

Clemens, Marius; Röger, Werner

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Temporary VAT Reduction during the Lockdown - Evidence from Germany

Marius Clemens*, Werner Röger**

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Abstract

This paper evaluates the temporary VAT reduction invoked by the German government over the third and fourth quarter of 2020 as part of the COVID-19 stimulus package. There is considerable controversy. Critics argue that VAT reductions are ineffective in the presence of lockdown measures in place and because of limited pass-through of temporary measures into consumer prices. Advocates emphasize positive effects on durables and stress that these measures can at least partly substitute for a limited monetary policy response under the ZLB.

This paper sets up a DSGE model which is capable to address these issues. Our model distinguishes between sectors directly and indirectly affected by the lockdown. This allows us to trace economic spillovers of lockdown measures to the rest of the economy and the differentiated impact of VAT measures on the two sectors. We disaggregate consumption into durables and non-durables for both financially constrained and unconstrained households and we allow for imperfect pass-through of VAT measures into consumer prices, by noticing that the standard price setting model with convex cost of adjustment, makes strong predictions about magnitude and speed in which retailers are adjusting consumer prices to VAT shocks.

We analyse the impact of the VAT in conjunction with the two lockdown shocks in 2020 Q2 to Q4. We use non-linear solution techniques to solve the model in the presence of a ZLB and a lockdown constraint and we carefully take into account the information set available for the private sector in each quarter on current and future policy measures. We find sizeable effects of VAT measures on consumption (esp. durables) with a multiplier larger than one on GDP and can match well the main macroeconomic aggregates over that period.

JEL:E62, E65, H21

Keywords: Fiscal Policy, DSGE Modelling, COVID-19 Lockdown, Tax Multiplier

*DIW Berlin, BERA, University of Potsdam. E-mail address: mclemens@diw.de.

**DIW Berlin, EIIW, VIVES KU Leuven. E-mail address: w.roeger@web.de.

1 Introduction

Due to the COVID-19 pandemics the German government decided to stimulate the economy via a temporary VAT rate reduction. From the 1st July 2020 to the end of the year the regular VAT rate has been reduced by 3 percentage points from 19 to 16. The VAT rate on necessities, i.e. food, books has been reduced from 7 to 5 percent.¹ The VAT reduction is part of a large stimulus package of 160 billion Euro that the German government launched in order to stabilize and stimulate the economy after the first lockdown.

However, the VAT measure of the German Government was received with considerable reservation. "Not targeted enough", "ineffective in the presence of lockdown measures in place" and "too costly (because of limited pass-through into consumer prices)" were the main arguments against this instrument. Furthermore, the initial plan to invoke VAT cuts after the lockdown until the end of the year 2020 has been counteracted by the second lockdown which started in the 4th quarter.

But there are also arguments in favour of VAT reductions: It has been argued (see [Guerrieri et al. \(2020\)](#)) that lockdown measures have negative demand spillovers on other consumer goods providing sectors which are not directly affected by the lockdown. Thus, a broad instrument as a VAT reduction can also stabilize demand in not directly affected sectors. Furthermore, VAT reductions could especially be powerful if the central bank operates at the zero lower bound (ZLB) (see [Correia et al. \(2013\)](#)). In particular if the lockdown measures are disinflationary. In this case consumer durable consumption will generally be more negatively affected because of the implied temporary increase in the real interest rate. Thus VAT reductions could stabilize the demand for consumer durables.

In this paper we analyze the macroeconomic effects of a temporary VAT change in general and for the specific case of Germany during the (partial) lockdown. In order to shed some light on the effectiveness of temporary VAT reductions for Germany, we use the structural vector autoregressive (SVAR) methodology and German National Official Statistics data from 1Q1991:4Q2019 to estimate the average effects of VAT changes on durable and non-durable consumption. We find robust evidence for strong positive immediate effects on consumer durables on average which confirms results from the microeconomic models (see [Büttner and Madzharova \(2017\)](#)) within a macro framework. However, our empirical model neither explains the channels at work nor does it account for the specific situations of the pandemics and monetary policy at the zero lower bound. Therefore, we set up a dynamic stochastic general equilibrium (DSGE) model for Germany under a (partial) lockdown and with monetary policy operating at the ZLB. We add the following features which makes it especially suitable to deal with the issues raised above.

First, in the model we distinguish between durables and non-durables and address both the issue of whether demand spillovers are stronger to durables in a lockdown under ZLB and the possibly larger impact of temporary VAT reductions on durables. Ignoring durables could lead to an underestimation of the VAT impact.

¹Furthermore, in June 2020 a reduced VAT rate has been applied to restaurant supplies (supplies of prepared food in place) until June 2021. Due to the second lockdown this temporary measure will be extended until the mid of 2022.

Second, we explicitly distinguish between sectors affected and not affected by the lockdown. This allows us to adequately trace the macroeconomic effects of measures which only affect specific sectors of the economy but which have spillover effects to the rest of the economy. In this way we are also not inflating the effects of VAT measures since we control for the fact that a fraction of the retail sector is closed.

Third, we consider imperfect pass-through of VAT measures onto consumer prices, by noticing that the standard price setting model with convex cost of adjustment, makes predictions about the magnitude and the speed in which retailers are adjusting consumer prices in the event of VAT shocks.

We calibrate the model for Germany and show the impact of the VAT reduction of 3 percentage points on relevant macroeconomic aggregates between lockdown and relaxation in 2Q2020:4Q2020. In our simulation exercise we take into account that the VAT reduction in the 3rd quarter and the lockdown in the 4th quarter are unanticipated. Within our model setup, we first simulate the total effect of the unexpected VAT reduction against the two lockdown shocks. Additionally, we estimate how the 2nd lockdown shock has influenced the effectiveness of the VAT rate reduction. Finally, we analyze to what extent the VAT rate reduction can mimic the monetary policy reaction to the lockdown if monetary policy is not limited by the zero lower bound. In order to tackle these research objectives, we conduct three policy experiments: In the first experiment we simulate the actual timing of events, i.e. the 1st lockdown shock in the 2Q, the VAT reduction between 3Q2020:4Q2020 and finally the 2nd Lockdown shock in 4Q. By partially removing shocks we can measure the impact of the lockdown and VAT in the respective quarters.

The paper is organized as follows: In section 2 we start with a short classification of our contribution into the existing literature. In the next step, we empirically motivate our research objective and estimate the general empirical effect of VAT revenue changes with time series data for Germany and alternative SVAR identification strategies. In section 3 we explain our DSGE model setup, the lockdown shock and the model parameterization. In section 4 we start with an analysis about the mechanisms how the VAT reduction affects the economy and test the robustness regarding different parameter specifications. In the next step we apply the model to the specific case of Germany and run three specific policy experiments. We then evaluate the VAT reduction by means of calculated GDP multipliers. Finally, section 5 concludes.

2 Empirical evidence

2.1 Literature

Our study relates to several strands of research on the macroeconomic effects of tax changes. First, we contribute to the literature on theoretical effects of a temporary VAT rate changes. [Barrell and Weale \(2009\)](#) identify three possible effects: Agents benefit from a lower cost of living during the period of the reduction (income effect). Furthermore, agents shift their consumption forward (substitution effect). Finally, they buy non-durable goods before the end of the period of low VAT for consumption after the VAT rate as been raised. We consider these channels within a 2-sector dynamic stochastic general equilibrium model with durable and non-durable consumption goods. We add three additional channels into our theoretical framework. Consistent with empirical micro-data

evidence by Büttner and Madzharova (2017) our model features a specific durable investment channel through which intertemporal substitution of durable consumption becomes much stronger than for non-durable consumption. This increases the total reaction of consumption demand. Furthermore, we explicitly allow liquidity-constraint households to buy and consume durable goods. Although liquidity-constraint households cannot invest into the capital stock, they are now allowed to "invest" into consumer durables. Finally, similar to Voigts (2016) we consider an limited VAT rate pass-through channel, where the specific price adjustment costs are included in the price setting function of intermediate and retail firms. Thus, firms will not fully pass-through the VAT-related price changes to consumer.

Second, we contribute to the empirical literature on temporary VAT changes, which has rarely been empirically observed, especially in the case of Germany. The most prominent international example in the last years was a temporary VAT cut from 17.5% to 15% in the United Kingdom from December 2008 until the the end of 2009. For the UK's VAT reduction from 17% to 15% Barrell and Weale (2009) find a 1 per cent increase of consumption and a half per cent GDP increase. Once the VAT converges back both consumption and GDP are depressed. Furthermore, Crossley et al. (2009) find that the income effect is small, while the intertemporal substitution effect is large. According to their estimates, households' willingness to move spending from one year into an earlier (or later) year suggests that a 1% fall in the price today will translate into a 1% increase in spending. Since roughly only half of goods purchased are subject to VAT, the cut in the rate by 2.5% is like a cut in contemporaneous prices by 1.25%. Crossley et al. (2014) find a significant fall in sales after the VAT cut ended. Thus an indirect tax cut stimulates significant intertemporal substitution in purchases. To the best of our knowledge there are only two studies that analyse the recent German VAT reduction. Fuest et al. (2021) and Dullien et al. (2020) find that total consumption has increased by 0.6 percentage points. However, both studies rely on household surveys where it is difficult to detect intertemporal substitution effects.² Furthermore, they are not consistent to official National Account Statistics. In contrast to existing work, we use our DSGE model and simulate a specific sectoral lockdown shock in order to match the official data during the situation of 2 temporary lockdown shocks from 2Q2020 to 4Q2020. We run a counterfactual analysis in order to estimate the effects of the German VAT rate reduction in July 2020. Our estimates confirm the results of previous international studies of high substitution effects in case we explicitly consider the durable consumption goods. Our results for the effect of the VAT reduction are larger than the effects measured in survey studies, mainly because of the intertemporal substitution of consumer durables.

Finally, we contribute to the general debate about tax multipliers. Blanchard and Perotti (2002) show within a SVAR framework that tax multipliers in the USA are in general smaller than one. Mertens and Ravn (2011) summarizes that existing empirical estimates of US nationwide tax multipliers vary from close to zero to very large. They use a narrative measure as proxies for structural shocks to total tax revenues in an SVAR and find estimated tax multipliers at the higher end of the range: around two on impact and up to three after 6 quarters. They explain

²For example, a question to households "if additional consumption can solely traced back to the VAT reduction" can hardly measure the intertemporal substitution effect, which is rather a shift of consumption plans from subsequent years (e.g. household buys a car that he has planned to buy in 2022) than an additional consumption. Furthermore, the substitution effect is not only limited to the next year, but rather the whole lifetime consumption plan, which also includes this year. Thus, the VAT reduction could motivate households to consume what they originally planed in 2020 but what they postpone due to the pandemics.

earlier findings of lower multipliers by an output elasticity of tax revenues assumption that is contradicted by empirical evidence or by failure to account for measurement error in narrative series of tax shocks. Similarly [Romer and Romer \(2010\)](#) find that tax changes have very large effects on output in the USA. Their baseline specification suggests that an exogenous tax increase of one percent of GDP lowers real GDP by roughly three percent. In robustness checks they find that tax multiplier is well over two. However, most of these studies concentrate on total tax revenues for the US and do not consider the VAT rate in particular or European countries perspective. For the European case [Sims and Wolff \(2018\)](#) analyse state-specific specific tax shocks, also for the VAT rate. They find VAT multipliers of 0.2-0.5 on impact and 0.6-0.8 at the maximum depending on various factors, e.g. share of liquidity-constraint households. Therefore, from a public finance the VAT rate reduction seems not very effective. Furthermore, [Claus \(2013\)](#) explicitly analyses the effectiveness of a VAT rule as stabilization instrument. She finds that an VAT rule is not as effective as a monetary policy rule. However, we differ from both studies by incorporating durable and non-durable consumption, and analyze explicit situations such as the lockdown shock and a zero lower bound environment. Thus, we provide evidence for tax multipliers considering the durable investment effect during or shortly after an economic lockdown and under restricted monetary policy.

Finally, we also contribute to the literature on the effectiveness of fiscal policy measures if monetary policy is limited to the zero lower bound. [Correia et al. \(2013\)](#) show in the standard New Keynesian model, that tax policy can deliver such stimulus at no cost and in a time-consistent manner. Furthermore, [D'Acunto et al. \(2017\)](#) show that differences in timing of the announcement and start of the tax policy can generate inflation expectations and effect consumption expenditure. They especially concentrate on the announcement of a permanent VAT rate increase in Germany in 2006. Besides this general effects, a VAT rate reduction has specific advantages if monetary policy is limited when the zero lower bound on nominal interest rates binds. We contribute to this literature and compare the VAT reduction in a zero lower bound environment with an active monetary policy as stabilizing tool in a lockdown shock. Our simulation generally confirms the results that the VAT reduction can mimic monetary policy also in the specific situation of the lockdown.

2.2 Temporary VAT reduction in Germany 3Q2020-4Q2020

Due to the COVID-19 pandemics the German government decided to stimulate the economy via a temporary VAT rate reduction. From the 1st July 2020 to the end of the year the regular VAT rate has been reduced by 3 percentage points from 19 to 16. The VAT rate on necessities, i.e. food, has been reduced from 7 to 5 percent, originally planned until the mid of 2021, but will be extended to the end of 2022. The VAT reduction is part of a large stimulus package of 160 billion Euro that the German government launched in order to stabilize and stimulate the economy after the first lockdown.

