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On fiscal multipliers in New Keynesian small open economy models

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Introduction

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Introduction

Starting point:

- Dynamic **New Keynesian** general equilibrium models (NK) are widely used; **'workhorse model'** in modern macroeconomics
- **one of the three main approaches** for quantifying **fiscal multipliers**
- **cross-study comparisons** of results notoriously difficult

Research question: What is the **quantitative relevance** of the chosen assumptions/parameters in NK models for estimating fiscal multipliers?

Approach: use a standard **medium-sized NK model** to

- **systematically** check the **sensitivity of fiscal multipliers**
- to the model's **key assumptions** and parameters
- for an **array** of fiscal instruments (**'unified framework'**).

Focus: **small open** economy in a **monetary union**; **short** and **long run**.

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Literature

The paper connects to three strands of the literature:

- Series of instructive papers using **simple models** to derive **analytical results** on the determinants of the size of fiscal multipliers:
  - Neoclassical model: e.g. Baxter and King, 1993; Heijdra and Ligthart, 2000
  - NK model: e.g. Hall, 2009; Woodford, 2011; Christiano et al., 2011
- Benchmarking of the applied **big scale models** of large institutions (ECB, EC, IMF, OECD) w.r.t. output effects of fiscal stimulus: e.g. Coenen et al., 2012
- **Long-run/growth effects** of fiscal policy: e.g. Turnovsky, 2004; Gemmel et al., 2016

NK small open economy model

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Model description 1/2

Vanilla NK model (e.g. Galí and Monacelli, 2005) with the usual **medium-size extensions**:

- **Small open economy**: imperfect substitution of domestic and foreign goods, downward sloping foreign demand for domestic goods
- **Fixed exchange rate**: economy is part of a **monetary union**, monetary policy does not react to domestic fiscal shocks
- **Microfounded** decisions of households and firms
- **Infinitely** vs. **finitely** lived households
- **'Consumption-smoothers'** (Ricardian households) vs. **'hand-to-mouth' consumers** (constrained households)
- Sluggish consumption and labor supply responses due to **external habits**
- ...

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Model description 2/2

- ...
- **Monopolistic competition** on product and labor markets
- Sluggish resetting of **nominal prices** and **wages** (**Calvo** assumption)
- **Capital** and **labor** as production factors
- Investment decision according to **Tobin's-q-theory** including **capital adjustment costs**
- Endogenous **capacity utilization**
- **Risk premium** depending on the amount of foreign debt
- **Large fiscal block** (default: lump-sum tax budget closure $\approx$ debt financing)
- Benchmark calibration for **Austria** at **quarterly frequency** and parameter range from the literature
- Simulation of **deterministic** version of the model

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Fiscal instruments considered

- C^G: public consumption
- I^G: public investment
- sub^I: investment subsidy
- sub^L: (unconditional) cash flow subsidy
- τ^C: tax on consumption
- τ^W: tax on labor (employees' side)
- τ^F: tax on labor (employers' side)
- τ^{prof}: tax on profits
- τ^K: tax on capital
- τ^R: tax on capital income
- ($\tau^{L,C}$: lump-sum tax on constrained households)
- Exp: average expenditure shock
- Rev: average tax shock
- PB: average primary balance shock

Measurement of fiscal multipliers

ex-ante: $$m^Y = \frac{\text{absolute real change in value added}}{\text{absolute ex-ante change in value of fiscal instrument}}$$

- Fiscal shock measured as **static estimate**, i.e. excluding the consequences of changes in prices and behavior.

ex-post: $$\bar{m}^Y = \frac{\text{absolute real change in value added}}{\text{absolute real change in primary balance}}$$

- The measurement of the fiscal shock includes all indirect changes in the budget effect of the same and other fiscal instruments (**self-financing**).
- In the paper we focus on the concept of **'present-value'** multipliers measuring the change in **value added**. GDP multipliers include the effects on tax revenue on products. Fiscal shocks are always assumed to be **expansionary**.

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Results

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Benchmark results NK model 1/2

Table: Benchmark results for the New Keynesian model (permanent shock)

	impact	short run (4 quarters)				medium run (4 years)				long run (30 years)			
	m_1^Y	$m_{1,4}^Y$	$\bar{m}_{1,4}^Y$	$\varepsilon_{1,4}^T$	$sf_{1,4}$	$m_{1,16}^Y$	$\bar{m}_{1,16}^Y$	$\varepsilon_{1,16}^T$	$sf_{1,16}$	$m_{1,120}^Y$	$\bar{m}_{1,120}^Y$	$\varepsilon_{1,120}^T$	$sf_{1,120}$
C^G	0.817	0.670	0.821	-	0.199	0.645	0.743	-	0.142	0.775	0.929	-	0.159
I^G	0.956	0.786	1.177	-	0.362	0.749	1.019	-	0.294	1.626	4.230	-	0.580
sub^I	1.683	1.532	2.886	-	0.481	1.580	2.737	-	0.411	2.284	6.901	-	0.569
sub^L	-0.072	-0.033	-0.038	-	0.125	-0.144	-0.157	-	0.100	-0.231	-0.237	-	0.039
τ^C	0.161	0.227	0.262	0.242	0.136	0.312	0.377	0.298	0.170	0.413	0.525	0.300	0.199
τ^W	0.335	0.444	0.591	0.239	0.247	0.652	0.984	0.289	0.323	0.882	1.563	0.347	0.403
τ^F	0.657	1.012	4.652	0.944	0.728	0.881	5.758	1.091	0.807	0.579	2.218	1.039	0.717
τ^{prof}	0.684	0.973	1.498	0.491	0.314	0.970	1.702	0.349	0.398	0.867	1.418	0.277	0.354
τ^K	1.023	0.962	1.882	1.301	0.495	0.968	1.793	1.269	0.454	1.356	3.294	1.288	0.530
τ^R	-0.087	0.033	0.030	0.303	-0.134	0.326	0.337	0.293	-0.009	0.487	0.574	0.249	0.122
Exp	0.804	0.661	0.829	-	0.219	0.632	0.743	-	0.162	0.852	1.094	-	0.211
Rev	0.381	0.549	0.840	-	0.331	0.628	1.077	-	0.397	0.672	1.202	-	0.416
PB	0.539	0.591	0.836	-	0.289	0.630	0.921	-	0.309	0.739	1.153	-	0.339

