consumer price inflation, nominal rates is almost constant and consumption has a dynamic closer to the benchmark case.

Two conclusions emerge from this analysis. First, optimal monetary policy should always target the sticky price. This result is in line with Benigno (2004).[9] In our framework, the weights of producer price and consumption price inflation in the monetary rule should be equal to the share of IT and EoT sticky-price firms in the consumption bundle. But this "simple rule" has to be refined. There is a bias in favor of the consumption price. In our benchmark where 1/4 of PPS firms, the optimal simple rule is given by a share around 1/5 of producer price inflation in the monetary policy rule. (see figure 2). This bias is robust to many parameter values (wage stickiness, intertemporal elasticity of substitution, etc.).

[9]He assumes a common monetary policy for two countries with heterogeneous price stickiness.

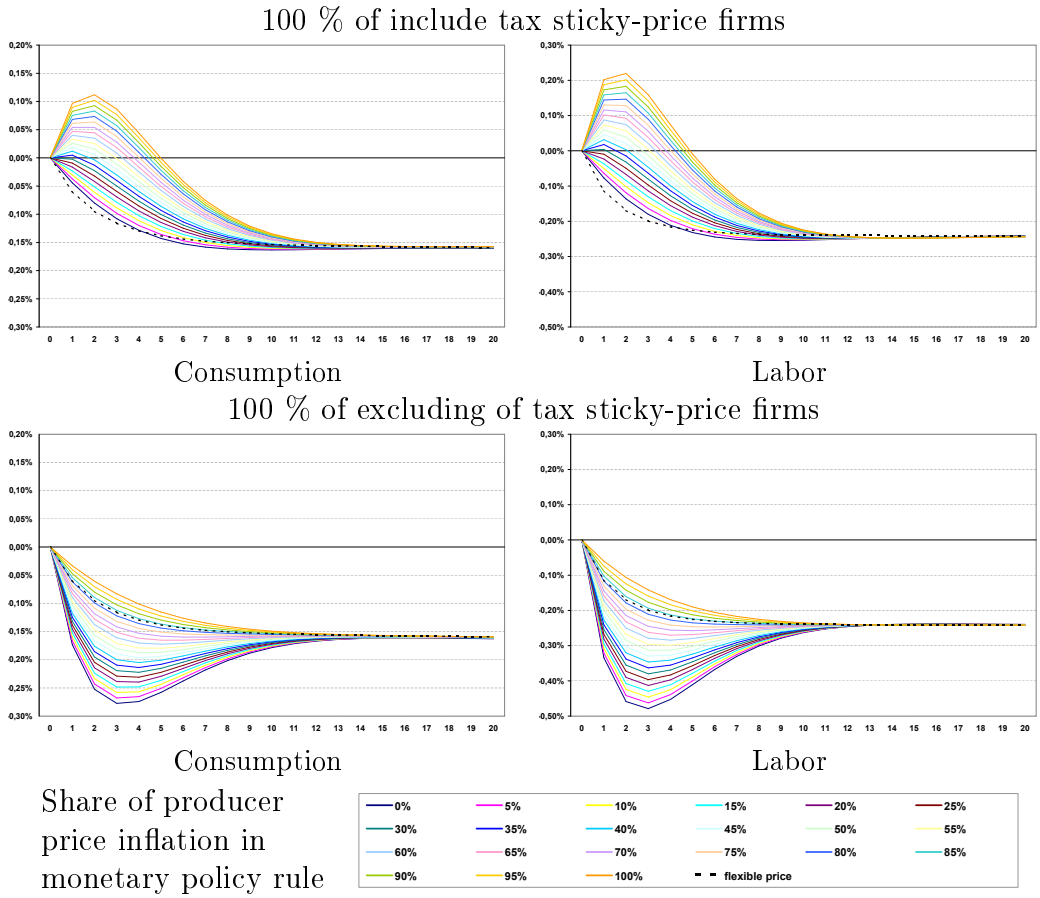
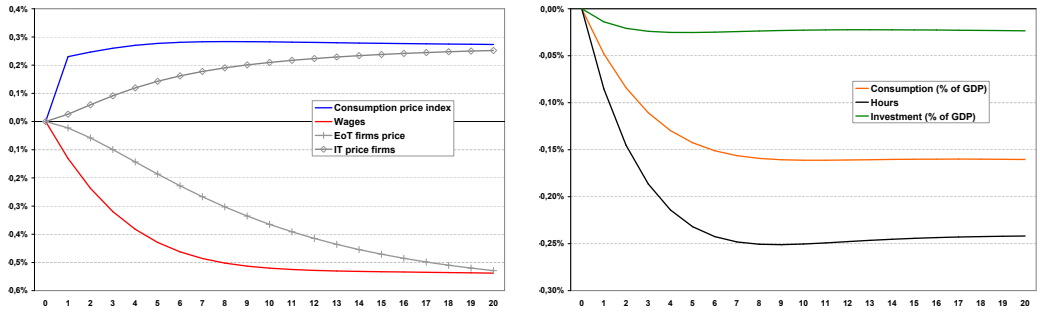