The first lockdown occurred in the last 2 weeks of the 1st quarter 2020 and lasts until May 2020. Thus, the economy was most affected in the 2nd quarter 2020. [Figure 1](#) depicts the quarter-to-quarter growth rates of different consumption goods: expendable, short-lived, long-lived and services. This stylized patterns show that

durable goods, which are defined as short- and long-lived goods, were strongly affected by the lockdown shock.³ Especially the demand for long-lived goods was reduced cumulatively by almost 15 percent until 2Q2020 compared to the 4th quarter of 2019. Together with short-lived goods, the durable goods decreased by 14 percent. In the non-durable section, expandable goods, i.e. food, necessities, remained almost constant. However, in total, non-durable goods decreased by 11 percent, because the service sector, i.e. hotels, restaurants, was strongly affected (-17 percent). However, comparing consumer durables (short- and long-lived goods) and non-durables (expandables and services), the former seems to be more affected than the latter during the 1st lockdown period, mainly because also production capabilities were closed.

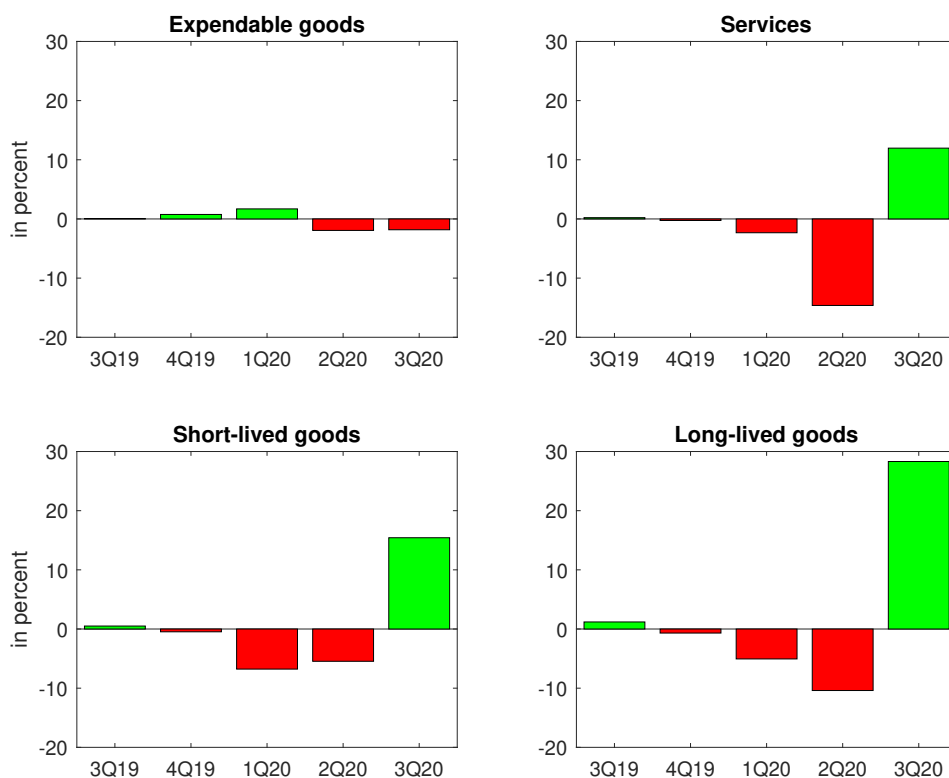


Figure 1: Real consumption by durability and the COVID-19 pandemics, quarterly q-o-q growth rate, 2019Q3-2020Q3

In the 3rd quarter all consumption components indicate a strong increase, but the increase for consumer durables was much larger than for all other goods. Especially, demand for long-lived goods increased strongly, by almost 28 percent compared to the previous quarter. Thus, the loss of total durables of the first two quarters was

³Consumer durable goods include furniture and household appliances (including kitchen equipment), personal transport equipment (i.e. vehicles), recreational and entertainment goods (including computers and communications equipment), other goods such as jewellery, clocks and watches, and therapeutic medical appliances and equipment. See [Casalis and Krustev \(2020\)](#) for a detailed description.

partially compensated in the 3rd quarter. In contrast, the recovery of non-durable consumption was much smaller. Two major aspects lead to this strong overshooting of durable consumption relative to non-durables. First, the recovery process leads to this V-shaped pattern. Second, the VAT rate reduction supports this development via the intertemporal substitution effect that pushes the recovery process. However, the question remains to what extend the VAT rate contributes to the recovery process.

However, the thrilling time patterns do not end at the 3rd quarter 2020. In the last quarter the pandemic development pushed Germany and many other countries into a 2nd lockdown, both durable and non-durable consumption decreases again. However, durable good producer did not closed down the production capabilities due to restrictions. Thus, the second question arises to what extend the 2nd lockdown dampens the effectiveness of the VAT reduction.

Following these time patterns and the questions arised, we build a structural dynamic general equilibrium model which incorporates not only durable and non-durable consumption but also the specific sectoral lockdown situation in Germany. We want to answer the two question that directly arise from observing the time patterns: First we assess how large the effect of the VAT rate reduction is and disentangle the VAT rate reduction from the lockdown shock and recovery process. Furthermore, we can use the advantage of structural modelling and run counterfactual analysis in order to measure the effect of the (unexpected) 2nd lockdown shock to the effectiveness of the VAT rate reduction.

However, before we can analyse this specific case of Germany in section 5, we want to start with a more general analysis of VAT rate changes. We need this exercise for two reasons: First, we want provide evidence for the durable investment channel, i.e. that VAT rate changes have relatively strong effects on durable goods in Germany. Thus, not considering the durable investment effect in DSGE models would underestimate the effectiveness of VAT rate changes. Second, we need empirical evidence of VAT rate changes and durable consumption goods to match specific parameters of the DSGE model.

2.3 SVAR evidence

We provide further, more general evidence on the strong and significant durable investment effects of VAT rate changes by estimating a structural vector autoregressive model (SVAR). Therefore, we use time series data for VAT revenues, durable and non-durable consumption in Germany from 1Q1991:4Q2018. In our baseline SVAR estimation, we apply the identifying assumption by [Blanchard and Perotti \(2002\)](#) and use evidence from a tax micro simulation model for Germany⁴ on the VAT elasticity to consumption in order to construct the cyclically adjusted reduced form tax residuals as instrument.⁵ Our basic VAR representation is

$$X_t = A(L, q)X_{t-1} + U_t \quad (1)$$

where $X_t \equiv [T_t^{vat}, G_t, C_t^i]'$ is a three dimensional vector with the logarithm of VAT revenues, public consumption and specific private consumption all in real terms. For private consumption $C_t^i = [ID_t, ND_t]$ we use either durable

⁴See [Bach et al. \(2006\)](#).

⁵See [Appendix B](#) for a description of the approach.

or non-durable consumption. $A(L, q)$ is a four-quarter distributed lag polynomial and U_t is a corresponding vector of reduced form residuals which in general has non-zero cross correlations. Usually, VAT revenues are paid with a delay of around 2 months, however in crisis situation tax deferrals are a widely used instrument. By allowing for four lags due to the quarterly data structure, we consider tax delays and deferrals. Furthermore, we consider quarterly dummies in order to capture specific tax-related seasonality.⁶ We apply the VAT elasticity of durable and non-durable consumption. According [Mourre and Princen \(2015\)](#) the VAT elasticity to total consumption lays between 0.9-1.4 in the EU. [Bach et al. \(2006\)](#) estimate steady-state VAT elasticities for different consumption groups in Germany. Based on these estimations we calculate an average tax elasticity for durable consumption of 1.76 and 0.8 for non-durable consumption.⁷ Finally, we control for announcement effects that occur because large permanent tax rate changes were implemented with a time up to 4 quarters. We also run an alternative estimation where we instrument the VAR rate changes with a series of official tax revenue estimates due to legislative tax law changes by the German Ministry of Finance.⁸

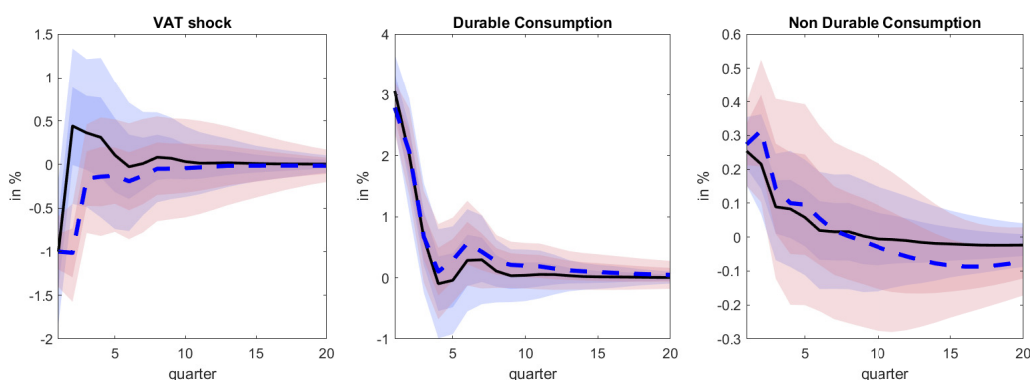


Figure 2: DSGE vs. SVAR, 1991Q1-2018Q4

black line, dark and light blue shaded area: Estimation based on [Blanchard and Perotti \(2002\)](#) Identification via tax revenue elasticity, mean, 68 and 95 percent significance level.
blue dashed line, dark and light red shaded area: Estimation based on a narrative series of exogenous tax law changes, mean, 68 and 95 percent significance level.

The estimated impulse response function are depicted in [Figure 2](#). The light and dark blue shaded areas depict the 68% and 95% significance level. Our estimations show that a one percent VAT revenue reduction increases durable consumption significantly by 2.7 percent on average (black line). Thus, the effect of the VAT reduction is much stronger for durable goods than for non-durable goods, where the 1 percent VAT revenue reduction increases non-durables by 0.25 percent. The positive effect to consumer durable is significant for 3 quarter, afterwards we observe a small negative counteraction. In case of non-durable the small positive effects smooth out after one year. This empirical evidence speaks in favor of the VAT rate as effective stabilization instrument and triggers our interest regarding the macroeconomic effects of VAT reduction: Therefore, in a next step we want to explore the main channels that drive this result. Then, we want to investigate how effective the VAT reduction is in the

⁶Furthermore, we control for reunification 1Q1991:2Q1992 and the financial crisis 4Q2008:2Q2009. However, both dummy variables do not change the results significantly.

⁷See section [B](#) in the Appendix for description.

⁸See table [5](#) in section [A](#) in the Appendix for the summary.

specific situation of a lockdown shock and under monetary at the zero lower bound. Both will give us further insights into the effectiveness of temporary VAT changes as a possible stabilization tool instrument in crisis.

3 Model

The model considers two infinitely-living household types which differ with respect to their savings behavior. Unrestricted households, also known as Ricardian households, have full access to financial markets, liquidity-constrained households, also known as Hand-to-mouth consumer, consume their total within period income. Both types buy durable and non-durable consumption goods produced by two different sectors $j = 1, 2$. Sector 1 produces durables, non-durables and investment goods and is completely closed if a lockdown shock occurs. Sector 2 produces all other private and public consumption and investment goods and is not directly affected by a lockdown shock. Firms are perfectly competitive and transform the final good into corporate investment, non-durables and durable investment using a linear production technology. The VAT rate affects households consumption demand and firms price setting behavior (limited pass-through).

3.1 Private households

The economy is populated by a continuum of households on the interval $[0, 1]$ of which a fraction n are liquidity-constrained and a fraction $1 - n$ are unrestricted households who own capital and firms. The liquidity status of household types are marked by the superscript l . Both household types $l = n, u$ optimize private consumption and leisure according to the following utility function

$$E_0 \sum_{t=0}^{\infty} c_t^d \left(\frac{(C_t^l)^{1-\sigma^c}}{1-\sigma^c} - \chi^j \frac{(L_t^l)^{1+\sigma^l}}{1+\sigma^l} \right), \quad (2)$$

where h considers the share of consumption habits and σ^c is the inverse intertemporal substitution elasticity. Both household types supply labor in both sectors j and consume non-durable goods $P^N N^{j,l}$ and durable goods $P^{D,l} D^{j,l}$ produced by both sectors. Preferences for durables and non-durables are specified as a CES utility function:

$$c_t^l = \left[(\psi^N)^{\frac{1}{\sigma^{n,d}}} (N_t^l)^{\frac{\sigma^{n,d}-1}{\sigma^{n,d}}} + (\psi^D \psi^{D1})^{\frac{1}{\sigma^{n,d}}} (D_t^{1,l})^{\frac{\sigma^{n,d}-1}{\sigma^{n,d}}} + (\psi^D \psi^{D2})^{\frac{1}{\sigma^{n,d}}} (D_t^{2,l})^{\frac{\sigma^{n,d}-1}{\sigma^{n,d}}} \right]^{\frac{\sigma^{n,d}}{\sigma^{n,d}-1}} \quad (3)$$

with ψ^N and ψ^D denote the shares of durables and non-durables. ψ^{D1} and ψ^{D2} measures the sectoral production share of durable goods and $\sigma^{n,d}$ is the elasticity of intratemporal substitution between durable and non-durables. The total durable and non-durable consumption baskets can be composed due to the sectoral production:

$$D_t^l = \left[(\psi^{D1})^{\frac{1}{\sigma^d}} (D_t^{1,l})^{\frac{\sigma^d-1}{\sigma^d}} + (\psi^{D2})^{\frac{1}{\sigma^d}} (D_t^{2,l})^{\frac{\sigma^d-1}{\sigma^d}} \right]^{\frac{\sigma^d}{\sigma^d-1}}, \quad (4)$$

$$N_t^l = \left[(\psi^{N1})^{\frac{1}{\sigma^n}} (N_t^{1,l})^{\frac{\sigma^n-1}{\sigma^n}} + (\psi^{N2})^{\frac{1}{\sigma^n}} (N_t^{2,l})^{\frac{\sigma^n-1}{\sigma^n}} \right]^{\frac{\sigma^n}{\sigma^n-1}}, \quad (5)$$

where ψ^{N1} , ψ^{N2} are the sectoral production shares for non-durables. $\sigma^d = \sigma^n$ are the sectoral substitution elasticities.