$m_{1,t}^Y$: ex-ante present-value multiplier from periods 1 to t

$\bar{m}_{1,t}^Y$: ex-post present-value multiplier from periods 1 to t

$\varepsilon_{1,t}^T$: own tax base semi-elasticity (from periods 1 to t)

$sf_{1,t}$: self-financing degree (from periods 1 to t)

RBC results

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Benchmark results NK model 2/2

- Multiplier estimates **differ widely by instrument** (e.g. ranging from -0.09 to 1.68 on impact)
- Differences between **ex-ante and ex-post** multiplier by instrument also differ substantially
- In contrast to RBC case: τ^W and τ^F as well as τ^{prof} and τ^K are **no longer economically equivalent** (i.e. the same ex-post multiplier)
- The **ex-post multiplier** relevant for relative **ranking** of instruments
- **Average tax shock** has lower (higher) multiplier than **average expenditure shock** in ex-ante (ex-post) terms [except for very short run]

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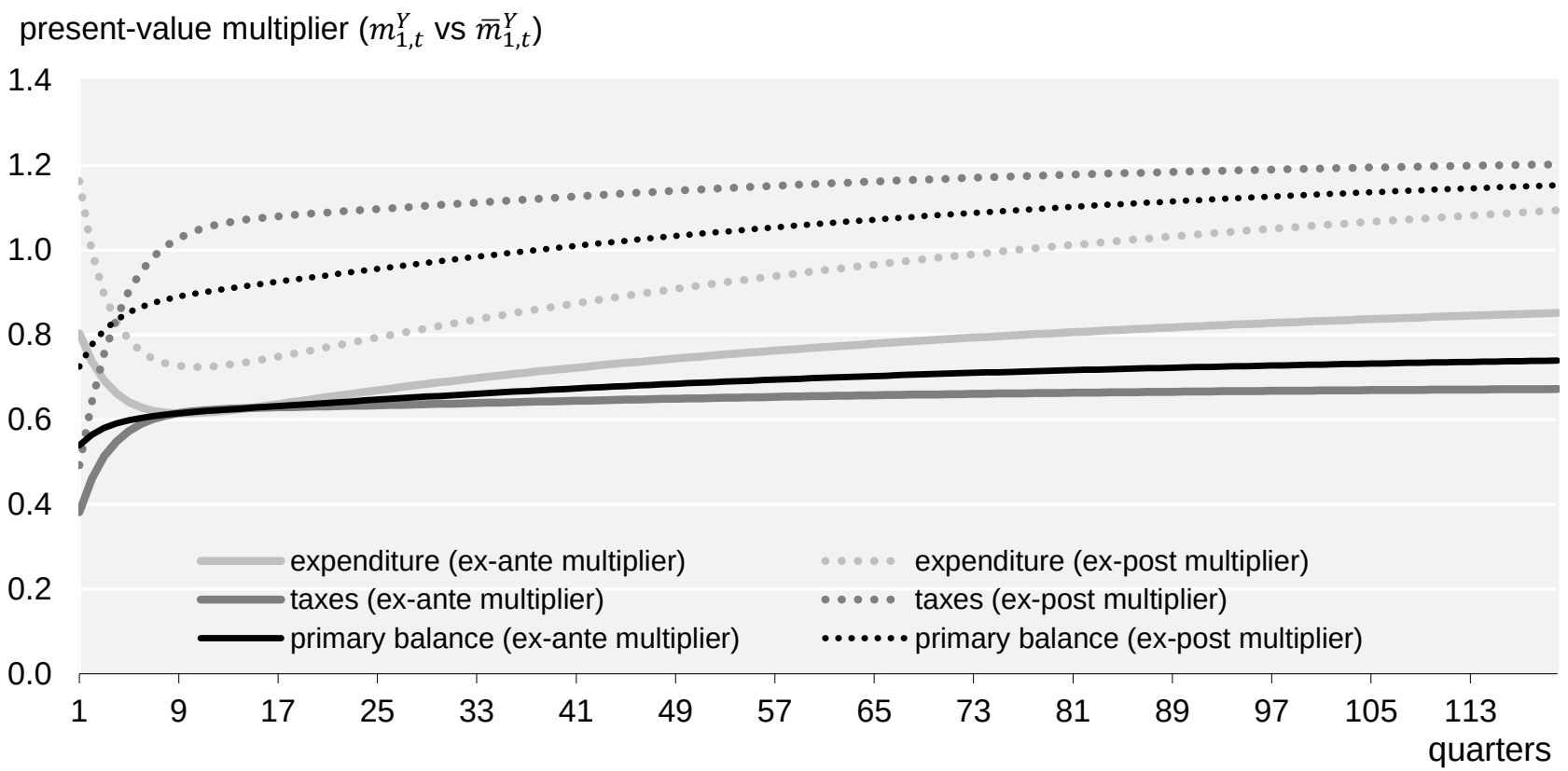
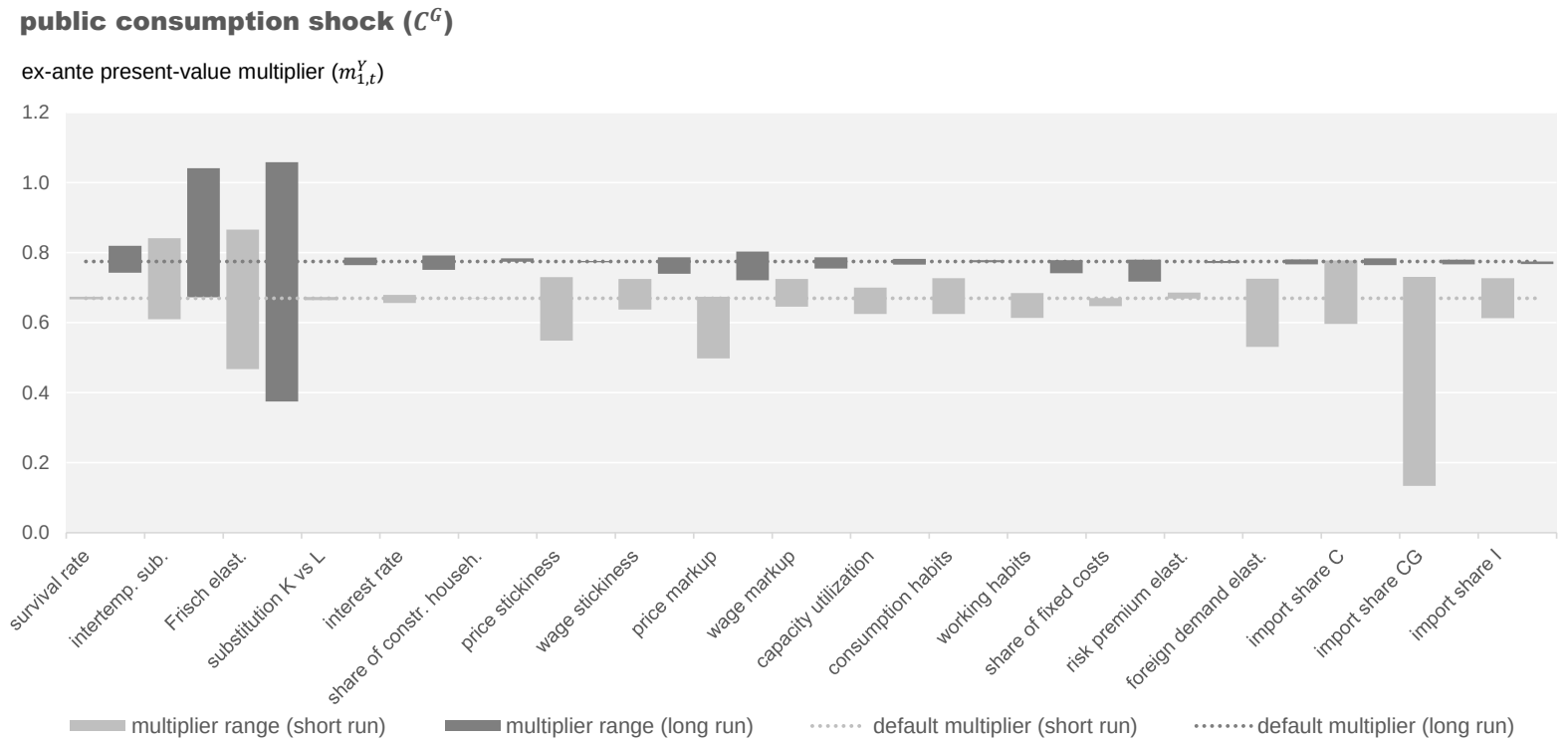
Aggregate multipliers