Figure 1: Consumption tax increase in a fully ricardian closed economy



$$i = i_0 + 0.65 * i(-1) + 0.35 * 2 * (0.2\pi + 0.8\pi^c)$$

Figure 2: Consumption tax increase with 1/4 of PPS firms

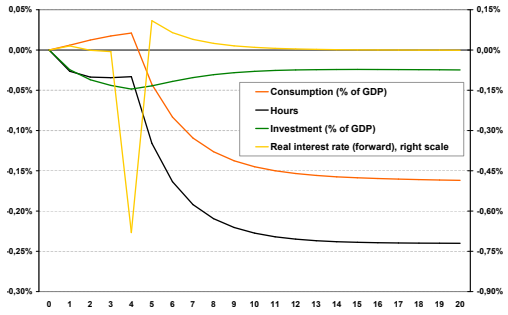


Figure 3: Consumption tax increase announced one year before, flexible prices

3.3 Pre-announcement of the policy

Without any nominal rigidity, an unanticipated value added tax increase is almost neutral on the capital accumulation in the short run: investment smoothly adjusts at is new steady state value. It is no more the case when the policy is announced before implementation because the real interest rate goes down the period just before the tax increase. As households perfectly forecast a higher consumption price tomorrow, they consume earlier and capital stock drops before the policy implementation and catch-up after the tax increase (see figure 3).

The pre-announcement of the policy puts the monetary authority in trouble. How far the monetary policy is able to accommodate the nominal rigidities inefficiencies following a simple rule depends on the share of EoT sticky-price firms. If this share is close to 1, the optimal monetary policy can be implemented with 75 % of producer price inflation in the monetary policy rule. If this share is too low, the real interest rate dynamic can't be reproduce by a simple rule: as headline inflation stay low the period of the tax increase (period 5), the forward interest rate the period before (period 4) can't drop, except if the central bank cuts rates and increases them on period 5 (see figure 4). In our calibration with 1/4 of PPS firms, the nominal interest rates cut on period 4 should be around 175 basis points, despite growing inflationary pressures (see figure 5).[10]

[10]There are also financial reasons to prefer low interest rate volatility and to reject this kind of policy.

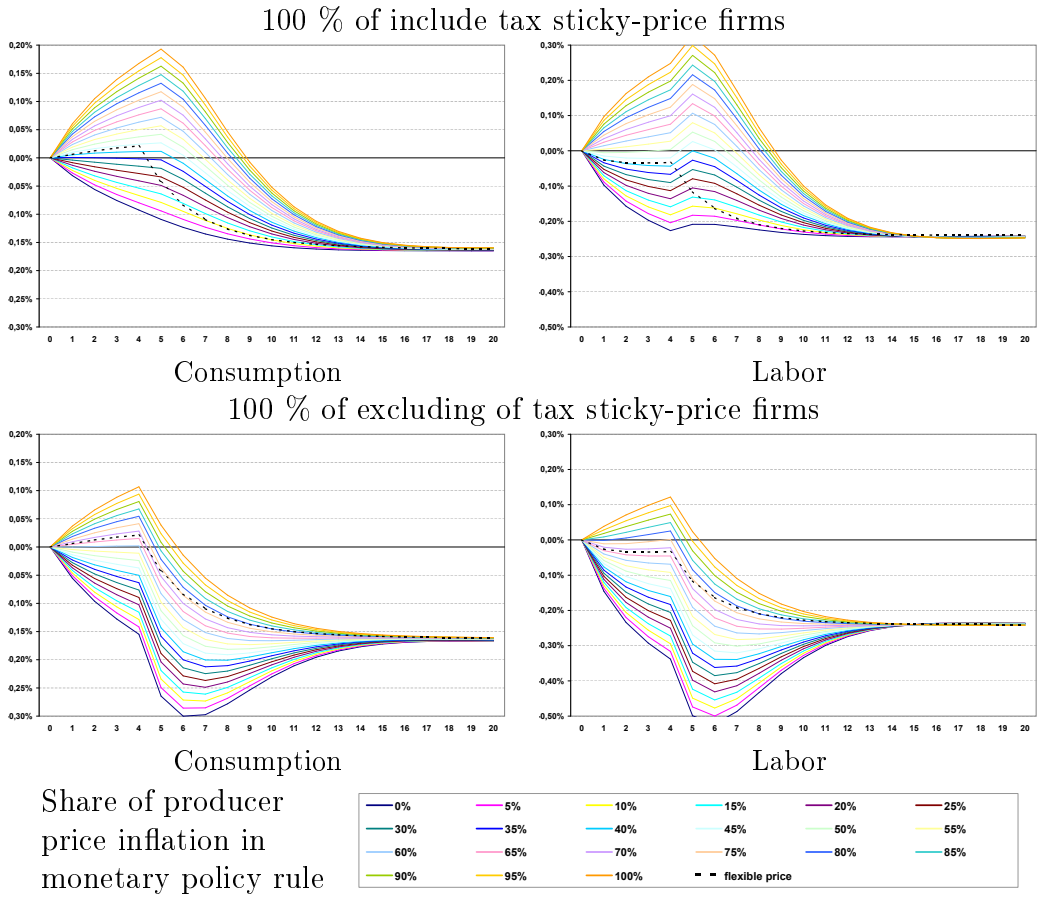
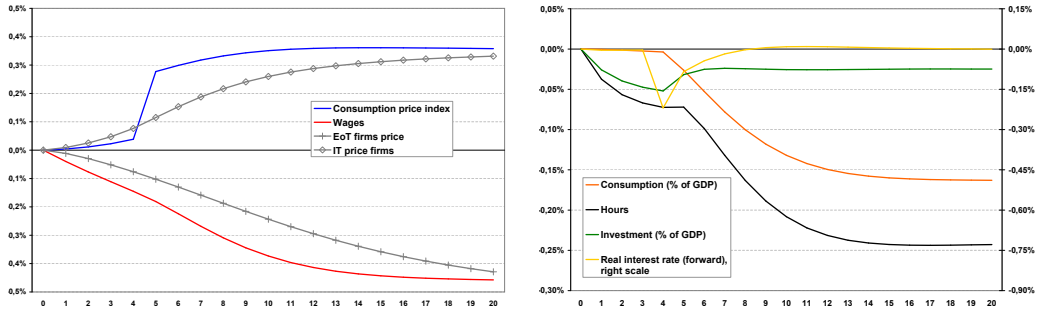