3.1.1 Unconstraint household

The household is not liquidity constraint and has access to one-period private domestic bonds B_t that pay 1 unit of the national currency in $t + 1$, sell at price R_t^{-1} . Additionally, the unconstraint household can rent out new capital to firms $P_t^I I_t$ and receives after-tax wage income, capital income from renting to firms, transfers from the government $P_t^Z Z_t$ and profits from firms D_t . The flow budget constraint for the unconstraint household is

$$\begin{aligned} & (1 + \tau_t^{vat})P_t^{1,N}N_t^{1,U} + (1 + \tau_t^{vat})P_t^{2,N}N_t^{2,U} + (1 + \tau_t^{vat})P_t^{1,D}ID_t^{1,U} + (1 + \tau_t^{vat})P_t^{2,D}ID_t^{2,U} + P_t^I I_t^U + B_t \\ & = R_{t-1}B_{t-1} + (1 - \tau_t^W)W_t L_t^U + R_t^k K_{t-1} - I_t \left(1 + \frac{\gamma^K}{2} \left(\frac{I_t}{K_t} - \frac{\bar{I}}{\bar{K}} \right)^2 \right) - \frac{\gamma^I}{2} (I_t - I_{t-1})^2 + Z_t + \Pi_t. \end{aligned} \quad (6)$$

The unconstraint household buys non-durable goods $N_t^{j,U}$ and new durable consumption $ID_t^{j,U}$ at net prices $P_t^{j,N}$ and $P_t^{j,D}$. She pays value added tax for the use of existing durables as well as for the purchase of new durables. $P_t^{j,N}$ and $P_t^{j,D}$ are the non-durable and durable net consumer prices set by the firms. The total labor income of the unconstraint household is $W_t L_t^U$. Furthermore, she holds the aggregate capital stock K_t and takes new investments I_t . Capital accumulation come along with capital adjustment costs $\frac{\gamma^K}{2} \left(\frac{I_t}{K_t} - \frac{\bar{I}}{\bar{K}} \right)^2$ and with investment adjustment costs $\frac{\gamma^I}{2} (I_t - I_{t-1})^2$. The aggregate capital stock and aggregate investment is used in both sectors $k_t = k_t^1 + k_t^2$ and $I_t = I_t^1 + I_t^2$. The sectoral capital stocks k_t^j evolve according to the following definition:

$$k_t^j = (1 - \delta^j)k_{t-1}^j + I_t^j. \quad (7)$$

where δ^j is the rate at which the capital stock depreciated. The relative price for capital q_t^j can be derived from the first order conditions under:

$$E_t R_{t+1}^k = \frac{(1 + E_t \pi_{t+1}^{C,U}) U_t^{C,U} q_t^j}{\beta (U_{t+1}^{C,U}) (E_t q_{t+1}^j)} - (1 - \delta) \quad (8)$$

The rate of capital return is:

$$E_t R_{t+1}^k = \alpha^k \left(1 - \left(\mu^P + \gamma^{1,P} \left(\beta \left(s^P \left(\pi_t^{1,N} + E_t \Delta \pi_{t+1}^{1,N} \right) + \left(1 - s^P \right) \pi_{t-1}^{1,N} \right) - \pi_t^{1,N} \right) \right) \right) P_t^{1,N} \frac{y_t^j}{k_t^j}. \quad (9)$$

. The stocks of durable goods D_t^S produced in both sectors $j = 1, 2$ which the saver household consumes or rent out follows the following accumulation rule:

$$D_t^{j,S} = (1 - \delta_t^d) D_{t-1}^{j,S} + P_t^{j,D} ID_t^{j,S}, \quad (10)$$

where $ID_t^{j,S}$ denotes the unconstrained household purchases of (new) durable investments in sector j and $P_t^{j,D}$ is the price of durable in sector j relative to the aggregate durable price.⁹

The first-order conditions of the optimization problem gives typical the intertemporal consumption and investment Euler equations, labor supply, optimal durable and non-durable consumption.¹⁰ Here, we focus on how the demand for durables and non-durables responds to actual and expected changes in value added taxes. The Euler equation for the consumption aggregate is

$$\frac{C_{t+1}^U}{C_t^U} = \beta(1 + i_t) \frac{P_t^{C,U}}{P_{t+1}^{C,U}} \quad (11)$$

where the consumer price deflator for unconstrained households consists of the price for non-durables and the service price for durables.¹¹

$$P_t^{C,U} = \left(\bar{\psi}^N (P_t^N)^{1-\sigma^{n,d}} + \bar{\psi}^D \left((1 + \tau_t^{vat}) P_t^D R_t^{D,U} \right)^{1-\sigma^{n,d}} \right)^{\frac{1}{1-\sigma^{n,d}}}, \quad (12)$$

where $\bar{\psi}^N$ and $\bar{\psi}^D$ are the consumption shares for durable and non-durable consumption. $R_t^{D,U}$ can be regarded as a rental price for durables which has to be considered as additional price component for new durables (durable investment price). R_t^D differs between household types, because the access to financial markets real rates determines the underlying opportunity costs. For the unconstrained household the real market rate is relevant:

$$R_t^{D,U} = r_t - E_t \pi_{t+1}^D + \delta^d - (E_t \tau_{t+1}^{vat} - \tau_t^{vat}) \quad (13)$$

A temporary reduction of the value added tax rate leads to an increase of current consumption because of an expected consumer price inflation effect. As can be seen from the first order conditions, in case of an expected temporary VAT reduction, durables and non-durables are affected differently

$$N_t^U = \bar{\psi}^N \left(\frac{(1 + \tau_t^{vat}) P_t^N}{P_t^{C,U}} \right)^{-\sigma^{n,d}} C_t^U, \quad (14)$$

$$D_t^U = \bar{\psi}^D \left(\frac{(1 + \tau_t^{vat}) P_t^D}{P_t^{C,U}} \left(R_t^{D,U} \right) \right)^{-\sigma^{n,d}} C_t^U, \quad (15)$$

Putting both together, we get the relative demand function for the unconstrained household:

$$\left(\frac{\bar{\psi}^D}{\bar{\psi}^N} \right)^{\frac{1}{\sigma^{n,d}}} \left(\frac{N_t^U}{D_t^U} \right)^{\frac{1}{\sigma^{n,d}}} = \frac{P_t^D}{P_t^N} R_t^{D,U} \quad (16)$$

In case of a temporary VAT reduction in period t , the ratio of durables to non-durables increases because the service price for durables declines in anticipation of a VAT increase in $t + 1$. This, however hinges on a constant nominal interest rate and limited expected inflation differential between the durables price and the price of final

⁹Note that by assumption durable goods are produced under perfect competitive markets and according to a linear production technology. Thus, the aggregate durable good price p^D is equal to the producer price p^y .

¹⁰See model description in Appendix.

¹¹For clarity reasons we do not display the sectoral demand functions.

goods π_{t+1}^D (both excluding VAT) as well as limited variation between the durables and non-durables price in t . In the current juncture, with a ZLB for the nominal interest rate, i_t remains constant. Because of limited pass-through there will be an expected decline of π_{t+1}^D , however, this effect will in general be smaller than the expected increase of VAT, except in the case of zero pass-through. The relative price between durables and non-durables remains likely to be small in the case without adjustment costs for durables, because both goods are affected by the same VAT shock. With adjustment costs for durables, P_t^D includes adjustment costs and thus increases relative to P_t^N . It should also be noted that even a small growth differential between the stock of durables and non-durables will lead to large differences in durable investment.

3.1.2 Liquidity-constrained households

We assume that the liquidity constrained household has identical preferences of durable and non-durable goods as the unconstrained household. With the choice over durables and non-durables the LC household also has to solve an intertemporal maximization problem constrained by a sequence of period budget constraints

$$(1 + \tau_t^{vat})P_t^{N1}N_t^{1,LC} + (1 + \tau_t^{vat})P_t^{N1}N_t^{2,LC} + (1 + \tau_t^{vat})P_t^{D1}D_t^{1,LC} + (1 + \tau_t^{vat})P_t^{D2}D_t^{2,LC} = (1 - \tau_t^W)W_tL_t^{LC} + Z_t, \quad (17)$$

where $W_tL_t^{LC}$ is the labor income and $P_t^Z Z_t^{LC}$ is the transfer income of the liquidity-constrained household. The budget constraint implies that expenditure over non-durables and new durables is constrained by current net income.

Furthermore, liquidity-constraint households face a durable accumulation constraint

$$D_t^{j,LC} = (1 - \delta_t^d)D_{t-1}^{j,LC} + P_t^{j,D}ID_t^{j,LC}. \quad (18)$$

$ID_t^{j,LC}$ denotes the liquidity-constraint household purchases of new durables produced in sector j . The allocation of spending across durables and non-durables is determined by the following first order conditions:

$$N_t^{LC} = \bar{\psi}^N \left(\frac{(1 + \tau_t^{vat})P_t^N}{P_t^{C,LC}} \right)^{-\sigma^{n,d}} C_t^{LC}, \quad (19)$$

$$D_t^{LC} = \bar{\psi}^D \left(\frac{(1 + \tau_t^{vat})P_t^N}{P_t^{C,LC}} (R_t^{D,LC}) \right)^{-\sigma^{n,d}} C_t^{LC}, \quad (20)$$

$$\frac{P_t^D}{P_t^N} = \left(\frac{\bar{\psi}^D}{\bar{\psi}^N} \right)^{\frac{1}{\sigma^{n,d}}} \left(\frac{N_t^{LC}}{D_t^{LC}} \right)^{\frac{1}{\sigma^{n,d}}} (R_t^{D,LC})^{-1} \quad (21)$$

These conditions are similar to case of unconstrained consumers. Note, however, without access to financial markets, the marginal rate of substitution between current and future consumption is not given by the market interest rate but by the rate of time preference, the expected growth rate of liquidity constrained consumption plus the expected growth rate of the consumer price index. Thus the rental rate R_t^{LC} is

$$R_t^{D,LC} = \rho + (E_t C_{t+1}^{LC} - C_t^{LC}) + E_t \pi_{t+q}^{C,LC} - E_t \pi_{t+1}^D + \delta^d - (E_t \tau_{t+1}^{vat} - \tau_t^{vat}) \quad (22)$$

Factors which increase the ratio of durables to non-durables in t are the expected increase in VAT as well as the expected decline of liquidity constrained consumption in $t + 1$. This is mitigated by the expected increase in the consumer price deflator and limited VAT pass-through.