Figure: Aggregate multipliers



Multiplier range for public consumption

Figure: Multiplier range for considered parameter space for public consumption



- **Short-run determinants**: import share of public consumption
- **Long-run determinants**: intertemporal elasticity of substitution and labor supply elasticity (which together determine income effect of labor supply)

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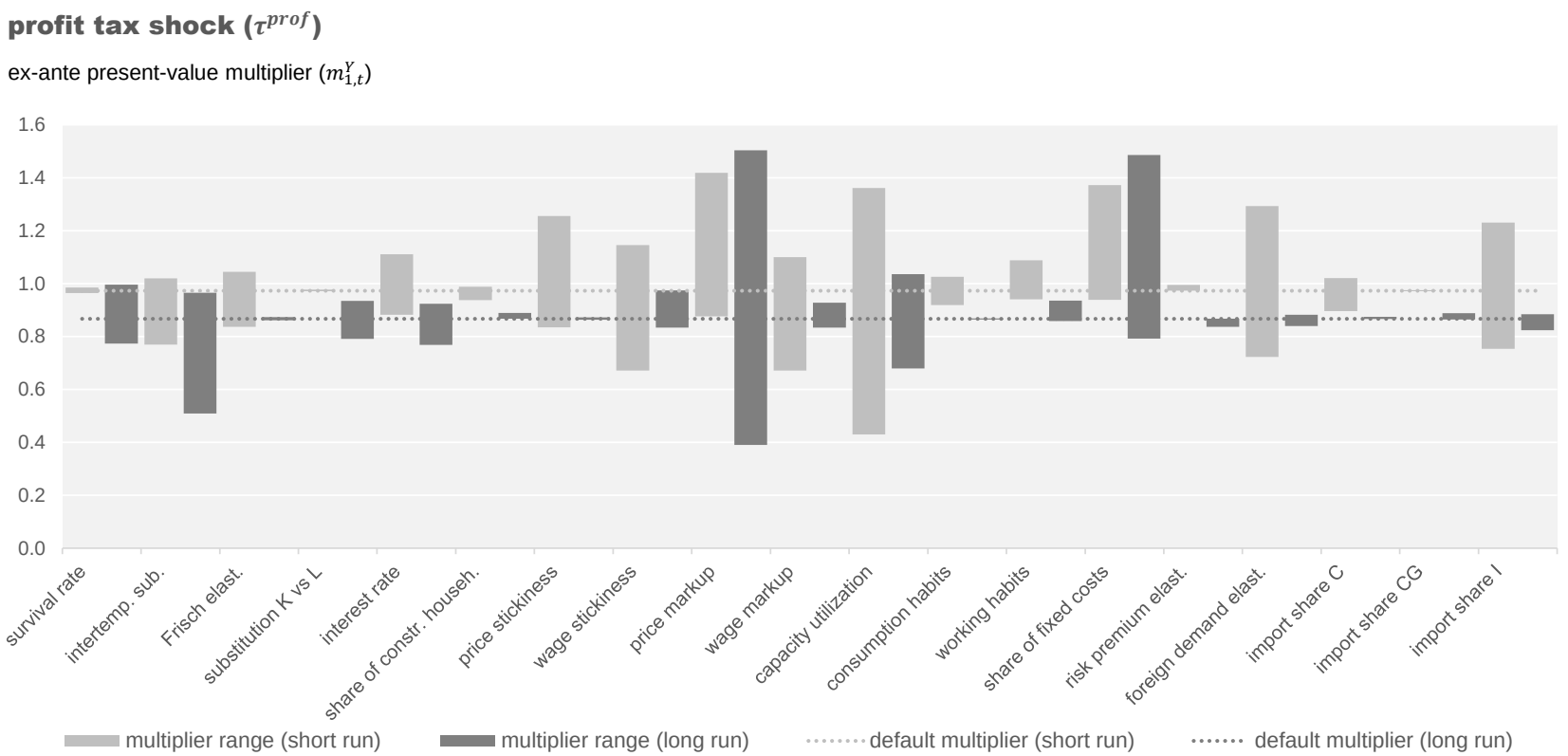
Sector-specific public consumption shocks in a multi-industry extension

Table: Multipliers of industry-specific permanent public consumption shocks

CPA code	industry	$m^Y_{1,4}$	$m^Y_{1,120}$	import share	capital share
A	Agriculture	0.36	0.82	0.26	0.68
B	Mining	0.48	0.79	0.23	0.50
C	Manufacturing	-0.58	0.62	0.93	0.29
D	Energy	0.30	0.75	0.38	0.47
E	Water services	0.66	0.76	0.13	0.53
F	Construction	0.51	0.70	0.25	0.28
G	Wholesale and retail trade	0.63	0.73	0.17	0.29
H	Transportation	0.61	0.75	0.18	0.35
I	Tourism	0.68	0.77	0.16	0.40
J	Information	0.47	0.71	0.26	0.28
K	Financial and insurance services	0.62	0.66	0.17	0.22
L	Real estate	0.84	0.88	0.07	0.76
M	Professional services	0.61	0.72	0.16	0.29
N	Administrative services	0.67	0.74	0.13	0.34
O	Public administration	0.75	0.62	0.12	0.08
P	Education	0.81	0.59	0.07	0.04
Q	Health	0.69	0.65	0.16	0.15
R	Arts and entertainment	0.78	0.78	0.13	0.41
S,T,U	Other services	0.72	0.69	0.13	0.23
correlation with import share		**-0.99**	-0.26	1.00	0.01
correlation with capital share		-0.06	**0.93**	0.01	1.00

Multiplier range for profit taxes

Figure: Multiplier range for considered parameter space for profit taxes



- **Short-run determinants**: capacity utilization, price markup
- **Long-run determinant**: price markup (which determines the share of 'pure economic rents' that are taxed)

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Permanent vs. temporary shock

Table: Ex-ante multipliers assuming permanent vs. temporary fiscal shocks (under a debt-financing rule)

	permanent shock ($\rho^{\epsilon} = 1$)				temporary shock ($\rho^{\epsilon} = 0.7$)			
	m_1^Y	m_1^C	$m_{1,4}^Y$	$m_{1,4}^C$	m_1^Y	m_1^C	$m_{1,4}^Y$	$m_{1,4}^C$
C^G	0.836	-0.108	0.653	-0.258	0.828	0.089	0.641	0.031
I^G	0.971	0.168	0.771	0.141	0.865	0.116	0.739	0.092
sub^I	**1.692**	0.109	1.520	0.030	**2.748**	0.336	2.319	0.225
sub^L	-0.021	0.203	-0.047	0.300	-0.001	0.005	-0.002	0.012
τ^C	0.216	0.394	0.218	0.454	0.253	0.531	0.251	0.679
τ^W	0.391	0.545	0.440	0.646	0.252	0.345	0.381	0.381
τ^F	0.724	0.330	1.017	0.506	0.427	0.127	0.730	0.235
τ^{prof}	**0.763**	0.238	0.972	0.399	**0.311**	-0.025	0.611	0.067
τ^K	**1.042**	0.118	0.952	0.102	**0.217**	-0.001	0.344	0.041
τ^R	-0.010	-0.232	0.027	-0.330	-0.010	-0.025	-0.006	-0.033
$\tau^{L,C}$	**0.215**	0.623	0.006	0.372	**0.428**	1.037	0.126	0.942
Exp	0.824	-0.058	0.645	-0.182	0.813	0.091	0.639	0.040
Rev	**0.441**	0.405	0.546	0.510	**0.290**	0.305	0.433	0.391
PB	0.584	0.232	0.583	0.251	0.486	0.225	0.510	0.260