Figure 4: Consumption tax increase in a fully ricardian closed economy



$$i = i_0 + 0.65 * i(-1) + 0.35 * 2 * (0.4\pi + 0.6\pi^c)$$

Figure 5: Consumption tax increase announced one year before with 1/4 of PPS firms

4 Three national tax policies in a currency union

4.1 A two countries model

4.1.1 The international structure

The currency union is divided in two parts: one country (implementing the tax policy) and the rest of the Euro Area (REA); we ignore the rest of the world in the model. The two economies share the same structure and differ only by their size. they also share the same nominal interest rate but labor and physical capital markets are segmented. Short term bonds in euro are the only financial asset that is internationally traded (we assume no international risk sharing). Firms are specialized to a segment of the market, some are PPS, others are CPS both for the domestic and the foreign market. Goods are not perfectly substitute and preferences exhibit home bias.

4.1.2 Calibration

The German economy weights 30% of the Euro Area (1999-2005 average). The calibration of trade linkage between Germany and REA requires some statistical treatment. First, we compute the bilateral value added flows between Germany, the rest of the Euro Area and the rest of the world. Products flows (imports and exports) and value added flows differ by large amount when one look at bilateral flows among many countries and particularly for small open economies (processing trade). The methodology is developped in appendix C and shows a 45% overestimation for German↔REA flows if the product-value added correction is ignored. In the second step, one has to choose which degree of openess to keep for Germany and the REA. As we look at spillovers from Germany to the rest of the Euro Area, we ignore trade with the rest of the world : German (value added) openess represents only 10 % of GDP.[11]

4.2 Consumption tax increase

After a 1 point increase in the consumption tax in Germany, monetary policy is almost unresponsive because the area wide inflation stay low, but one see opposite inflation dynamic

[11] This assumption is unsatisfactory: relative prices affects bilateral trade but also relative trade shares with other partners. A two country model is unable to reproduce this kind of feature. We will discuss this point after.

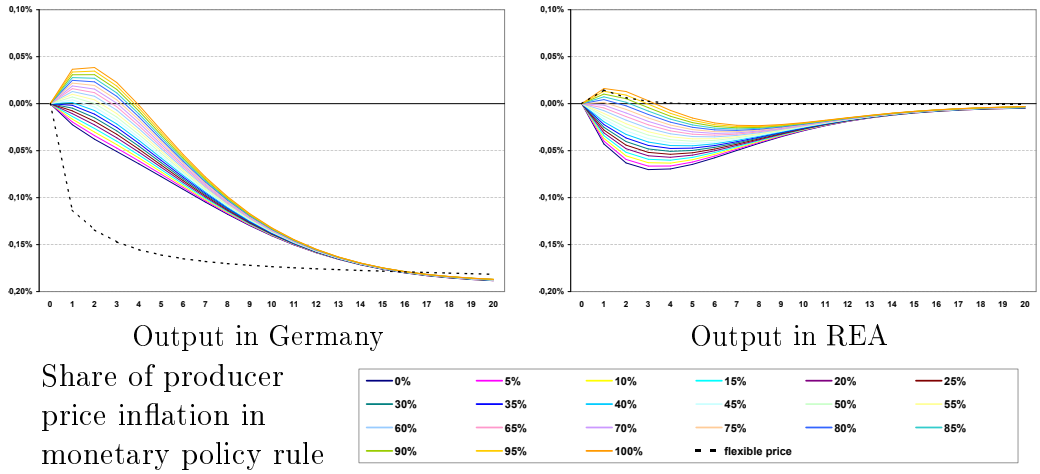
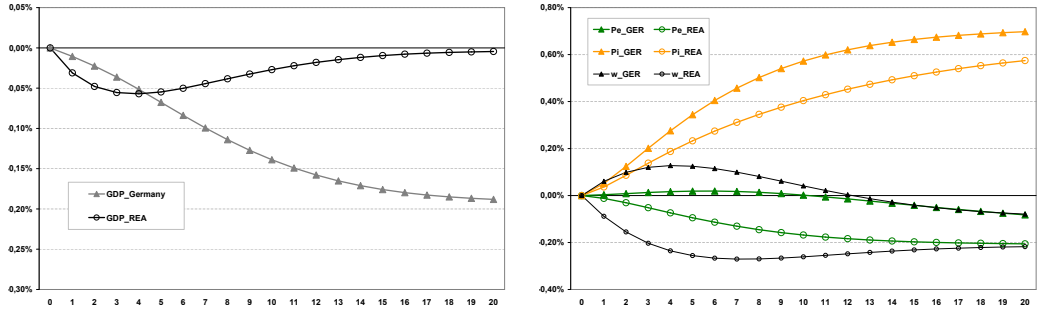