3.2 Intermediate goods producer and VAT

In each sector there exists a continuum of intermediate firms indexed by $i \in [0,1]$. Each firm i in sector $j = 1,2$ produces an intermediate good according to the following production technology:

$$y_t^j(i) = A^j k_t^j(i)^{\alpha^k} (L_t^j)^{\alpha^L}, \quad (23)$$

where $\alpha^k, \alpha^L \in [0,1]$ are the partial production elasticities. A^j is the total factor productivity in each sector. Cost minimization under an identical production technology implies that firms have identical marginal costs per unit of output

$$MC_t^j = (\alpha^L)^{-\alpha^L} (\alpha^k)^{-\alpha^k} (W_t^j)^{\alpha^L} (R_t^{1,k})^{\alpha^k}. \quad (24)$$

We assume that individual firms in each sector pass-through the same average VAT tax as the average firm over both sectors. Furthermore, the elasticity of intraindustrial substitution η^j is equal in both sectors. Thus, the demand for firm i 's output is given by

$$Y_t^j(i) = \left(\frac{(1 + \tau_t^{vat}) P_t^j(i)}{(1 + \tau_t^{vat}) P_t^j} \right)^{-\eta^P} Y_t^j = \left(\frac{P_t^j(i)}{P_t^j} \right)^{-\eta^P} Y_t^j, \quad (25)$$

where Y_t^j is the final demand and P_t^j is the sectoral producer price. The prices are set according to [Rotemberg \(1982\)](#) via quadratic adjustment costs which includes the value added tax:

$$\Delta_t^{j,P} = \frac{\gamma^{j,P}}{2} Y_t \left[\frac{P_t^j(i)(1 + \tau_t^{vat})}{\Pi_{t-1}^{s^P} \bar{\Pi}_t^{1-s^P} P_{t-1}^j(i)(1 + \tau_{t-1}^{vat})} - 1 \right]^2. \quad (26)$$

Taking into account that the firm knows that all competitors also pay VAT the price setting problem simplifies and VAT only appears in the price adjustment cost term. The problem firm i faces when there is an exogenous change in τ_t^{vat} is how to set the price $P_t^j(i)$ such that the price adjustment cost for $(1 + \tau_t^{vat}) P_t^j(i)$ is minimized.

$$\Pi_t^j = E_t \sum_{t=0}^{\infty} (\beta)^t \left(\left(\frac{P_t^j}{P_t^j} \right) Y_t^j - \frac{W_t^j L_t^j(i)}{P_t^j} - \frac{\gamma^{j,P}}{2} Y_t \left[\frac{P_t^j(i)(1 + \tau_t^{vat})}{\Pi_{t-1}^{s^P} \bar{\Pi}_t^{1-s^P} P_{t-1}^j(i)(1 + \tau_{t-1}^{vat})} - 1 \right]^2 \right). \quad (27)$$

Maximizing the profit Π_t^j with respect to the demand equation (25) and the production function (23) gives the price-setting equation:

$$MC_t^j = \left(1 + \frac{1}{\eta^P} \right) + \beta \frac{\gamma^P}{\eta^P} \left(E_t \pi_{t+1}^j + \left(\frac{1}{1 + \tau^{vat}} \right) (E_t \tau_{t+1}^{vat} - \tau_t^{vat}) - \frac{\gamma^P}{\eta^P} \left(\pi_t^j + \left(\frac{1}{1 + \tau^{vat}} \right) (\tau_t^{vat} - \tau_{t-1}^{vat}) \right) \right). \quad (28)$$

3.3 Retail sector

Firm j in the retail sector transforms final goods $Y(j)_t$ into consumer goods $Y_t^C(j)$. We assume that retailers have market power (monopolistic competition) and face quadratic costs of adjusting prices (including VAT). The retailer buys inputs at price P_t and sells them at price $P_t^C(j)(1 + \tau_t^{vat})$. Firm j maximizes profits

$$\Pi_t = P_t^C(j)(1 + \tau_t^{vat})Y_t^C(j) - P_t Y_t - \frac{\gamma^P}{2} \left[\frac{P_t^C(j)(1 + \tau_t^{vat})}{(\Pi_{t-1}^C)^{s^P} (\Pi_{t-1}^C)^{1-s^P} P_{t-1}^C(j)(1 + \tau_{t-1}^{vat})} - 1 \right]^2 - \tau_t^{vat} P_t(j) Y_t(j) \quad (29)$$

subject to a simple linear production technology

$$Y_t^C(j) = Y_t(j) \quad (30)$$

and the demand equation

$$Y_t^C(j) = \left(\frac{P_t^C(j)(1 + \tau_t^{vat})}{P_t^C(1 + \tau_t^{vat})} \right)^{-\eta^P}, \quad (31)$$

where the VAT is not relevant because competitors face the same VAT. Taking into account that the firm knows that all competitors also pay VAT the price setting problem simplifies and VAT only appears in the price adjustment cost term. The problem firm j faces when there is an exogenous change in τ_t^{vat} is how to set the price $P_t(j)$ such that the price adjustment cost for $P_t(j)(1 + \tau_t^{vat})$ is minimized.

$$\Pi_t(j) = E_t \sum_{t=0}^{\infty} (\beta)^t \left(\left(\frac{P_t^C(j)}{P_t^C} \right) Y_t(j) - \frac{P_t Y_t(j)}{P_t^C} - \frac{\gamma^{j,P}}{2} Y_t \left[\frac{P_t^C(j)(1 + \tau_t^{vat})}{\Pi_{t-1}^{s^P} \bar{\Pi}_t^{1-s^P} P_{t-1}^C(j)(1 + \tau_{t-1}^{vat})} - 1 \right]^2 \right). \quad (32)$$

Maximizing the profit $\Pi_t(j)$ with respect to the demand equation (25) and the production function (23) gives the price-setting equation:

$$MC_t^C = \frac{P_t^C}{P_t^Y} = \left(1 + \frac{1}{\eta^P} \right) + \beta \frac{\gamma^P}{\eta^P} \left(E_t \pi_{t+1}^j + \left(\frac{1}{1 + \bar{\tau}^{vat}} \right) (E_t \tau_{t+1}^{vat} - \tau_t^{vat}) - \frac{\gamma^P}{\eta^P} \left(\pi_t^j + \left(\frac{1}{1 + \bar{\tau}^{vat}} \right) (\tau_t^{vat} - \tau_{t-1}^{vat}) \right) \right). \quad (33)$$

Suppose there is a VAT reduction in t and an expected increase (to previous level) in $t + 1$. From the equation above we can see that it is optimal for the firm to increase the mark-up temporarily. Both $\tau_t^{vat} - \tau_{t-1}^{vat} < 0$ and $E_t \tau_{t+1}^{vat} - \tau_t^{vat} > 0$ affect the mark-up positively. This implies that an expected temporary reduction of the mark-up leads to a larger increase in the mark-up compared to a permanent reduction of τ_t^{vat} or an expected permanent increase of $E_t \tau_{t+1}^{vat}$. In this case it is optimal for the firm to increase the mark-up already in t such as to avoid adjustment costs from an abrupt change of prices in $t + 1$.

3.4 Labor agency

Each household supplies a continuum of differentiated labor services indexed by l . These differentiated labor services are supplied by both savers and liquidity-constrained households. A competitive labor agency combines

the differentiated labor services into a homogeneous labor input which is sold to the intermediate firms. The labor demand function for different labor types is

$$L_t(l) = n_t \left(\frac{W_t(l)}{W_t} \right)^{-\frac{1+n_t^w}{\eta_t^w}}, \quad (34)$$

where n_t is the demand for composite labor services and W_t is the aggregate nominal wage that satisfies $W_t = \left(\int_0^1 W_t(l)^{\frac{1}{\eta_t^w}} dl \right)^{\eta_t^w}$. The real wage can be derived from solving the optimal labour supply decision of the households:

$$w_t^{j,C} = \frac{(1 - LD_t^j) (-u_t^{j,n}) (1 + \mu^W + \gamma^{j,W} (\beta (s^P (\pi_t^{j,W} + E_t \Delta \pi_{t+1}^{j,W}) + (1 - s^P) \pi_{t-1}^{j,W}) - \pi_t^{j,W}))}{(nu^{LC} U_t^{C,LC} + U_t^{C,S} (1 - nu^{LC})) (1 - \tau^w)}, \quad (35)$$

where $u_t^j = -\chi * (n_t^j)^\rho$ is the marginal utility of supplying an extra unit labor. The dynamic wage equation can be transformed into the well known Wage Phillips Curve.¹²

3.5 Monetary and fiscal policy

Monetary policy is conducted by the central bank according to the following rule:

$$i_t = \max \left[\underline{i}, (1 - \phi^i) (\bar{r} + \phi^\pi (\pi_t^Y) + \phi^{dy} (y_t - y_{t-1})) + \phi^i i_{t-1} + e_t^i \right], \quad (36)$$

where ϕ^π and ϕ^Y denote the weights for inflation and growth target of the central bank. If the interest rate is above the lower bound \underline{i} , the central bank follows a Taylor-type rule in which nominal interest rate i_t responds to its lagged value, the current inflation rate, and current output growth.

We assume a simplified government budget function, where the government spends a constant fraction of steady-state GDP g and finances its expenditures either with new debt $B_t - B_{t-1}$ or different taxes on value added, labor income and a lump-sum tax or transfer (if negative). Furthermore, the government pays interest rates on issued debt $r_t^B B_{t-1}$:

$$B_t = \bar{G} + \left(1 - \frac{u_t^r}{U_t^{C,S}} \right) (1 + r_{t-1}^B) B_{t-1} - L_t^2 W_t^2 \tau^w - L_t^1 P_t^{1,N} \tau^w W_t^1 - Z_t - N_t \tau_t^{vat} - ID_t \tau_t^{vat}. \quad (37)$$

The real interest rate on government debt differs from the real rate by its risk premium $\Delta_t^{rb-r} = \left(1 - \frac{1+r_t^b}{1+r_t} \right) U_t^{C,S}$. The VAT rate follows a mean-reverting process $\tau_t^{vat} = \bar{\tau}^{vat} + \epsilon_t^{vat}$, where ϵ_t^{vat} a VAT rate shock with mean zero and positive variance. The government follows a fiscal debt rule, where lump-sum taxes or transfers (if negative) are set according to the recent debt to GDP ratio. In case of the lockdown shock, we assume that the government break off the fiscal rule for 8 quarters. Afterwards it is reintroduced.

$$Z_t = (D_t^B + \phi_z) Z_{t-1} + D_t^B (1 - \phi_z) (1 - e_t^b) \left(\phi_{by} \left(\frac{B_t}{y_t} - \left(\frac{\bar{B}}{\bar{y}} + u_t^r \right) \right) + \phi_{db} (B_t - B_{t-1}) \right), \quad (38)$$

¹²See [Orlandi et al. \(2018\)](#).

where ϕ_z is a persistence parameter of the fiscal rule and ϕ_{by} measures the responsiveness of the lump-sum tax to deviations in the debt-to-GDP ratio from its target value. Furthermore, within the fiscal rule the responsiveness of new debt issued is weighted by ϕ_b . Finally, $D_t^B = [0,1]$ is a dummy variable that allows to turn off the debt rule temporary.

3.6 Market clearing

Market clearing in both sectors imply that sectoral supply must equal demand:

$$y_t^1 = nID_t^{1,LC} + (1-n)ID_t^{1,S} + nN_t^{1,LC} + (1-n)N_t^{1,S}, \quad (39)$$

$$y_t^2 = nID_t^{2,LC} + (1-n)ID_t^{2,S} + nN_t^{2,LC} + (1-n)N_t^{2,S} + I_t^1 + I_t^2 + g, \quad (40)$$

where capital goods are only produced in the sector 2. The gross domestic product is defined as $y_t = y_t^1 + y_t^2$. The GDP deflator is defined as:

$$p_t^Y = (1-s_t)p_t^{1,y} + s_t p_t^{2,y} \quad (41)$$

with $s_t = \frac{y_t^2}{y_t}$ representing the time-varying share of the non-affected sector output.

3.7 Parameterization

The empirical validation of our model is provided by setting parameters such that empirical observations for Germany are matched by the theoretical model. The parameter set is split into two different types of parameters. We calibrate the first subset of parameters either by relying on values commonly used in the literature or by matching long-run trends and policy targets.¹³ The second part of parameter values consist of lockdown-specific parameters for which a direct empirical counterpart is hard to detect. Therefore, we set them to match the reaction of durable and non-durable consumption after the lockdown shock. Table 1 displays a summary of parameters.

We assume that the utility function is logarithmic in consumption and set the inverse of the intertemporal substitution elasticity σ^c equal to one. Furthermore, the time preference factor β is set to 0.995 to match a steady-state interest rate of 2 percent. The capital share $\alpha = 0.3$ correspondes to the average capital share in Germany between 1991 to 2018. The parameter that determines the Frisch elasticity (at the intensive and extensive margin) of total labor volume (supply) σ^l is set to one. The share of liquidity-constraint households n is set to 0.28 according to [Grabka and Halbmeier \(2019\)](#). The quarterly depreciation rate for private investments δ^j is set to 0.015 as in [Coenen et al. \(2013\)](#) and we adopt this value to set the quarterly depreciation rate for durable consumption goods δ^d .¹⁴ We set government consumption per GDP \bar{g}/\bar{y} and durable consumption per total consumption ψ^d both to 20 percent according to the observed time series average value.

The second parameter blocks consist of adjustment cost and lockdown parameters. Price adjustment costs are set to $\gamma^{p,1} = 8$ in the non-affected sector and $\gamma^{p,2} = 16$ in the affected sector. The parameter values are smaller

¹³See i.e. [Gadatsch et al. \(2016\)](#), [Drygalla et al. \(2020\)](#).

¹⁴[Monacelli \(2009\)](#) discusses the heterogeneity between durable goods regarding the depreciation rate, because goods like vehicles have high annual depreciation rates around 15 percent, while long-lived durables like housing has much lower rates between 1% and 3%. He chooses an annual value of 1% because he mainly focuses on housing.

than usually observed in the literature for two reasons: First, because we want to analyze the temporary VAT shock, we would expect that firms - in case they pass-through VAT changes - will relatively fast change prices once the VAT rate is reduced but also if the VAT rate raises back to its steady state value. Second, the lockdown shock is a very specific situation because in the affected sector the market breaks down such that the shadow price go to almost infinity. If we assume high price rigidity this large price fluctuations would translate into subsequent periods. Further adjustment costs for wages $\gamma^{w,1}$, $\gamma^{w,2}$, investments γ^j and capital γ^k are set closed to values found in the literature.¹⁵ Finally, the adjustment cost parameter for durable consumption γ^d is set to 5. The non-durable consumption per GDP ratio is set to the empirical counterpart of 0.43. The affection rates $\psi^{D,LD}$, $\psi^{ND,LD}$ are difficult to determine empirically, because our design of the lockdown shock, affected firms reduce production by 100 percent. But many affected firms are not closed down fully. Thus, the affection rates measure the full affection equivalent. We finally calibrate the affection rates for durable and non-durable such that it matches the reaction of durable and non-durable consumption in response to the lockdown shocks. Similarly, we proceed in case of calibrating the production shares of durable and non-durable ψ^{D1} , ψ^{N1} in the lockdown sector to match the observed GDP path. We choose a low substitution elasticity between durables and non-durables $\sigma^d = 0.25$ to mimic that both sectors are affected from the lockdown shock. If we follow [Monacelli \(2009\)](#) and choose $\sigma^d = 1$ the strong reduction of non-durables during the lockdown period is partially compensated by an increase of durable consumption demand. Finally, we set the sectoral substitution elasticity $\sigma^{1,2}$ equal to 0.9 in order to consider the complementing structure of affected and non affected sectors.¹⁶

Finally, monetary and fiscal policy parameters are set mainly according to the literature. As for the monetary policy rule - if it applies - , we set the weight for interest rate smoothing ϕ^i to 0.85, the CPI inflation stabilizing weight ϕ^π to 1.5, the output gap target parameter ϕ^y to 0.1 and the output growth target ϕ^{dy} to 0.2.¹⁷ In the fiscal sector, we set the steady state government debt-to-GDP ratio \bar{b}/\bar{y} equal to 60% on an annual basis. The steady state VAT rate $\bar{\tau}^{vat}$ is equal to 0.17, which matches the average VAT rate.¹⁸ The parameter ϕ_b captures the strength of the reaction of lump-sum taxes to deviations of total government debt level from target is set to 0.63. The parameter that accounts for issuing new debt ϕ_b is set to 0.06.