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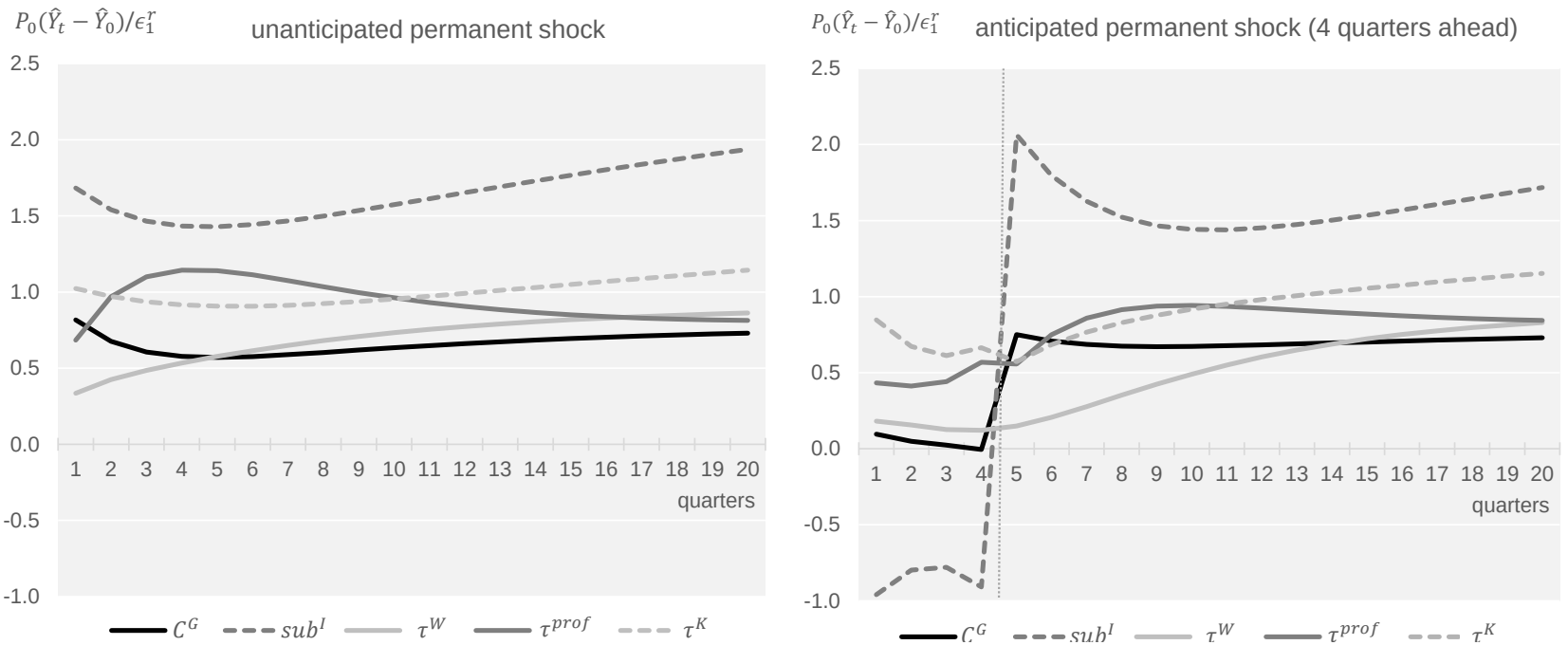
Role of prior announcement

Figure: Multipliers of unanticipated vs. anticipated shocks



- **Hardly affected**: public consumption (C^G), taxes on labor (τ^W)
- **Positive effect at announcement**: taxes on capital (τ^K) and profits (τ^{prof})
- **Negative effect at announcement, positive at implementation**: investment subsidy (sub^I)

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Ranking fiscal instruments

Table: Ranking of fiscal instruments in the benchmark calibration by multiplier (from highest to lowest)

model	NK	NK	NK	NK	RBC	RBC	NK	NK	NK
persistence	perm.	perm.	perm.	perm.	perm.	perm.	temp.	perm.	perm.
anticipation	unant.	unant.	unant.	unant.	unant.	unant.	unant.	antic.	antic.
measurement	ex-ante	ex-ante	ex-post	ex-post	ex-post	ex-post	ex-post	ex-ante	ex-ante
horizon	short run	long run	short run	long run	short run	long run	short run	announc.	short run
	sub^I	sub^I	τ^F	sub^I	τ^F	sub^I	sub^I	τ^K	sub^I
	τ^F	I^G	sub^I	I^G	τ^W	I^G	C^G	τ^{prof}	τ^F
	τ^{prof}	τ^K	τ^K	τ^K	τ^R	τ^K	I^G	τ^F	τ^{prof}
	τ^K	τ^W	τ^{prof}	τ^F	sub^I	τ^{prof}	τ^F	I^G	τ^K
	I^G	τ^{prof}	I^G	τ^W	C^G	τ^R	τ^{prof}	τ^W	C^G
	C^G	C^G	C^G	τ^{prof}	τ^K	τ^F	τ^W	C^G	I^G
	τ^W	τ^F	τ^W	C^G	τ^{prof}	τ^W	τ^K	τ^R	τ^W
	τ^C	τ^R	τ^C	τ^R	τ^C	C^G	τ^C	sub^L	τ^C
	τ^R	τ^C	τ^R	τ^C	I^G	τ^C	sub^L	τ^C	τ^R
	sub^L	sub^L	sub^L	sub^L	sub^L	sub^L	τ^R	sub^I	sub^L

- Instrument rankings are **sensitive** to type of **measurement** (ex-ante vs. ex-post), assumed **shock persistence**, considered **time horizon**, whether or not the shock is **anticipated**
- However, typically **large multiplier**: sub^I, I^G, τ^K
- And, typically **small multiplier**: sub^L, τ^R, τ^C