Figure 6: Consumption tax increase with 1/4 of PPS firms

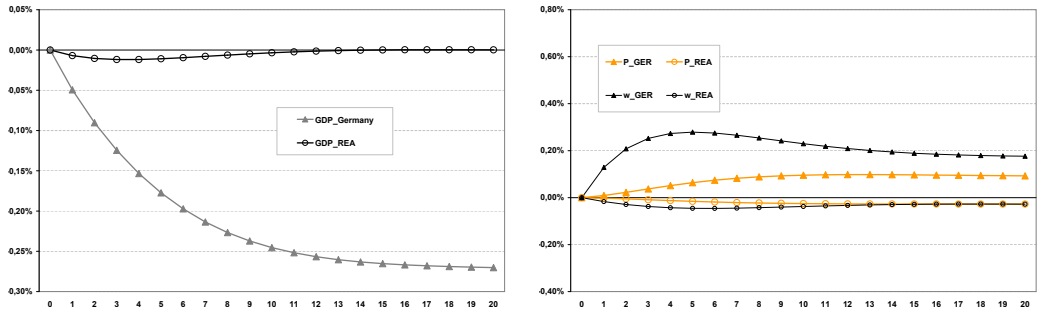


$$i = i_0 + 0.65 * i(-1) + 0.35 * 2 * (0.2\pi + 0.8\pi^c)$$

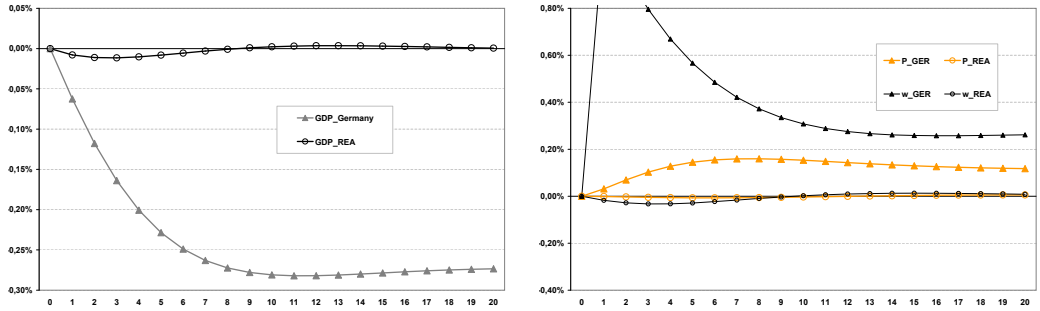
Figure 7: Domestic and external effects of consumption tax increase with 1/4 of EoT sticky price firms

in Germany (where prices go up) and in the REA (where prices go down). The real interest rate is higher in the REA than in Germany instead of being equal like in the flexible price case. In the short run, The rest of the Euro Area share the weight of the German's downturn. The model limits the consumption behavior of households to the traditional Euler equation. Introducing Rule-of-Thumb households (Galí et al., 2007) will produce a more reasonable dynamic of consumption in Germany following a consumption tax increase as the reduction of wages purchasing power diminishes consumption. This modified picture will enhance the spillover effect. Spillovers vanish in the long run when relative price adjustments have occurred (see figure 7).

The monetary authority is not well equipped to accommodate the inconvenience of price rigidities. Whatever the policy rule she follows, the economy stays far from the fully flexible wages and prices equilibrium (see figure 6).



Employers' social contribution



Employees' social contribution

Figure 8: Domestic and external effects of wage tax increase

4.3 Wage tax increase

Figure 8 shows the macroeconomic impact of a wage tax increase in Germany calibrated such that the amount of public expenditure it finances is the same than in the consumption tax increase in the long run (around 0,6% of GDP). Tax rate increase is 1.33 % for employers and 1.21 % for employees.[12] Comparing to consumption tax increase, thoose policies have moderate external effects on the rest of the Euro Area. Even if one takes into account the current income impact on consumption of employees' tax increase, the negative effect is less important than in the case of a VAT increase (including Rule-of-Thumb households will enhance by the same amount the effects in both case). The third market competitive effect in the case of employers' tax increase may reverse the impact on REA GDP (labor cost increase in Germany boosts exports of partners) and wage purchasing power maintains such that current income doesn't depress consumption in Germany.

[12]The result is different if the aim of taxation is to finance pension and unemployement benefits and if the policy maintains the purchasing power of transferts.

4.4 Discussion

Based on the analysis of this simple two countries, the external impact of national tax policies crudely depends on the levies of action. Consumption tax increase may have larger negative effect on partners of the currency union, in particular if a large share of firms delays the impact on consumers. Wage tax increase impacts two a lower extend the rest of the Euro Area.

There is a major concern for countries to shift taxation from labor to consumption: for a constant total amount of taxation, the effect on GDP and welfare is positive (but small) in the long run. How this policy impact the economy in the short run in a closed economy is uneasy to assess. But it seems that a monetary union may enhances the short term positive impact of wage tax cuts and lower the negative impact of consumption tax increase. A currency union modifies the incitation of governments to implement those policies. At the same time, negative spillovers appear and the rest of the currency union inherit the burden of the policy.

5 Conclusion

We propose a framework to analyze the impact of many tax shifts in a currency union. There is some heterogeneity between firms according to the way they set prices. Some of them set an excluding of tax price and the remainder set an including tax price. When prices are sticky, households does not face a unique price even if marginal costs is share among firms. This schedule also impact on inflation dynamic and the response of the monetary policy.