4 Results

4.1 Main Channels of a Temporary VAT reduction

We first start with a general model-based assessment of the temporary VAT reduction without considering the specific situation of Germany, i.e. the lockdown and the monetary policy operating at the zero lower bound.¹⁹

¹⁵See [Burgert et al. \(2020\)](#).

¹⁶See [Guerrieri et al. \(2020\)](#).

¹⁷Although in the counterfactual simulation of the VAT reduction we model a zero lower bound scenario, the monetary policy rule is still important because agents it determines the expectations in case of price increases. Furthermore, we simulate VAT shocks more generally and analyze relevant channels.

¹⁸Note that the VAT tax rate for most consumption goods is 19 percent. Some consumption goods, i.e. food, necessities, have reduced tax rates of 7 percent.

¹⁹In this exercise, we solve the model with respect to a 1 percentage points decrease of the VAT rate, without lockdown shocks and with a active monetary policy following a standard Taylor Rule.

Table 1: Parameterization

	Parameter	Value	Note
Structural parameter			
Time preference	β	0.995	Annual real rate $\bar{r} = 1\%$
Liquidity constraint HH	n	0.28	Direct Match
Capital share	α	0.33	
SE labour supply	σ^l	1	See text
SE intertemporal consumption	σ^c	1	See text
Share depreciation rate (investment)	δ^j	0.015	Burgert et al. (2020)
Share depreciation rate (durables)	δ^d	0.015	See text
Gov. consumption/GDP	\bar{g}/\bar{y}	0.2	Direct Match
Durable consumption share	ψ^d	0.2	Direct Match
Adjustment costs			
Price adj. costs (A sector)	$\gamma^{p,1}$	8	See text
Price adj. costs (NA sector)	$\gamma^{p,2}$	16	Burgert et al. (2020)
Wage adj. costs (A sector)	$\gamma^{w,1}$	80	See text
Wage adj. costs (NA sector)	$\gamma^{w,2}$	80	See text
Investment adj. costs	γ^j	60	See text
Capital adj. costs	γ^k	20	Burgert et al. (2020)
Durable adj. costs	γ^d	10	See text
Lockdown sector parameter			
Non-Durable consumption per GDP	LD	0.43	Direct Match
Affection rate durable (full aff. equiv.)	$\psi^{D,LD}$	0.004	Lockdown match
Affection rate non-durable (full aff. equiv.)	$\psi^{ND,LD}$	0.055	Lockdown match
Production share A sector (durables)	ψ^{D1}	0.038	Lockdown match
Production share A sector (non-durables)	ψ^{N1}	0.124	Lockdown match
SE between sectors	$\sigma^d = \sigma^n$	0.9	Lockdown match
SE between durables and non-durables	$\sigma^{n,d}$	0.25	See text
Labour supply preference (lockdown sector)	χ^1	0.9	$\bar{w}(1 - \bar{\tau}^w) \left(\frac{n}{\bar{c}^{LC}} + \frac{1-n}{\bar{c}^S} (\bar{L}^1)^{-\sigma^l} \right)$
Labour supply preference (sector 2)	χ^2	0.9	$\bar{w}(1 - \bar{\tau}^w) \left(\frac{L}{\bar{c}^{LC}} + \frac{1-n}{\bar{c}^S} (\bar{L}^2)^{-\sigma^l} \right)$
Monetary policy			
Taylor Rule: IR smoothing	ϕ^i	0.85	
Taylor Rule: Inflation	ϕ^{pi}	1.5	
Taylor Rule: Output	ϕ^y	0.2	
Fiscal policy			
Public debt to GDP	\bar{b}/\bar{y}	2.4	60% Debt-to-GDP ratio
VAT rate (average)	$\bar{\tau}^{vat}$	0.19	
Fiscal rule: Stance of public debt level	ϕ_b	0.625	
Fiscal rule: Stance of new debt	ϕ_b	0.0625	
Fiscal rule: Smoothing	ϕ_t	0.1	

The objective is to describe briefly the main channels at work and classify our results regarding the inclusion of consumer durables and an incomplete pass-through into the relevant literature.

In our model we distinguish between major channels through which the value added tax affects private consumption:²⁰ substitution, income, durable investment, pass-through effects. The effects are quantified via different model simulations and summarized in table 2.²¹ The GDP effect (VAT multipliers) is defined as:

²⁰See Barrell and Weale (2009).

²¹We disentangle the effects by deactivation of the respective channel via parameterization.

$$\frac{\sum_{t=0}^k \Delta y_{t+k}}{\sum_{t=0}^k \left(\Delta \tau_{t+k}^{VAT} ((1 - \psi^D) \bar{d} + \psi^D \bar{i}^d) \right)} \bar{y}' \quad (42)$$

Similarly the effects on real consumption is:

$$\frac{\sum_{t=0}^k \Delta c_{t+k}}{\sum_{t=0}^{20} \left(\Delta \tau_{t+k}^{VAT} ((1 - \psi^D) \bar{d} + \psi^D \bar{i}^d) \right)}. \quad (43)$$

We abstract from heterogeneities across consumption goods, sectors and households. Thus, we set the shares of durable goods $\gamma^{Dj} = 0$ on total consumption demand and do not account for structural differences between both sectors. In this rudimentary scenario the substitution effect works as people bring their consumption forward. Furthermore, an income effect can occur as people benefit from lower cost of living during the period of reduction. If the share of liquidity-constraint households is zero, the income effect diminishes because saver households expect that recent tax reductions are financed via future tax changes or expenditure reductions. Therefore, they only shift consumption over time. However, in our baseline parameterization households use the income increase directly to consume more.

Table 2: VAT Multiplier and Effects - Main Channels

Frequency	GDP ¹	Consumption ²	Investment ³
Impact multiplier (1st year)			
only income effect	0.25	0.24	0
with substitution effect (w/o durables)	0.35	0.37	-0.03
with durable effect (incomplete pass-through)	1.00	1.01	0.01
with durable effect (full pass-through)	1.87	1.87	0.00
Cumulative multiplier (after 5 years)			
only income effect	0.23	0.23	-0.03
with substitution effect w/o durables	0.31	0.40	-0.08
with durable effect (incomplete pass-through, 60%)	1.24	1.14	0.10
with durable effect (full pass-through)	2.31	2.14	0.21

The relevant behavioral parameter to disentangle the income from the substitution effect is the elasticity of intertemporal substitution σ . If we set the elasticity equal to zero, the households will not shift consumption across period due to price changes. Only the liquidity-constraint household consume. With an elasticity of intertemporal substitution of greater than zero, the saver household changes his consumption path due to the relative price change. In our baseline model the income effect will increase by 0.25 Euro on impact and 0.23 Euro in total per unit VAT revenue reduction. The substitution effect increases total consumption on impact but is smaller in subsequent periods. Therefore, in total the VAT tax multiplier is 0.35 on impact and 0.31 cumulative over 5 years considering only substitution and income effect in our baseline calibration. As can be seen, the total effect is mainly driven by private consumption, which increases by 0.37. The investment response is negative, considering only the substitution and income effect with immediate wage and price adjustments and full pass-through, leads to little crowding-out of investment, because the saver household reduces investment spending in order to pay higher

lump-sum tax which increases due to debt consolidation.

Our findings confirms the results of previous studies for the quantitative effects of temporary VAT reductions in the literature²² and the implications that the VAT reduction is an effective but not the most efficient instrument to stabilize the business cycle.²³ However, until now we do not distinguish between durables and non-durables. Thus, the durable investment and arbitrage effect is not included. Usually, households buy non-durable goods before the end of the period of low VAT for consumption after the VAT rate as been raised. Furthermore, as shown in the model - similar to an interest rate decrease - the expected VAT change directly affects the prices for durable goods, and thus total consumption. If we include durable and non-durable consumption, the consumption effect increases significantly to more than 1 in the first year even slightly increases over the medium-term. Furthermore, simulating the model with an full pass-through the durable effect almost doubles. Besides the strong positive consumption effect, also investments increases over the medium term. The main reason for the observed crowding-in effect of investments is the accommodating monetary policy response.

4.2 Parameter robustness

In this section we test the robustness of our results with respect to the chosen parameter set. For specific policy and behavioral parameters we set a maximum and minimum range of plausible values out of our literature review. Thereby, we want to detect important parameters that drive the macroeconomic effects of the VAT change significantly and provide further robustness to our results. Table 3 summarizes our robustness exercise. Three

Table 3: Robustness

	span	GDP		Consumption		Investment	
		1y	5y	1y	5y	1y	5y
Monetary policy							
IR smoothing	0.60-0.95	1.03-1.12	1.01-1.53	1.01-1.09	0.96-1.33	0.00	0.00-0.18
Inflation target	1.01-2.00	1.06-1.26	1.16-2.00	1.05-1.21	1.08-1.42	0.00	0.06-0.31
Output target	0.00-0.30	0.78-1.09	0.38-1.56	0.82-1.06	0.54-1.31	-0.05-0.02	-0.16-0.24
Adj. costs							
Inv. adj. costs	40-120	1.08-1.09	1.26-1.27	1.06-1.07	1.15-1.17	0.00	0.08-0.10
Price adj. costs	0-40	1.01-1.16	1.16-1.52	1.01-1.12	1.08-1.32	0-0.02	0.07-0.18
Price adj. costs Retailer	0-40	0.84-1.36	1.11-1.55	0.82-1.34	1.06-1.40	0-0.01	0.03-0.13
Wage adj. costs	60-120	1.07-1.10	1.14-1.39	1.06-1.07	1.09-1.23	0-0.01	0.04-0.15
Durable adj. costs	0-10	0.83-3.90	0.91-5.51	0.82-3.80	0.87-4.49	0-0.09	0.02-0.96
Consumption habit	0-0.8	1.08-1.15	1.26-1.44	1.06-1.13	1.16-1.35	0.00	0.07-0.09

aspects are noteworthy: First, the VAT multiplier with durable consumption across plausible parameter values reaches values between 0.7 and 3.9 in the first year and between 0.4 and 5.5 over the medium term. The multiplier is mainly driven by the consumption effect. Investment does only react significantly over the medium term, here, we find evidence for both crowding-out and crowding-in effects. Second, the form of monetary policy has a strong impact on the effectiveness of the VAT change, especially the output target parameter. If the central bank has no output target the effects of the VAT reduction are larger on impact but significantly smaller overall. The reason is

²²See [Sims and Wolff \(2018\)](#)

²³See [Claus \(2013\)](#).

straightforward: The VAT reduction reduces CPI inflation. If the central bank wants to stabilize output it reduces the policy rate immediately. Thus, the real rate decreases and consumption today increases but decreases in the future. With an output target, the central bank will increase the nominal interest rate in order to stabilize the growth rate. This will reduce consumption today, but increase consumption in the future which will trigger investments.²⁴ Third, the most relevant adjustment cost parameter defines the adjustment costs for durable consumption. With low durable adjustment costs the GDP effects is above three in the first year and even higher than five over the medium term. On the one hand higher retail price adjustment costs reduce the effects, because the VAT pass-through will be incomplete. On the other hand higher intermediate price adjustment costs increase the effect.

4.3 The VAT reduction in Germany during the COVID-19 pandemics

The previous results are important to understand the channels in general, but the specific situation under which the German government decides to reduce the VAT matters. There are two specific states that have to be considered to analyze adequately how the VAT reduction has affected the German macro economy: The lockdown and the zero lower bound. Both states feature nonlinear effects of a VAT rate reduction. Thus, we simulate the nonlinear model in these two states for different counterfactual scenarios. In order to match our simulated series to the observed time series data we follow [Christiano et al. \(2015\)](#) and compare the model simulations with empirically estimated "target gaps" of relevant macro variables. Finally, we can disentangle the scenario of VAT reduction from counterfactual scenarios without VAT reduction: First, we analyze the total effect of an unexpected VAT reduction between both lockdown shocks. Second, we estimate how the 2nd lockdown shock has influenced the effectiveness of the VAT rate reduction. Third, we want to analyze to what extent the VAT rate reduction can mimic the monetary policy reaction to the lockdown if it would not have been limited by the zero lower bound.