Summary and conclusions

Summary: Fiscal multipliers in NK models

- Considerable **variation** in fiscal multipliers **by instrument**
- An **average tax** shock has a lower (higher) multiplier than an **average expenditure** shock in ex-ante (ex-post) terms
- **Ex-post multiplier** is the metric of choice for **ranking fiscal instruments**
- **Key parameters** also differ by instrument and considered time horizon. As a rule of thumb:
  - **long-run**: preference and technology parameters
  - **short-run**: import shares, degree of price stickiness,...
- Alternative **budget reaction assumptions** are of little **quantitative importance** as long as lump-sum taxes are used as endogenous instrument (although Ricardian equivalence does not hold)
- **Instrument rankings** vary with considered time horizon, shock persistence and anticipation assumptions.
- However, instruments **can be grouped**: typically large multipliers (sub^I, I^G, τ^K) and typically low multipliers (sub^L, τ^R, τ^C)

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Overall conclusion: Multiplier project 1/2

- **Problem** with cross-study comparison and existing meta studies: **'apples and oranges'** (diverging assumptions, multiplier definitions, underlying data sets, . . .)
- **Our path**: use a **unified framework** in each of the two most frequently used approaches (VAR and NK models) to isolate the quantitatively important determinants by running thousands of differently specified simulations/specifications
- **Complementary approaches**:
  - **VAR**: data driven, comparably few assumptions required; only short-run analysis for aggregate fiscal variables possible
  - **NK model**: model driven, a number of assumptions needed; short- and long-run analysis assuming temporary or permanent shock for individual instruments possible

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Overall conclusion: Multiplier project 2/2

- The **short-run** mean/benchmark multiplier for **aggregate spending** are of similar magnitude in both approaches (around 0.7–0.8), while the **aggregate revenue multiplier** is somewhat larger in the VAR analysis (when looking at present value multipliers)
- Using unified approaches helps to **narrow down the range** where one should expect fiscal multipliers in Austria. However, still quite some **uncertainty** and **variation** remains.
- Large variations by instruments and other circumstances in the NK model in particular suggest: there is **no 'one size fits all'** multiplier

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Thank you for your attention!

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Appendix

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Household problem

An **unconstrained household** (U) of cohort v maximizes

$$\max_{\{C_t^{U,v}\}} \sum_{s=0}^{\infty} (\beta\gamma)^s \left[\frac{(\tilde{C}_{t+s}^{U,v})^{1-1/\sigma} - 1}{1 - 1/\sigma} - \eta \frac{(\tilde{L}_{t+s}^{I})^{1+1/\sigma^F}}{1 + 1/\sigma^F} \right]$$

subject to

$$\tilde{C}_t^{z,v} = C_t^{z,v} - \kappa \bar{C}_{t-1}^{z,v}, \qquad \tilde{L}_t^{I} = L_t^{I} - \kappa^L \bar{L}_{t-1}$$

$$\gamma A_{t+1}^{U,v} = \Big(1 + \underbrace{i_{t+1}^{W}}_{i_{t+1}(1-\tau_t^R)} \Big) \left[A_t^{U,v} + \underbrace{W_t^W}_{(1-\tau_t^W)W_t} \hat{L}_t - \underbrace{P_t^C}_{(1+\tau_t^C)\bar{P}_t^C} C_t^{U,v} - P_t \tau_t^L \right].$$

and delegates the labor supply decision to a trade union. A **constrained household** (C) consumes disposable income every period

$$C_t^C = \left[W_t^W \hat{L}_t - P_t \tau_t^L - P_t \tau_t^{L,C} \right] / P_t^C,$$

Union problem

The **union** sets wages for each labor type l by weighting with average marginal utility ($\tilde{\lambda}_t$)

$$W_t^* = \arg\max_{W_t^l} \sum_{s=0}^{\infty} (\theta^w \beta)^s \left[W_t^l L_{t+s}^l \tilde{\lambda}_{t+s} - \eta \frac{(\tilde{L}_{t+s}^l)^{1+1/\sigma^F}}{1+1/\sigma^F} \right],$$

subject to demand for each labor variety

$$L_t^l = \left(\frac{W_t}{W_t^l} \right)^{\epsilon^w} \hat{L}_t, \quad \text{with} \quad W_t = \left[\int_0^1 (W_t^l)^{1-\epsilon^w} dl \right]^{1/(1-\epsilon^w)}.$$

This results in the usual Calvo-style **aggregate dynamic wage equation**

$$W_t^{1-\epsilon^w} = (1-\theta^w)(W_t^*)^{1-\epsilon^w} + \theta^w (W_{t-1})^{1-\epsilon^w}.$$

Value added producer problem

A **value added producer** i sets prices for output variety i

$$P_t^* = \arg\max_{P_t^i} \sum_{s=0}^{\infty} (\theta)^s \, \varrho_{t,t+s} (1-\tau_{t+s}^{prof}) \left[\left(P_t^i - MC_{t+s} \right) Y_{t+s}^i - P_{t+s} FC_{t+s} \right],$$

subject to demand for output variety i and minimized marginal costs

$$Y_t^i = \left(\frac{P_t}{P_t^i} \right)^{\epsilon} Y_t, \quad \text{with} \quad P_t = \left[\int_0^1 (P_t^i)^{1-\epsilon} di \right]^{1/(1-\epsilon)}.$$

$$MC_t = \left[\alpha \left((1+\tau_t^K) P_t^K \right)^{1-\sigma^P} + (1-\alpha) \left((1+\tau_t^F) W_t \right)^{1-\sigma^P} \right]^{1/(1-\sigma^P)} / \Phi_t.$$