Following a consumption tax increase, a simple monetary policy rule aiming at reproduce the flexible price dynamic has to weight headline inflation and producer inflation (almost) proportionally to the share of including tax sticky firms and excluding of tax sticky firms. However, monetary policy is less equipped to address anticipated consumption tax increase.

In a currency union, national consumption tax policies spill over the rest of the union whereas national wage tax policies are more neutral. The incitation scheme on governments to implement a tax shift from wage to consumption is modified at the expense of the rest of the currency union.

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A Price setting and wage setting

A.1 Price setting

Let $p^{*sect} = \tilde{P}(n)/P^{sect}$. The first order conditions for optimal price setting of excluding of tax sticky price and including tax sticky price firms are:

$$p^{*sect} = \frac{\theta_p}{\theta_p - 1}\frac{\mathcal{X}_t^{sect}}{\mathcal{Y}_t^{sect}}$$

With:

$$\begin{aligned}
\mathcal{X}_t^e &= \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\mu_p)^j \lambda_{t+j} \left(\prod_{k=1}^{j} {\pi_{t+k-1}^e}^{\nu_p}\right)^{-\theta_p} \left(\frac{P_{t+j}^e}{P_t^e}\right)^{\theta+1} \frac{MC_{t+j}}{P_{t+j}^e}\frac{CP_{t+j}}{CP_t} D_{t+n}^e \\
\mathcal{Y}_t^e &= \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\mu_p)^j \lambda_{t+j} \left(\prod_{k=1}^{j} {\pi_{t+k-1}^e}^{\nu_p}\right)^{1-\theta_p} \left(\frac{P_{t+j}^e}{P_t^e}\right)^{\theta} \frac{CP_{t+j}}{CP_t} D_{t+j}^e \\
\mathcal{X}_t^i &= E_t \sum_{j=0}^{\infty} (\beta\mu_p)^j \lambda_{t+j} \left(\prod_{k=1}^{j} {\pi_{t+k-1}^i}^{\nu_p}\right)^{-\theta_p} \left(\frac{P_{t+j}^i}{P_t^i}\right)^{\theta+1} \frac{MC_{t+j}}{P_{t+j}^i}\frac{CP_{t+j}}{CP_t} D_{t+n}^i \\
\mathcal{Y}_t^i &= \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\mu_p)^j \lambda_{t+j} \left(\prod_{k=1}^{j} {\pi_{t+k-1}^i}^{\nu_p}\right)^{1-\theta_p} \left(\frac{P_{t+j}^i}{P_t^i}\right)^{\theta} \frac{CP_{t+j}}{CP_t} \frac{D_{t+j}^i}{1+\tau_c}
\end{aligned}$$

The four expressions can be defined recursively (see Schmitt-Grohe & Uribe (2005)):

$$\begin{aligned}
\mathcal{X}_t^e &= \lambda_t^{ric} \frac{MC_t}{P_t^e} D_t^e + \beta\mu_p \mathbb{E}_t \left\{ \frac{\left(\pi_t^e\right)^{-\nu_p\theta_p} \left(\pi_{t+1}^e\right)^{\theta_p+1}}{\pi_{t+1}} \mathcal{X}_{t+1}^e \right\} \\
\mathcal{Y}_t^e &= \lambda_t^{ric} D_t^e + \beta\mu_p \mathbb{E}_t \left\{ \frac{\left(\pi_t^e\right)^{\nu_p(1-\theta_p)} \left(\pi_{t+1}^e\right)^{\theta_p}}{\pi_{t+1}} \mathcal{Y}_{t+1}^e \right\} \\
\mathcal{X}_t^i &= \lambda_t^{ric} \frac{MC_t}{P_t^i} D_t^i + \beta\mu_p \mathbb{E}_t \left\{ \frac{\left(\pi_t^i\right)^{-\nu_p\theta_p} \left(\pi_{t+1}^i\right)^{\theta_p+1}}{\pi_{t+1}} \mathcal{X}_{t+1}^i \right\} \\
\mathcal{Y}_t^i &= \lambda_t^{ric} \frac{D_t^i}{1+\tau_c} + \beta\mu_p \mathbb{E}_t \left\{ \frac{\left(\pi_t^i\right)^{\nu_p(1-\theta_p)} \left(\pi_{t+1}^i\right)^{\theta_p}}{\pi_{t+1}} \mathcal{Y}_{t+1}^i \right\}
\end{aligned}$$

A.2 Wage setting

Let $w^* = \tilde{W}(u)/W$. The first order conditions for optimal wage setting of the union is:

$$w^* = \frac{\theta_w}{\theta_w - 1} \frac{\mathcal{X}_t^w}{\mathcal{Y}_t^w}$$

With:

$$\begin{aligned}
\mathcal{X}_t^w &= \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\mu_p)^j \lambda_{t+j} \left(\prod_{k=1}^{j} \pi_{t+k-1}^{w\,\nu_w^1} \pi_{t+k-1}^{c\,\nu_w^2} \right)^{-\theta_w} \left(\frac{W_{t+j}}{W_t} \right)^{\theta_w} mrs_{t+j} L_{t+n} \\
\mathcal{Y}_t^w &= \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\mu_p)^j \lambda_{t+j} \left(\prod_{k=1}^{j} \pi_{t+k-1}^{w\,\nu_w^1} \pi_{t+k-1}^{c\,\nu_w^2} \right)^{1-\theta_w} \left(\frac{W_{t+j}}{W_t} \right)^{\theta_w - 1} \frac{W_{t+j}}{CP_{t+j}} (1 - \tau_{\mathrm{h}}) L_{t+n}
\end{aligned}$$