4.3.1 Lockdown shock

In a first step we setup a benchmark lockdown scenario. A lockdown is a regulatory measure, which closes certain contact intensive businesses (which provide consumer goods and services) over a certain period, i. e. it is a quantity constraint imposed on both consumers and producers. Such a measure is difficult to capture in a macroeconomic framework, since it affects sectors in an asymmetric fashion. Since it imposes restrictions on consumers and producers simultaneously it is both a demand and a supply constraint.

By emphasising the demand side, the disinflationary impact is likely to be overestimated since the supply reduction is overlooked. By stressing the supply side and focusing on the restrictions imposed on factor demand (employment in particular), the inflationary impact is likely to be overestimated since restrictions on factor demand act like a positive mark-up shock. Modelling the lockdown as combination of a supply and demand shock remains inadequate, because it misses the sector specific nature of a lockdown.

Especially in an environment with limited factor mobility, constraints imposed on supply and demand in one

²⁴Inversely, both the degree of interest rate smoothing and the inflation target parameter reduces the GDP effects of VAT changes in the medium term.

sector will only marginally effect factor markets in the remaining sectors and largely affect these markets via income and substitution effects, i. e. demand spillovers. Thus it is likely that the macro effect will be larger than the initial sectoral shock. This has also been shown by [Guerrieri et al. \(2020\)](#). Adopting a purely aggregate perspective, would miss the fact that both sectors are affected differently from the lockdown. It would also be difficult to capture factor immobility across sectors. Implicitly a pure macroeconomic perspective assume a high degree of factor mobility across sectors.

Finally, the analysis of certain policy measures, such as VAT reductions will affect lockdown and non-affected sectors differently. Since no production takes place in a lockdown sector VAT is ineffective for these sectors. Whether it has a stabilising effect for other sectors depends on whether there are negative or positive spillovers from the lockdown to these sectors.

In this paper we therefore take the sector specific nature of a lockdown into account by dividing the economy into a sector which is directly affected by the lockdown and a sector which is only indirectly affected by the lockdown via demand and income linkages. In the remainder of the paper, the sector directly affected by the lockdown is denoted as sector one, and the remaining production sector is denoted as sector two. The lockdown on sector one is implemented as a full closedown of production over a prespecified period t . This makes firms and households subject to quantity constraints.

The lockdown shock is introduced as an indicator variable LD_t . If the government decides to close down specific branches $LD_t = 1$ for one period, output of sector one Y_t^1 is restricted to zero. The production lockdown implies zero demand for labour input in sector 1 and period t .

$$L_t^1 = 0. \quad (44)$$

We further assume that labour is immobile across the two sectors. Capital is idle in period t and we assume that firms in sector 1 reduce their investment to zero. This can be regarded as a lower bound on investment in the presence of capital mobility restrictions and leads to a reduction of the capital stock.

$$K_t^1 = (1 - \delta)K_{t-1}^1. \quad (45)$$

Zero investment would be optimal in the absence of adjustment costs and capital immobility. With adjustment costs investment would remain positive. However, because of liquidity constraints it is likely that firms directly affected by the lockdown postpone their investment plans.

It is assumed that sector one produces consumer durables ID_t^1 and non-durables ND_t^1 . Therefore a quantity constraint on household decisions for durables and non-durables applies in period t

$$ID_t^1 = ND_t^1 = 0. \quad (46)$$

All other demand and savings decisions of the household are only subject to an (intertemporal) budget constraint.

The household receives zero wage and capital income from sector 1

$$W_t^1 L_t^1 = 0, \quad (47)$$

$$r_t^K K_t^1 = P_t^1 Y_t^1 - W_t^1 L_t^1. \quad (48)$$

We further assume that wages in sector 1 are indexed to wages in the rest of the economy in the lockdown period. I. e. the level of wages entering the period after the lockdown is equal across both sectors (but allowed to diverge from $t + 1$ onwards). Finally, since there is no market for good 1, its price is removed from the consumer price index in period t .

$$P_t^C = P_t^2. \quad (49)$$

Figure 3 depicts the reaction of aggregate and sector specific variables due to a lockdown in 2Q. As can be seen the lockdown shock lockdown reduces GDP by 9 percent, consumption by 12 percent and investment by 5 percent. Durable and non-durable consumption are both negatively affected by 13 and 11 percent. All together our lockdown shock matches the actual development of the main aggregates compared to 1Q2020 well. Other components as the production of the affected and non-affected sectors or the consumption of unconstrained

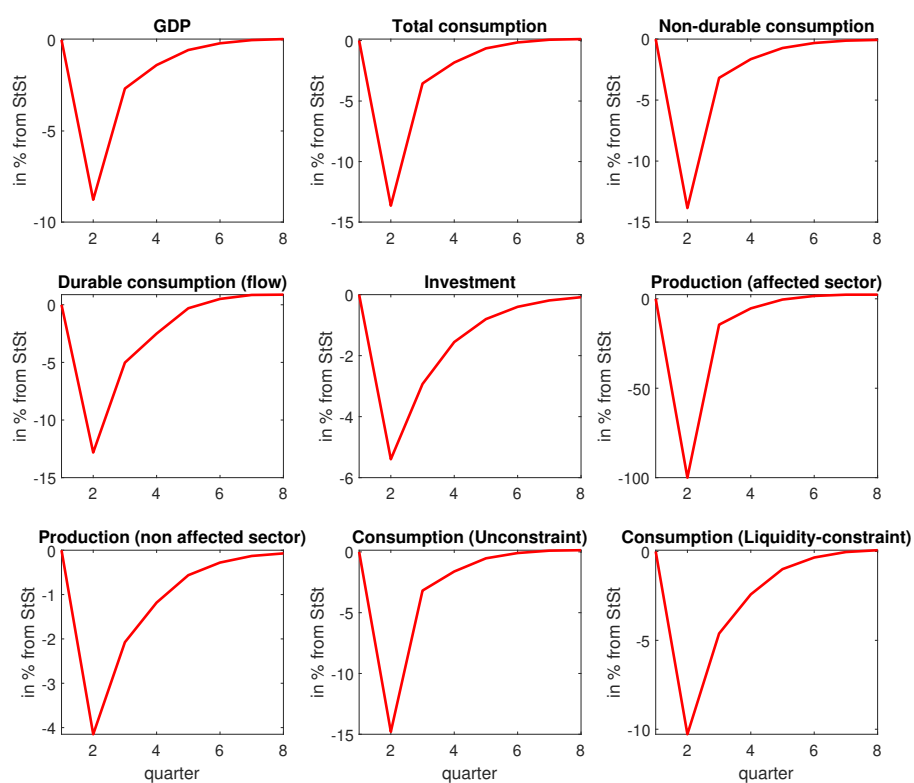


Figure 3: Unexpected lockdown shock in 2Q and 4Q with (blue) and without (red) an unexpected VAT rate reduction by 3 pp (Q3-Q4)

and constraint households are not comparable to observed time series. But by means of our model structure

the potential reactions consistent with the aggregate behavior can be simulated. We find that by definition the lockdown shock reduces production in the affected sector by 100 percent. But also the production in the non-affected sector is strongly reduced by 4 percent. This is an important result, because it legitimates broad policy measures, that stabilize the demand also in the not directly (but indirectly) affected sector, as interest rate cuts or the VAT reductions. Furthermore, the strong reduction in durable consumption provides further arguments in favor of a VAT reduction that stimulate the demand for durables stronger than for non-durables.

4.3.2 Counterfactual simulations

In the second step we calculate target gaps that should be used as benchmark for our model simulations. "Target gaps" are the empirical counterparts of the model simulations. Since for most macroeconomic variables data are already available until the 3rd quarter 2020, we only have uncertainty regarding the correct empirical "steady state" or trend value. In order to account for this uncertainty, we follow [Christiano et al. \(2015\)](#) and calculate max-min ranges. Thereby, we compute for each variable of interest the linear trend from date $x \in \{1991:Q1, \dots, 2015:Q4\}$ to 2020:Q1. From last observation onward, the trend growth rate is extrapolated by an AR(1) process. We then calculate the "target gaps", i.e. the differences between actual and projected values at different time horizons. Since their true values are not known, we construct the min-max range of the computed gaps which should serve as benchmark for our model predictions. In the second step, we conduct three distinct policy experiments. In the first experiment we simulate the first lockdown shock in 2Q2020, the VAT reduction between 3Q2020:4Q2020 and finally the 2nd Lockdown shock in 4Q2020. We compare the results with the same simulated series without the VAT reduction. In the second experiment we run the same simulations without the 2nd lockdown such that we could measure how effective the VAT reduction would have been if the 2nd lockdown has not occurred. In the third experiment, we add a simulation where the central bank is not limited by the zero lower bound but operates according to a Taylor Rule. We compare the VAT reduction with this active rule-based monetary policy. We assume that all shocks are unexpected in the period when they take place.²⁵

Policy Experiment I: How effective is the VAT reduction during the lockdown situations? Figure 4 depicts the development of GDP, consumption, non-durable consumption, durable consumption, private investments, the Debt-to-GDP ratio, CPI inflation, nominal interest rate and the ex-ante real interest rate.²⁶ All variables are represented in real terms and in form of target gaps, i.e. deviation from max-min trend range (blue shaded area). We simulate two unexpected Lockdown shock in 2Q2020²⁷ and in 4Q2020 as benchmark without the

²⁵The first lockdown and also the VAT shock, which was called the surprise feature of the German stimulus package, were not expected. However, the assumption regarding the second lockdown is discussing because epidemiologist warned about a second wave already in summer 2020. However, official economic forecasts from the government, research institutes, central banks did not include it in their benchmark projection, but only in their risk analysis.

²⁶See subsection A.2 in the Appendix for detailed data description.

²⁷More precisely, the lockdown started already in the last week of the 1st quarter. The two lockdowns have many elements in common but they are not identical. Using mobility data a recent study by the Roszbach von Storch Institute shows that on average, mobility and visits in retail stores were about 75% as much affected in the second compared to the first lockdown, when measured as average over the second and fourth quarter. However temporary close downs in industry was stronger in the first lock down. Since the drop in GDP and components in the first quarter is mainly related to the reduction in trade, especially with China and other Asian countries. In order to concentrate on the pure lockdown effects we decided to start our analysis in the 2Q2020.

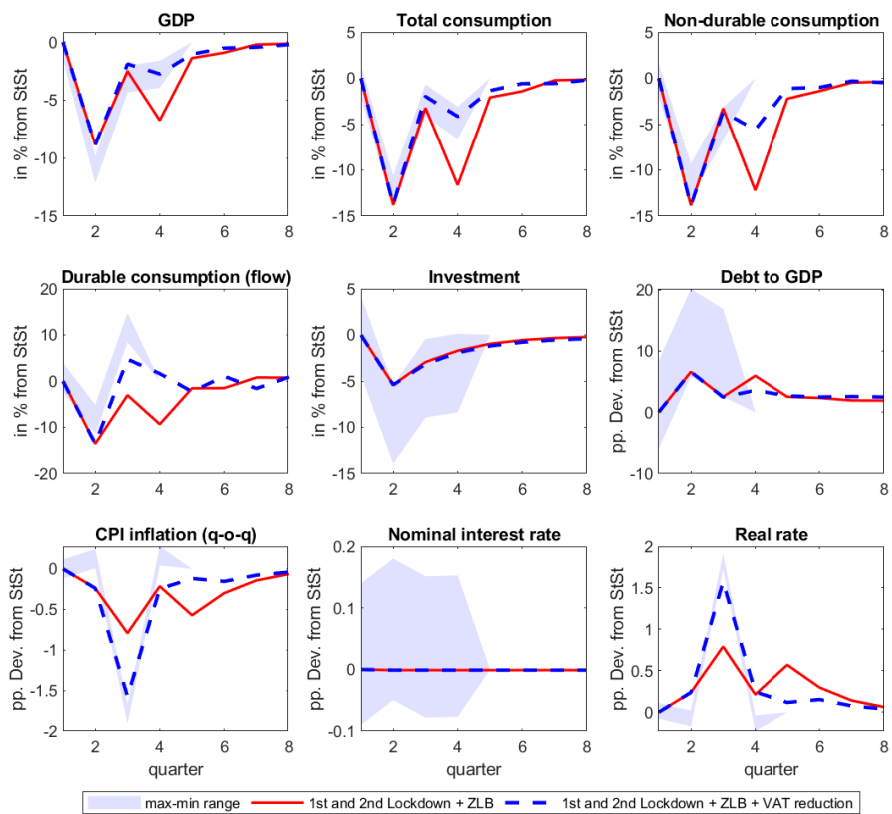


Figure 4: Unexpected lockdown shock in 2Q and 4Q with (blue) and without (red) an unexpected VAT rate reduction by 3 pp (Q3-Q4)

VAT reduction (red line). Furthermore, we run a simulation where we include an unexpected VAT reduction in 3Q2020:4Q2020 (blue dashed line) into this setup.²⁸ As can be seen this simulated series with all three shocks traces back the empirically observed paths quite well. We can see that the VAT reduction in the short-run mainly works through durable and non-durable consumption. It strongly increases durable consumption in 3Q2020 and 4Q2020, because the VAT change has reduced the rental price for durables (durable investment effect). The VAT reduction propagates its largest effect in the 4th quarter, because here in addition to higher demand for consumer durables, households also increase non-durable consumption in expectation for future price increases (arbitrage effect). All together the VAT reduction raises real GDP by roughly 0.7 percent in comparison to the steady state value. Total consumption increases in the short run by 1.9 percent and 1.5 percent in total (compared to steady-state). In contrast to 'normal times' private investment reduces slightly in the short- and medium-run, mainly because the accommodating monetary policy response does not appear.