This results in the usual Calvo-style **aggregate dynamic price equation**

$$P_t^{1-\epsilon} = (1-\theta)(P_t^*)^{1-\epsilon} + \theta (P_{t-1})^{1-\epsilon}.$$

Capital good producer problem

The **capital good producer** builds up the **economy-wide capital stock** and rents capital to the value added producers

$$\max_{\{\tilde{I}_t\},\{o_t\}} \sum_{s=0}^{\infty} \varrho_{t,t+s} \left[P^K_{t+s} \hat{K}_{t+s} - P^I_{t+s}(\tilde{I}_{t+s} + J_{t+s}) - T^F_{t+s} \right],$$

subject to

$$T^F_t = \tau^{prof}_t \left[P^K_t \hat{K}_t - P^I_t \delta_0 K_t \right] - sub^L_t P_t - sub^I_t P^I_t \tilde{I}_t, \quad J_t = \frac{\psi K_t}{2} \left[\frac{\tilde{I}_t}{K_t} - \delta_0 \right]^2,$$

$$\hat{K}_t = o_t K_t, \quad K_{t+1} = (1-\delta_t) K_t + \tilde{I}_t, \quad \delta_t = \delta^0 + \delta^1 (o_t - 1) + \frac{\delta^2}{2} (o_t - 1)^2.$$

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Benchmark calibration 1/2

Parameter	Symbol	Value	Range
survival rate (yearly)	γ	0.975	[0.952,1]
interest rate (yearly)	i_0	0.03	[0.02,0.05]
discount factor (yearly)	β	0.987	-
depreciation rate K (yearly)	δ_0	0.082	-
depreciation rate K^G (yearly)	δ_0^G	0.05	[0.03,0.15]
capacity utilization costs	δ^2	0.05	[0.02,∞)
intertemporal elasticity of substitution	σ	0.7	[0.2,1]
Frisch labor supply elasticity	σ^F	1	[0.25,4]
habit persistence consumption	κ	0.5	[0,0.75]
habit persistence labor supply	κ^L	0.25	[0,0.75]
capital share production function	α	0.327	-
elast. of subst. capital vs. labor	λ^P	1	[0.8,1.2]
capital adjustment speed	ψ	10	-
scaling disutility of labor	η	11.6	-
productivity of public capital	σ^G	0.08	[0,0.15]
share of constrained households	$1-\pi$	0.3	[0,0.7]
price elast. of demand: value added	ϵ	11	[7,∞)
price elast. of demand: labor varieties	ϵ^w	11	[7,∞)
Calvo parameter prices	θ	0.7	[0,0.8]
Calvo parameter wages	θ^w	0.5	[0,0.8]
fixed costs parameter	$\overline{FC}$	0.1	[0,1]
sensitivity of risk premium	ψ^{DF}	0.15	[0,0.1]
import share consumption	ξ^C	0.277	[0.05,0.7]
import share investment	ξ^I	0.371	[0.05,0.7]

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Benchmark calibration 2/2

Parameter	Symbol	Value	Range
import share public consumption	ξ^{C^G}	0.116	[0.05,0.7]
import share public investment	ξ^{I^G}	0.116	[0.05,0.7]
elast. of subst. dom. vs. imp. for C	λ^C	1.2	[0.5,1.5]
elast. of subst. dom. vs. imp. for I	λ^I	1.2	[0.5,1.5]
elast. of subst. dom. vs. imp. for C^G	λ^{C^G}	0.8	[0.5,1.5]
elast. of subst. dom. vs. imp. for I^G	λ^{I^G}	0.8	[0.5,1.5]
price semi-elasticity of export demand	λ^E	1.2	[0.5,5]
consumption tax rate	τ_0^C	0.235	-
payroll tax rate	τ_0^F	0.22	-
wage tax rate	τ_0^W	0.34	-
capital tax rate	τ_0^K	0.015	-
profit tax rate	τ_0^{prof}	0.15	-
interest tax rate	τ_0^R	0.1	-
lump-sum tax rate (constrained only)	$\tau_0^{L,C}$	0	-
lump-sum tax rate	τ_0^L	-0.156	-
investment subsidy	sub_0^I	0.01	-
lump-sum subsidy	sub_0^L	0.01	-
public consumption	C_0^G	0.197	-
public investment	I_0^G	0.03	-
public debt	D_0^G	0.7	-
gross domestic product	GDP_0	1	-
capacity utilization	o_0	1	-
domestic final goods price	P_0	1	-
imported final goods price	P_0^m	1	-
wage rate	W_0	1	-

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Benchmark results RBC model

Table: Benchmark results for the RBC model (permanent shock)

	impact	short run (4 quarters)				medium run (4 years)				long run (30 years)			
	m_1^Y	$m_{1,4}^Y$	$\bar{m}_{1,4}^Y$	$\varepsilon_{1,4}^T$	$sf_{1,4}$	$m_{1,16}^Y$	$\bar{m}_{1,16}^Y$	$\varepsilon_{1,16}^T$	$sf_{1,16}$	$m_{1,120}^Y$	$\bar{m}_{1,120}^Y$	$\varepsilon_{1,120}^T$	$sf_{1,120}$
C^G	0.470	0.479	0.485	-	0.028	0.510	0.523	-	0.035	0.604	0.646	-	0.063
I^G	0.180	0.232	0.237	-	0.080	0.425	0.470	-	0.140	1.431	2.959	-	0.488
sub^I	0.689	0.789	0.735	-	0.002	1.122	1.200	-	0.089	2.167	4.780	-	0.447
sub^L	0.000	0.000	0.000	-	0.099	0.000	0.000	-	0.099	0.000	0.000	-	0.099
τ^C	0.346	0.352	0.428	0.248	0.172	0.372	0.457	0.246	0.177	0.434	0.550	0.259	0.196
τ^W	0.656	0.668	1.006	0.311	0.327	0.706	1.089	0.313	0.336	0.823	1.378	0.327	0.371
τ^F	0.356	0.362	1.007	0.990	0.635	0.383	1.090	0.991	0.640	0.446	1.380	0.999	0.660
τ^{prof}	0.402	0.460	0.463	0.205	0.051	0.655	0.717	0.132	0.102	1.264	1.997	-0.113	0.309
τ^K	0.338	0.387	0.464	1.215	0.203	0.551	0.719	1.223	0.246	1.064	2.000	1.285	0.419
τ^R	0.713	0.731	0.744	0.077	-0.066	0.799	0.854	0.079	-0.016	1.149	1.660	0.086	0.243
Exp	0.415	0.430	0.437	-	0.037	0.483	0.501	-	0.051	0.695	0.797	-	0.121
Rev	0.482	0.494	0.746	-	0.332	0.534	0.829	-	0.343	0.663	1.134	-	0.389
PB	0.457	0.470	0.601	-	0.222	0.515	0.674	-	0.234	0.675	0.975	-	0.289