The recursive expressions of $\mathcal{X}_t^w$ and $\mathcal{Y}_t^w$ are given by:

$$\begin{aligned}
\mathcal{X}_t^w &= \lambda_t mrs_t L_t + \beta\mu_w \mathbb{E}_t \left\{ \left(\pi_t^{w\nu_w^1} \pi_t^{c\nu_w^2} \right)^{-\theta_w} \left(\pi_{t+1}^w \right)^{\theta_w} \mathcal{X}_{t+1}^w \right\} \\
\mathcal{Y}_t^e &= \lambda_t \frac{(1 - \tau_{\mathrm{h}}) W_t}{CP_t} L_t + \beta\mu_w \mathbb{E}_t \left\{ \left(\pi_t^{w\nu_w^1} \pi_t^{c\nu_w^2} \right)^{1-\theta_w} \left(\pi_{t+1}^w \right)^{\theta_w - 1} \mathcal{Y}_{t+1}^w \right\}
\end{aligned}$$

B Disaggregated price index

The classification of a product on EoT sticky or IT sticky needs an important statistical work. Many price index have seasonal component with time varying coefficients, like clothing, or include administrated prices like electricity (see figure B). We apply the Airline model of seasonal adjustment [ARIMA (0,1,1)(0,1,1)] to all consumption price sub index (in log) for German following European Central Bank (2000), the list of items and their share in the consumption price index is given in table 1.

Many drawbacks limit the ability to classify products in our two categories 'EoT sticky' 'IT sticky'. Some sub index may embody both products; others may embody products taxed at the normal rates and other at an other rate. The price movements reflect many shocks, like production cost, who are not observed, etc. We follow a rule-of-thumb to classify products : a visible break in a time serie at the beginning of year 2007 (modification of a tendency) is attributed VAT increase (material on demand). Better tools will be implemented in further researches based on statistical breakdown identification and comparison of prices with the benchmark of similar countries where no tax increase occurred (Countries of the Euro Area that share a border with Germany).

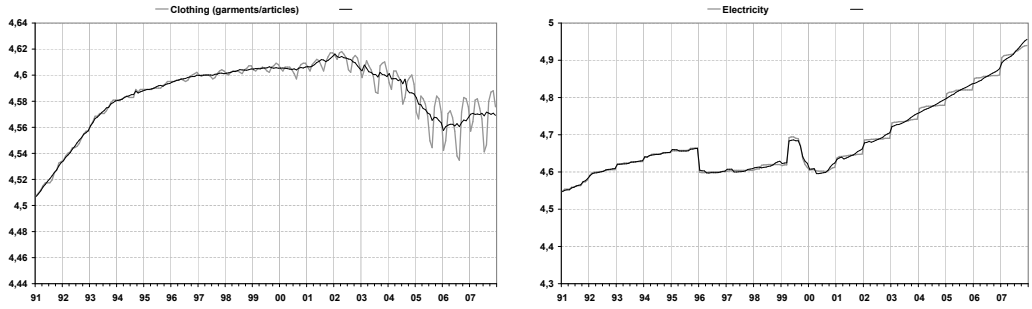
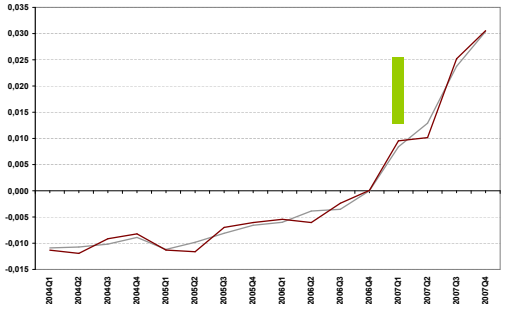


Figure 9: Example of seasonal adjustments

Furniture and furnishing

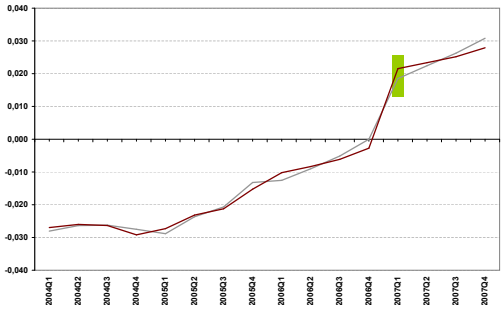
Glassware, tableware and household...

Small electric household appliances

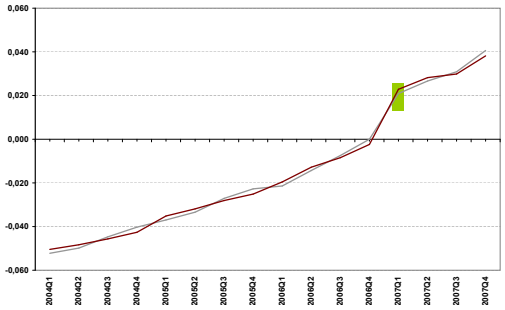


Musical inst. and major durables...