Besides analyzing the real economic effects it is noteworthy to have a short look at the CPI inflation as well as public finance and the Debt-to-GDP ratio. In case of the CPI inflation rate we can see that the sharp drop in 2Q2020 is to some extent attributed to demand disruptions as consequence of the lockdown shock. But roughly 50 percent of the drop can be attributed to the VAT reduction. In terms of public finance, our model predicts that the debt-to-GDP ratio increases by 5 percent in the first year.²⁹ This can be explained by lower tax revenues. However, due to its relative effectiveness the VAT change reduces the Debt-to-GDP ratio by 2 percentage points.

Policy Experiment II: How does the 2nd Lockdown affects the Effectiveness of the VAT reduction In the second policy experiment we simulate the model setup without the second lockdown shock. Figure 5 depicts the relevant counterfactual simulated paths. There are three aspects noteworthy to mention: First, the timing of the adjustment patterns for durable and non-durable consumption after the VAT reduction are very similar to the first experiment. Durable consumption pushes the economy especially in the 3rd quarter, non-durable consumption in the 4th quarter. Second, without the 2nd lockdown our model predicts that total consumption and GDP increases above the (pre-crisis) steady-state value in the 4th quarter. Excluding the 2nd lockdown shock, the annual GDP would have been lower due to the VAT reduction.

Policy experiment III: Could a VAT reduction mimic Monetary Policy during the Lockdown? On the one hand our simulations and robustness analysis have shown that the role of monetary policy is a key element determining the effectiveness of VAT changes. On the other hand [Correia et al. \(2013\)](#) and [D'Acunto et al. \(2017\)](#) show that VAT rate changes are a powerful instrument of fiscal policy if the monetary policy is restricted due to the zero lower bound.

In a third policy experiment we explore this finding in case of a lockdown shock. We want to analyze to what extent the VAT reduction is able to mimic a central bank reaction in case of the 1st lockdown shock. Therefore,

²⁸The German government has announced the VAT reduction in the mid of June 2020. Thus, the last 2 weeks of 2Q2020 consumption could also be affected by announcement effects which would shift consumption from 2Q2020 into 3Q2020.

²⁹The simulated series is at the lower bound of the max-min range, because we do not consider further government discretionary expenditures, e.g. Short-time work payments, financial aid for firms and households, additional government spending from the stimulus package.

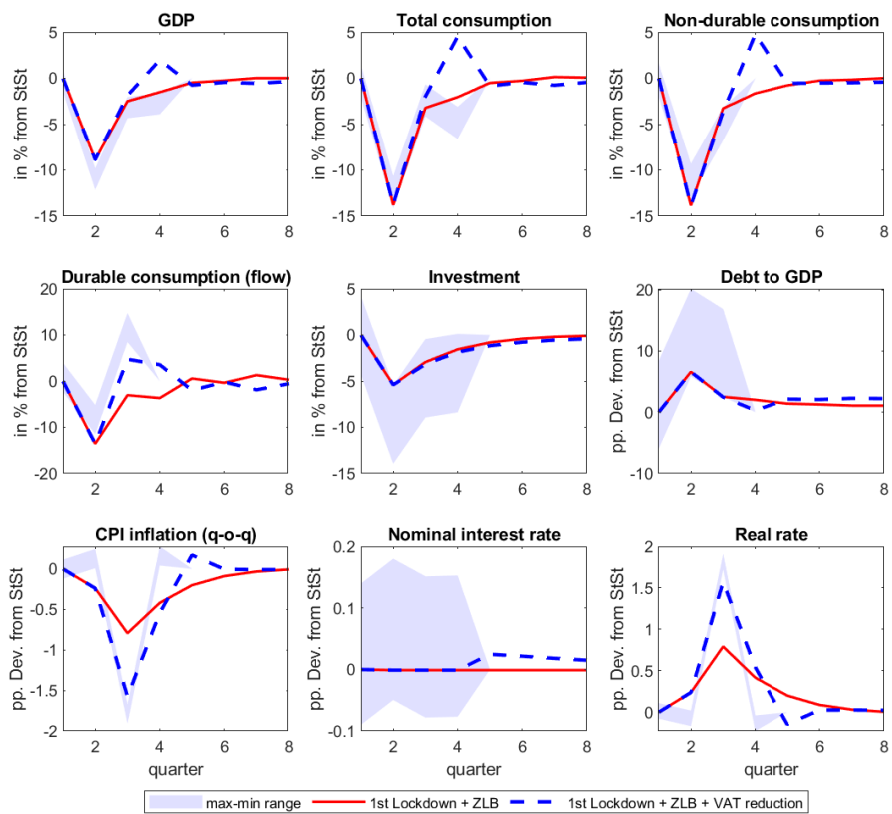


Figure 5: Unexpected lockdown in 2Q2020 with (blue) and without (red) an unexpected VAT rate reduction by 3 pp (Q32020:Q42020)

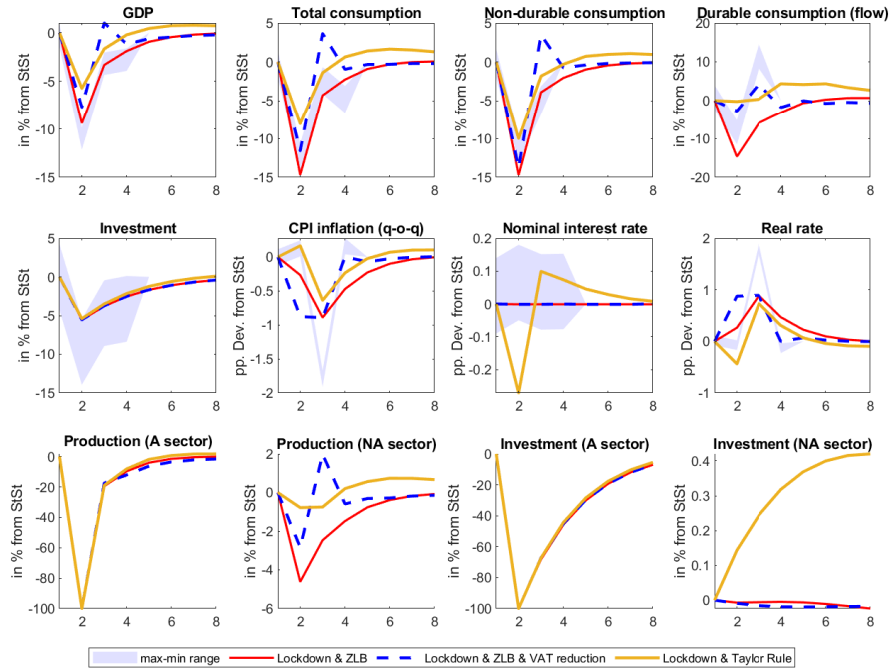


Figure 6: ZLB & VAT reduction after lockdown pd. (Q3-Q4) compared with Active Monetary Policy under Taylor Rules

we change our model simulation in two dimensions. First, we introduce a third counterfactual simulation where we assume the central bank does not operate at the zero lower bound but follows a standard monetary policy rule a la [Taylor \(1993\)](#) (yellow line). Second, in order to compare the the VAT effects with the effects of an immediate rule-based central bank response we assume that also the VAT reduction is launched immediately, i.e. during the lockdown in 2Q2020 (blue dashed). The third counterfactual series represents similar to our previous experiments the response to the lockdown shock without VAT reduction in case the central bank operates at the zero lower bound (red line).

Figure 6 shows the simulated series. Although this exercise is purely hypothetical, we still leave the max-min range as benchmark. Furthermore, we extend the dynamic responses of output and private investments in the affected and the non-affected sector.³⁰

The rule-based monetary policy reaction stipulates a nominal interest rate cut of 25 bp.³¹ In general our simulations show, that the VAT reduction is able to mimic the standardized central bank response to the lockdown shock. GDP and total consumption react almost similar. If the VAT reduction lasts for two periods, it additionally pushes durable consumption and lead to a sharp increase of GDP and consumption. However, there are differences that are mainly driven by sector-specific reactions. Surely, both, the VAT reduction and the monetary policy reaction cannot reduce the negative effects in the affected sector during the lockdown. Neither output nor

³⁰For all four series we do not have empirical counterparts.

³¹In the specific situation of the lockdown shock it might be possible that standard Taylor Rule coefficients are not a realistic description, but rather a policy with low interest rate smoothing. However, we decided to compare the VAT reduction with a standard monetary policy response.

investment demand are significantly lower in the lockdown period. But the interest rate cut has small but constant positive effects in the subsequent periods. In the non-affected both instruments differ significantly. The interest rate cut raises investments strongly and boosts production. Compared to this the VAT reduction has only small direct effects on private investments and the production is less affected. Thus, to fully mimic central bank policy additional general private investment support, e.g. via grants or change of the investment tax law, for all sectors are necessary.

4.4 Temporary VAT Multipliers

Finally, we present a robust validation of temporary VAT multipliers and effects based on the different model simulations. We calculate the tax multipliers for GDP:

$$\frac{\sum_{t=0}^k \Delta y_{t+k}}{\sum_{t=0}^k \left(\Delta \tau_{t+k}^{VAT} \left((1 - \psi^D) \bar{d} + \psi^D \bar{i}^d \right) \right)} \frac{\bar{c}}{\bar{y}} \quad (50)$$

Similarly, we calculate the effects on real consumption and real investments. Table 4 summarizes the results. In general we distinguish between the upper block with the 1st year impact ($k = 4$) and the lower block with the cumulative 5-year (medium-term) multipliers ($k = 20$). In the first two lines of each block we add the multipliers based on the benchmark calibration³² with and without durable goods from the general model for comparison. Remind again that for simulations without the durable investment effect we confirm the result of the literature, that the VAT reduction is not very effective, especially on impact. However, if we consider durable goods, the effect becomes effective on impact and over the medium term. In the specific situation of the lockdown the effectiveness of the VAT reduction reduces no matter of the duration...

Table 4: Multiplier - State dependence (PCM)

Frequency	GDP	Consumption	Investment
(1) Impact multiplier (1st year)			
w/o durables	0.35	0.37	-0.03
with durables	1.00	1.01	0.01
Lockdown, Taylor	0.86	0.87	-0.02
Lockdown, ZLB	1.07	1.08	-0.01
1st and 2nd Lockdown, ZLB	1.02	1.04	-0.02
Forced savings			
State aid program			
(2) Cumulative multiplier (after 5 years)			
w/o durables	0.31	0.40	-0.08
with durables	1.24	1.14	0.10
Lockdown, Taylor	0.72	0.79	-0.07
Lockdown, ZLB	0.98	0.99	-0.02
1st and 2nd Lockdown, ZLB	0.88	0.92	-0.04
Forced savings			
State aid program			

³²See Table 1

5 Conclusion

In the aftermath of the first lockdown in June 2020 the German government decided to stimulate the economy via a temporary VAT rate reduction. Right after its announcements a lively debate has started in Germany about the advantages and disadvantage of this policy measure and its effectiveness during the pandemic situation.

This paper investigates the macroeconomic effects of a temporary VAT change in general and for the specific case of Germany during partial lockdown situations. We start with an empirical assessment and use SVAR identification and German National Official Statistics data as well as a narrative VAT revenue law series from 1Q1991:4Q2019 to estimate the average effects of VAT changes on durable and non-durable consumption. We find robust evidence for strong positive immediate effects on consumer durables on average. For non-durables the average VAT effect is significant but less intense. We thereby confirm results from the microeconomic models (see [Büttner and Madzharova \(2017\)](#)) within a macroeconomic framework. But their empirical model does neither explain the channels at work nor does it account for the specific situations of the pandemics and monetary policy at the zero lower bound. Therefore, we set up a DSGE model for Germany under a (partial) lockdown and with monetary policy operating at the ZLB. We extend the model further by specific features as durable and non-durable consumption, sectoral structure, imperfect VAT pass-through, which makes it especially suitable to do both, analyzing the channels at work and applying the model to the specific situation of Germany.

We find that VAT reduction reduce the cost of living during the period of the reduction (income effect) and agents shift consumption forward (substitution effect). In 'normal times' and without distinguishing between durable and non-durable consumption both effects are relatively small. Incorporating consumer durables and non-durables in the model increases the effectiveness of a temporary VAT reduction significantly. In this case the VAT reduction directly reduces the rental price of the durable good by a large amount (durable investment effect), which leads to stronger intertemporal substitution. We find sizeable effects of VAT measures on consumption (esp. durables) with a multiplier larger than one on GDP and can match well the main macroeconomic aggregates over that period. Further we find that the effectiveness of the temporary VAT measure in normal times is strongly influenced by the central bank behavior. A central bank policy with a strong interest rate smoothing accommodates the impact effects of the temporary VAT reduction. An output growth target dampens the consumption effect of the VAT change but increases its effect on investments. Furthermore, robustness tests of our model results over a broad set of parameter ranges confirms our benchmark results regarding the strong durable investment effect.