$m_{1,t}^Y$: ex-ante present-value multiplier from periods 1 to t

$\bar{m}_{1,t}^Y$: ex-post present-value multiplier from periods 1 to t

$\varepsilon_{1,t}^T$: own tax base semi-elasticity (from periods 1 to t)

$sf_{1,t}$: self-financing degree (from periods 1 to t)

NK results

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Value added vs. GDP multipliers

Table: Consumption and GDP multipliers in the New Keynesian model

	impact			short run (4 quarters)			medium run (4 years)			long run (30 years)		
	m_1^Y	m_1^C	m_1^{GDP}	$m_{1,4}^Y$	$m_{1,4}^C$	$m_{1,4}^{GDP}$	$m_{1,4}^Y$	$m_{1,4}^C$	$m_{1,4}^{GDP}$	$m_{1,120}^Y$	$m_{1,120}^C$	$m_{1,120}^{GDP}$
C^G	0.817	-0.251	0.769	0.670	-0.393	0.595	0.645	-0.475	0.555	0.775	-0.472	0.685
I^G	0.956	0.040	0.963	0.786	0.007	0.788	0.749	-0.013	0.747	1.626	0.373	1.697
sub^I	1.683	0.017	1.686	1.532	-0.076	1.517	1.580	-0.089	1.563	2.284	0.333	2.347
sub^L	-0.072	-0.004	-0.073	-0.033	0.161	-0.003	-0.144	0.190	-0.108	-0.231	0.017	-0.227
τ^C	0.161	0.180	0.195	0.227	0.297	0.283	0.312	0.378	0.384	0.413	0.408	0.491
τ^W	0.335	0.343	0.401	0.444	0.496	0.539	0.652	0.637	0.774	0.882	0.768	1.028
τ^F	0.657	0.182	0.692	1.012	0.470	1.101	0.881	0.567	0.989	0.579	0.496	0.674
τ^{prof}	0.684	0.011	0.686	0.973	0.281	1.026	0.970	0.393	1.045	0.867	0.294	0.923
τ^K	1.023	0.012	1.025	0.962	0.007	0.963	0.968	0.012	0.971	1.356	0.220	1.398
τ^R	-0.087	-0.518	-0.185	0.033	-0.551	-0.072	0.326	-0.433	0.244	0.487	-0.036	0.480
Exp	0.804	-0.202	0.765	0.661	-0.316	0.601	0.632	-0.386	0.559	0.852	-0.338	0.787
Rev	0.381	0.210	0.421	0.549	0.386	0.622	0.628	0.496	0.723	0.672	0.546	0.776
PB	0.539	0.056	0.550	0.591	0.123	0.614	0.630	0.167	0.661	0.739	0.215	0.780

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Balanced budget multipliers

Table: Balanced budget (ex-ante) multipliers in case of permanent fiscal shocks

policy	financing instrument											
	short-run present-value multiplier						long-run present-value multiplier					
	C^G	τ^C	τ^W	τ^{prof}	τ^K	τ^R	C^G	τ^C	τ^W	τ^{prof}	τ^K	τ^R
C^G	0.000	0.459	0.132	-0.774	-1.061	0.624	0.000	0.337	-0.521	-0.424	-2.250	0.284
I^G	0.262	0.624	0.345	-0.306	-0.375	0.760	1.361	1.457	0.833	0.988	0.733	1.447
sub^I	1.115	1.403	1.190	0.669	0.616	1.511	2.017	2.125	1.692	1.801	1.333	2.118
sub^L	-0.768	-0.270	-0.615	-1.587	-1.954	-0.082	-1.148	-0.747	-1.725	-1.636	-3.859	-0.808
τ^C	-0.481	0.000	-0.312	-1.170	-1.413	0.191	-0.318	0.000	-0.805	-0.713	-2.436	-0.049
τ^W	-0.161	0.251	0.000	-0.673	-0.802	0.422	0.366	0.589	0.000	0.079	-1.097	0.558
τ^F	0.817	0.940	0.886	0.722	0.598	1.006	0.325	0.438	0.195	0.204	-0.428	0.418
τ^{prof}	0.432	0.793	0.580	0.000	-0.215	0.950	0.292	0.543	-0.067	0.000	-1.369	0.506
τ^K	0.550	0.832	0.631	0.116	0.000	0.939	0.994	1.148	0.677	0.760	0.000	1.129
τ^R	-0.864	-0.253	-0.625	-1.618	-1.818	0.000	-0.292	0.045	-0.841	-0.715	-2.510	0.000

Note: Policy interventions (rows) are always expansionary, i.e. a rise in spending or a cut in taxes, while the opposite is true for the financing instruments (columns).