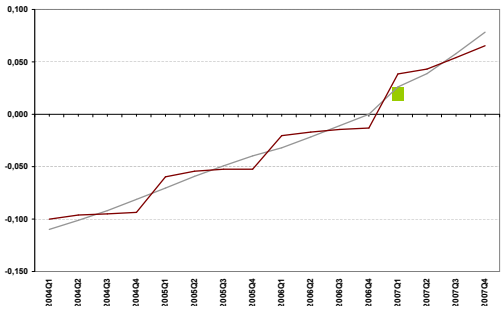
CPS sectors



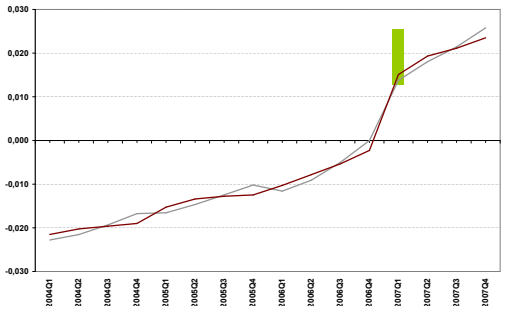
Motor car



Repair and hire of footwear



Electricity



Hairdressing salons and personal..

PPS sectors

Figure 10: How firms set prices

01	Bread and Cereals	1,72
02	Meat	2,27
03	Fish and Seafood	0,29
04	Milk, cheese and eggs	1,43
05	Oils and fats	0,29
06	Fruit	0,84
07	Vegetables	1,06
08	Sugar, jam, honey, chocolate and confectionery	0,76
09	Food product NEC	0,39
10	Coffee, tea and Cocoa	0,45
11	Mineral waters, soft drinks, fruit and vegetables juices	0,83
12	Spirits	0,21
13	Wine	0,49
14	Beer	0,99
15	Tobacco	1,99
16	Clothing (materials)	0,02
17	Clothing (garments/articles)	4,14
18	Other articles of clothing and clothing accessories	0,21
19	Cleaning, repair and hire of clothing	0,13
20	Shoes and other footwear	0,98
21	Repair and hire of footwear	0,04
22	Actual rentals Paid by tenants	21,22
23	Materials for the maintenance and repair of the dwelling	0,65
24	Services for the maintenance and repair of the dwelling	0,50
25	Water supply	1,08
26	Refuse collection	0,65
27	Sewage collection	0,90
28	Other services relating to the dwelling NEC	0,57
29	Electricity	1,87
30	Gas	0,94
31	Liquid fuels	0,79
32	Solid fuels	0,07
33	heat energy	1,04
34	Furniture and furnishings	2,80
35	Carpet and other floor coverings	0,44
36	repair of furniture, furnishings and floor coverings	0,12
37	Household textiles	0,48
38	Major Household appliances whether electric or not	0,81
39	Small electric household appliances	0,21
40	repair of household appliances	0,11
41	Glassware, tableware and household utensils	0,49
42	Major tools and equipment	0,18
43	Small tools and miscellaneous accessories	0,39
44	Non-durables household goods	0,60
45	Domestic services and household services	0,22
46	Pharmaceutical products	1,03
47	Other medical products	0,06
48	Therapeutic appliances and equipment	0,55
49	Medical services	0,66
50	Dental services	0,53
51	Pharmaceutical services	0,16
52	Hospital services	0,56
53	Motor car	3,32
54	Motor cycles	0,23
55	Bicycles	0,18
56	Spare parts and accessories for personal transport equipment	0,54
57	Fuels and lubricants for personal transport equipment	3,41
58	Maintenance and repair of personal transport equipment	2,37
59	Other services in respect of personal transport equipment	1,91
60	Passenger transport by railway	0,50
61	Passenger transport by road	0,19
62	Passenger transport by air	0,24
63	Passenger transport by sea and waterway	0,11
64	Combined passenger transport	0,82
65	Other purchased transport services	0,06
66	Communication	2,52
67	Reception, recording, reproduction sound and pictures	0,68
68	Photographic, cinematographic and optical equipment and instruments	0,20
69	Information processing equipment	0,89
70	Recording media	0,38
71	Repair audio-visual, photographic and info processing equipment	0,12
72	Major durable for outdoor recreation	0,08
73	Musical instruments and major durables for indoor recreation	0,09
74	Games, toys and hobbies	0,33
75	Equipment for sport, camping and open-air recreation	0,30
76	Gardens, plants and flowers	0,77
77	Pets and related products	0,43
78	Veterinary and other services for pets	0,06
79	Recreational and sporting services	0,68
80	Cultural services	1,59
81	Lottery tickets and game of chance	0,61
82	Books	0,67
83	Newspapers and periodicals	0,88
84	Miscellaneous printed matter	0,07
85	Stationery and drawing materials	0,29
86	Package holidays	1,98
87	Education	0,67
88	Restaurant, cafes and other food outlets	3,23
89	Canteens	0,46
90	Accommodation services	0,97
91	Hairdressing salons and personal grooming establishment	0,91
92	Electric appliances for personal care	0,02
93	Other appliances, articles and products for personal cares	1,04
94	Jewelery, clocks and watches	0,46
95	Other personal effects	0,37
96	Social protection	1,03
97	Insurance connecting to the dwellings	0,19
98	Medical insurance	0,89
99	Insurance connected with transport	0,76
100	Other insurance services	0,62
101	Financial services NEC	0,36
102	Other financial services	0,38

Table 1: Share of items in the consumption price index *in %*

C Trade model calibration

The model considers value added trade and not goods and service trade as in international statistics: the flow from a country i to a country j corresponds to the production of the country i which is consume in the country j (households consumption, investment or government purchase). For example, a German Airbus plant that exports to Toulouse a part of the plane which is assembled to the rest of the plane and sell it to British Airlines will appears in official statistics has two flows: an export of goods from Germany to the rest of the Euro Area and an export of goods from the rest of the Euro Area to the rest of the world. In the model accountability, two flows have to be considered: a value added export from Germany to the rest of the world and a value added export from the rest of the Euro Area to the rest of the world; those two flows increase United Kingdom capital stock[13].