In the next step we apply our model to the specific situation of Germany. Therefore, we match the model to German time series data and show the impact of the two lockdown shocks and the VAT shock on relevant macroeconomic aggregates in 2Q2020:4Q2020. In our simulation we take into account that both lockdowns and the VAT reduction are unanticipated and simulate the total effect of the two lockdown shocks with and without the VAT reduction. The difference between both scenarios yield the total effect of the VAT reduction. We find that the VAT reduction in Germany between two lockdowns is more effective as in 'normal times'. The specific situation of the zero lower bound and the 2nd lockdown rather increases the effectiveness of the VAT reduction. We find in particular that the VAT reduction in the third quarter has led to a sharp increase in the demand for

consumer durables, which is also the main transmission channel predicted by the model. Overall we find a VAT multiplier which is larger than one.

Finally, we run a third experiment in order to investigate to what extent the VAT reduction is able to mimic a central bank reaction in case of a lockdown shock. We find that for main aggregates the VAT reduction is able to mimic the standardized central bank response during a lockdown. GDP and total consumption react almost similar. If the VAT reduction lasts for two periods, it additionally pushes durable consumption and lead to a sharp increase of GDP and consumption. However, there are differences, mainly driven by sector-specific reactions. In the non-affected sector investment effects of both instruments differ significantly from each other. The interest rate cut raises investments strongly and boosts production. Compared to the monetary policy reaction the VAT reduction has only small direct effects on private investments and the production is less affected. Thus, to fully mimic central bank policy additional general private investment support, e.g. via grants or change of the investment tax law, are necessary.

Appendix

A Data

A.1 Historical VAT tax law changes in Germany

Table 5: Legislative Changes of the VAT Tax in Germany, 1Q1990-4Q2019

Date	Title	Announcement	Resolution	Volume (annually, in bn) €	Duration
30/03/1990	2nd VAT change law	1Q1990	2Q1990	-0.118	permanent
18/05/1990	Temporary VAT cut claim	2Q1990	3Q1990	-0.358	2Q1991
25/02/1992	VAT increase 14% to 15%	1Q1992	1Q1993	+6.204	permanent
25/08/1992	VAT single market law	3Q1992	3Q1992	-0.284	permanent
21/12/1993	VAT law change 1993	4Q1993	4Q1993	-0.432	permanent
09/08/1994	VAT law change 1994	3Q1994	1Q1995	-0.056	permanent
19/12/1997	VAT increase 15% to 16%	4Q1997	1Q1998	+5.778	permanent
24/03/1999	Tax reduction law 1999	1Q1999	2Q1999	+1.674	permanent
20/12/2001	Tax evasion law 2001	4Q2001	4Q2001	+2.500	permanent
15/12/2003	Tax law change 2003	4Q2003	1Q2004	+0.312	permanent
23/04/2004	Interim VAT law change	2Q2004	2Q2004	-0.090	4Q2004
21/07/2004	Interim VAT law change	3Q2004	3Q2004	-0.250	1Q2006
26/4/2006	Tax relief of growth end employment	2Q2006	3Q2006	-1.230	1Q2007
26/4/2006	Tax relief of growth end employment	2Q2006	1Q2007	-0.250	1Q2008
29/6/2006	VAT increase 16% to 19%	2Q2006	1Q2007	+22.946	permanent
19/12/2008	Tax law 2009	4Q2008	1Q2009	-0.185	permanent
22/12/2009	Accelerating growth law	4Q2009	1Q2010	-0.945	permanent
08/04/2010	Tax law change 2010	2Q2010	3Q2010	+0.300	permanent
08/04/2010	Tax law change 2010	2Q2010	3Q2010	+0.300	permanent

Source: German federal government, German Ministry of Finance

A.2 Data description

Gross Domestic Product: Federal Statistic Office, National Accounts Statistics, Series 18 1.2, Gross Domestic Product, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Consumption: Federal Statistic Office, National Accounts Statistics, Series 18 1.2, Private Consumption, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Expandable consumption: Federal Statistic Office, National Accounts Statistics, Series 18 1.2: Private Consumption and Disposable Income, Expandable Consumption, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Short-lived consumption: Federal Statistic Office, National Accounts Statistics, Series 18 1.2: Short-lived Consumption and Disposable Income, Expandable Consumption, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Long-lived consumption: Federal Statistic Office, National Accounts Statistics, Series 18 1.2: Private Consumption and Disposable Income, Long-lived Consumption, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Services: Federal Statistic Office, National Accounts Statistics, Series 18 1.2: Private Consumption and Disposable Income, Services, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Non-durable consumption: Expandable consumption + Services.

Durable consumption: Short-lived consumption + long-lived consumption.

Private investments: Federal Statistic Office, National Accounts Statistics, Series 18 1.2, Non-governmental

investments, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

CPI inflation rate: Federal Statistic Office, National Accounts Statistics, Series 18 1.2, Private consumption price deflator, price-adjusted (chain-linked volume), seasonally-adjusted, 1Q1991-3Q2020.

Nominal interest rate: FRED, Immediate Rates: Less than 24 Hours: Call Money/Interbank Rate for Germany, 1Q1991-3Q2020.

Ex-ante real interest rate: Nominal interest rate - CPI inflation rate.

B SVAR approach

Our baseline VAR specification is

$$X_t = A(L, q)X_{t-1} + U_t \quad (51)$$

where $X_t \equiv [T_t^{vat}, G_t, C_t^i]'$ is a three dimensional vector with the logarithm of tax revenues, public consumption and specific private consumption all in real terms. $A(L, q)$ is a four-quarter distributed lag polynomial and U_t is a corresponding vector of reduced form residuals which in general have non-zero cross correlations.

The reduced form residual vector has little economic significance because its elements are linear combinations of the structural VAT, public and private consumption shocks. Therefore, we use micro-level evidence for estimating the tax elasticity for durable and non-durable consumption. Here we follow [Bach et al. \(2006\)](#) who found a VAT elasticity between 0.9 and 1.4 for total consumption and 0.005 for public consumption. [Bach et al. \(2006\)](#) estimate steady-state VAT elasticities for different consumption groups. They report tax elasticities above 2 for the group of furnishing, household equipment, transport, education, which with the exception of education all belong to the segment how we define consumer durables.³³ [Bach et al. \(2006\)](#) also reports steady-state tax elasticities from a microsimulation model for Germany. They find above one elasticities for health (1.3) and recreation (1.1) which also counts partly to consumer durables. Non-durable goods have rather below one elasticities, as food (0.5), beverages (0.05), clothing (0.96), water (0.59), fuels (0.41), communication (0.40), restaurants (0.98), only the financial services (1.3) has above unity elasticities. Housing (0.8) is a special case, because the acquisition of housing and land is not recorded as a consumer durable in the national accounts but as investment. Housing services consumed and produced by households living in dwellings owned by them are reflected in household consumption as services. Weighting the tax elasticities with the consumption gives 1.76 for durable consumption and 0.8 for non-durable consumption:

$$A = \begin{bmatrix} 1 & -0.005 & \bar{a}_{1,3} \\ 0 & 1 & 0 \\ 0 & a_{3,2} & 1 \end{bmatrix}, \quad B = \begin{bmatrix} b_{1,1} & 0 & 0 \\ b_{2,1} & b_{2,2} & 0 \\ b_{3,1} & 0 & b_{3,3} \end{bmatrix},$$

where we set $\bar{a}_{1,3} = -1.76$ in case of durable and $\bar{a}_{1,3} = -0.8$ in case of non-durable consumption goods.

³³Consumer durable goods include furniture and household appliances (including kitchen equipment), personal transport equipment (i.e. vehicles), recreational and entertainment goods (including computers and communications equipment), other goods such as jewellery, clocks and watches, and therapeutic medical appliances and equipment. See [Casalis and Krustev \(2020\)](#).

We control for the German reunification between 1Q1991 to 4Q1992 and the financial crisis between 4Q2008 and 2Q2009 and consider seasonal dummy variables for each quarter. Further, we control for the time between announcement and implementation by considering the expected tax revenue change, this is the difference between announced and actual revenue change, as an exogenous variable. We estimate the model with 4 lags and a linear as well as a quadratic trend.

In our alternative VAR specification, instead of the full VAT revenue series, which may consider endogenous reactions of the VAT revenue, we consider only the expected VAT revenue changes due to adjustments of the VAT tax law as an exogenous instrument.

References

- Bach, S., P. Haan, O. Hoffmeister, and V. Steiner (2006). Increasing the Value-Added Tax to Re-Finance a Reduction of Social Security Contributions? - A behavioral microsimulation analysis for Germany.
- Barrell, R. and M. Weale (2009). The Economics of a Reduction in VAT. *Fiscal Studies* 30(1), 17–30.
- Blanchard, O. and R. Perotti (2002). An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *The Quarterly Journal of Economics* 117(4), 1329–1368.
- Burgert, M., W. Roeger, J. Varga, J. in 't Veld, and L. Vogel (2020, June). A Global Economy Version of QUEST: Simulation Properties. European Economy - Discussion Papers 2015 - 126, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.
- Büttner, T. and B. Madzharova (2017). The Effects of Pre-announced Consumption Tax Reforms on the Sales and Prices of Consumer Durables. Technical report.
- Casalis, A. and G. Krustev (2020). Consumption of Durable Goods in the Euro Area. *Economic Bulletin Articles* 5.
- Christiano, L. J., M. S. Eichenbaum, and M. Trabandt (2015). Understanding the Great Recession. *American Economic Journal: Macroeconomics* 7(1), 110–167.
- Claus, I. (2013). Is the value added tax a useful macroeconomic stabilization instrument? *Economic Modelling* 30(C), 366–374.
- Coenen, G., R. Straub, and M. Trabandt (2013). Gauging the Effects of Fiscal Stimulus Packages in the Euro Area. *Journal of Economic Dynamics and Control* 37(2), 367–386.
- Correia, I., E. Farhi, J. P. Nicolini, and P. Teles (2013). Unconventional Fiscal Policy at the Zero Bound. *American Economic Review* 103(4), 1172–1211.
- Crossley, T., H. Low, and C. Sleeman (2014, July). Using a Temporary Indirect Tax Cut as a Fiscal Stimulus: Evidence from the UK. IFS Working Papers W14/16, Institute for Fiscal Studies.
- Crossley, T. F., H. Low, and M. Wakefield (2009). The Economics of a Temporary VAT Cut. *Fiscal Studies* 30(1), 3–16.
- Drygalla, A., O. Holtemöller, and K. Kiesel (2020). The Effects Of Fiscal Policy In An Estimated Dsge Model—The Case Of The German Stimulus Packages During The Great Recession. *Macroeconomic Dynamics* 24(6), 1315–1345.
- Dullien, S., A. Herzog-Stein, P. Hohlfeld, K. Rietzler, S. Stephan, T. Theobald, S. Tober, and S. Watzka (2020). Rasche, aber unvollständige Erholung nach historischem Einbruch. IMK Report 161, Institut für Makroökonomie und Konjunkturforschung.

- D'Acunto, F., D. Hoang, and M. Weber (2017). The Effect of Unconventional Fiscal Policy on Consumption Expenditure. *ifo DICE Report* 15(01), 09–11.
- Fuest, C., F. Neumeier, and A. Peichl (2021). Hat die Mehrwertsteuersenkung den Konsum belebt? *ifo Schnelldienst Digital* 2(1).
- Gadatsch, N., K. Hauzenberger, and N. Stähler (2016). Fiscal policy during the crisis: A look on Germany and the Euro area with GEAR. *Economic Modelling* 52(PB), 997–1016.
- Grabka, M. M. and C. Halbmeier (2019). Vermögensungleichheit in Deutschland bleibt trotz deutlich steigender Nettovermögen anhaltend hoch. *DIW Wochenbericht* 86(40), 735–745.
- Guerrieri, V., G. Lorenzoni, L. Straub, and I. Werning (2020). Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages? NBER Working Papers 26918, National Bureau of Economic Research, Inc.
- Mertens, K. and M. O. Ravn (2011). Understanding the Aggregate Effects of Anticipated and Unanticipated Tax Policy Shocks. *Review of Economic Dynamics* 14(1), 27–54.
- Monacelli, T. (2009). New Keynesian models, durable goods, and collateral constraints. *Journal of Monetary Economics* 56(2), 242–254.
- Mourre, G. and S. Princen (2015, November). Tax Revenue Elasticities Corrected for Policy Changes in the EU. European Economy - Discussion Papers 2015 - 018, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.
- Orlandi, F., W. Roeger, and A. Thum-Thysen (2018). The Return of the European Wage Phillips Curve. European Economy - Discussion Papers 2015 - 085, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.
- Romer, C. D. and D. H. Romer (2010). The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks. *American Economic Review* 100(3), 763–801.
- Rotemberg, J. J. (1982). Monopolistic Price Adjustment and Aggregate Output. *Review of Economic Studies* 49(4), 517–531.
- Sims, E. and J. Wolff (2018). The State-Dependent Effects of Tax Shocks. *European Economic Review* 107(C), 57–85.
- Taylor, J. B. (1993). Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy* 39(1), 195–214.
- Voigts, S. (2016). VAT multipliers and pass-through dynamics. SFB 649 Discussion Papers SFB649DP2016-026, Sonderforschungsbereich 649, Humboldt University, Berlin, Germany.