Intuitively, value added flows are smaller and don't have the same geographic pattern as goods flows. In order to recreate value added flows from goods flows, we divide goods in three parts: those for final consumption A_i, for exportation X_i and for intermediary consumption IC_i. Let Y_i the total production (including intermediate consumptions), M_i total imports of goods (as in official statistics). The first countable equilibrium is:

$$Y_i + M_i = A_i + X_i + IC_i \tag{4}$$

Assumption 1: Let α and β the part of imports in final consumption and exportation (respectively). The remainder enters in intermediary consumption for domestic consumption.

We assume a complementary factor technology[14]. Those factors are foreign goods (intermediate consumption), domestic goods (intermediate consumption) and production factors (capital and labor) which amount is equal to value added.

$$Y_i = \min\left(\frac{{M_i}^{ic}}{1-\epsilon_i-\gamma_i}, \frac{{Y_i}^{ic}}{\epsilon_i}, \frac{F_i}{\gamma_i}\right) \tag{5}$$

${M_i}^{ic}$ represents the amount of imported goods by i for intermediary consumption uses, ${Y_i}^{ci}$ is total production of country i (including intermediate goods) and F_i is value added. One has:

$$Y_i = \underbrace{{M_i}^{ic} + {Y_i}^{ic}}_{\substack{\text{intermediary} \\ \text{consumptions}}} + F_i$$

For a given level of domestic final demand and exports, production and imports are:

$$Y_i = (1-\alpha_i)A_i + (1-\beta_i)X_i + \epsilon_i Y_i \tag{6}$$

[13] Even if the plane will be used on the Shanghai Tokyo line, the trade model is not in default. The problem comes from the segmentation of factors markets if flight attendants are Chinese.

[14] Which is equivalent to assume constant returns and relative prices.

$$M_i = \alpha_i A_i + \beta_i X_i + (1 - \epsilon_i - \gamma_i) Y_i \tag{7}$$

Assumption 2 The share of imports from country j is independent of the origin of the demand (intermediate consumption, final domestic demand, exports). Les θ_{ij} this share (one has $\sum_{j \neq i} \theta_{ij} = 1$).

We now can evaluate bilateral goods flows and total exports of each area.

$$M_{ij} = \theta_{ij}[\alpha_i A_i + \beta_i X_i + (1 - \epsilon_i - \gamma_i) Y_i]$$

$$X_i = \sum_{j \neq i} M_{ji} = \sum_{j \neq i} \theta_{ji}[\alpha_j A_j + \beta_j X_j + (1 - \epsilon_j - \gamma_j) Y_j]$$

One can reorder terms:

$$X_i - \sum_{j \neq i} \theta_{ji} \beta_j X_j = \sum_{j \neq i} \theta_{ji}[\alpha_j A_j + (1 - \epsilon_j - \gamma_j) Y_j]$$

We now have the three following equations that allow to evaluate value added flows :

$$(I - \Theta' D_\beta) X = \Theta' \left[D_\alpha A + (I - D_\epsilon - D_\gamma) Y \right] \quad \text{(exports)} \tag{8}$$

$$(I - D_\epsilon) Y = (I - D_\alpha) A + (I - D_\beta) X \quad \text{(demand)} \tag{9}$$

$$F = D_\gamma Y \quad \text{(supply)} \tag{10}$$

We develop the calculus in the case where domestic demand and exports don't command any imports ($\alpha = \beta = 0$):

$$\left[I - D_\epsilon - \Theta'(I - D_\epsilon - D_\gamma) \right] {D_\gamma}^{-1} F = A \qquad \text{or} \qquad F = \Omega A$$

With A and ΩA the matrix of value added consume and product (respectively).

$$\underbrace{F_i}_{\text{value added producted in } i} = \underbrace{w_{ii} A_i}_{\text{consumed domestically}} + \underbrace{\sum_{j \neq i} \omega_{ij} A_j}_{\text{exported}}$$

Exports of value added from i to j are equal to $\omega_{ij} A_j$

Remarks. Trade balances of bilateral goods flows and bilateral value added flows are exactly the same as total imports and total exports are diminish by the same amount. Total exports of value added is smaller that total exports of goods and the geography of trade is different for value added and goods has the former is less concentrated.

Bilateral trade data in percentage of world output for Germany, the rest of the Euro Area and the rest of the world is given for goods and value added in the following table (see table 2).

		to			to		
		Ger	REA	RoW	Ger	REA	RoW
from	Ger	0%	0,80%	1,10%	0%	0,57%	0,94%
	REA	0,65%	0%	2,00%	0,44%	0%	1,72%
	RoW	0,86%	1,94%	0%	0,69%	1,66%	0%
		Goods flows			Value added flows		

Table 2: World trade, 1999-2004 average. Sources : GTAP, author's calculation