Effective Demand, Profits and Prices, and the Multiplier

Kurt Kratena[1),2)]

CESAR Working Paper 00220

Published: November 2020

[1)] CESAR (Centre of Economic Scenario Analysis and Research), Fuhrmannsgasse 2A, A-1080 Vienna (Austria), www.cesarecon.at, [2)] WIFO (Austrian Institute of Economic Research), Arsenal, Objekt 20, A-1030 Vienna (Austria)

Abstract: In the standard input-output (IO) model, prices are determined by unit costs and output is demand-driven. There is no mutual feedback between prices and quantities. In extended macroeconomic IO models and CGE models demand is also determined by prices and some feedback from demand on prices is active as well, usually from the labor market. In this paper, a direct feedback from final demand shocks on the profit coefficient in the IO price equation is introduced into a simple macroeconomic IO model of the EU 28. Price effects have a feedback on real disposable income, while wages are rigid. This concept can be seen as an utmost simple Philipps curve and yields Keynesian multiplier effects. The elasticities of output and prices to changes in effective demand (Keynes (1936), chapter 20) are used for decomposing an exogenous *nominal* effective demand shock into an exogenous *real* demand shock and an output price shock. Different states of the economy in terms of capacity utilization (boom or recession) as well as different model specifications (CGE, IO, type II) can be defined by differences in the relative magnitude of the two elasticities with respect to an exogenous demand shock. In a boom, the GDP multiplier of an exogenous increase in investment is 0.15, whereas in a recession it is between 1.15 and 1.33. The GDP multiplier of the standard IO model is below unity (0.87), as expected, and the type II-multiplier without price feedback is 1.36. Assuming that the demand shock fully represents excess demand and therefore only leads to price reactions (CGE model specification), yields a small negative GDP multiplier.

Keywords: Macroeconomic input-output model, state-dependent multiplier, Keynes' General Theory

JEL-codes: E62, E12, D58

1. Introduction

Multiplier analysis is the core area of input-output (IO) modeling (see: chapter 6 in Miller and Blair, 2009). The simple IO model (type I) only includes inter-industry linkages into the multiplier, whereas type II models add an income/consumption loop into the multiplier concept. These models integrate positive feedback loops that lead to large multiplier effects from positive final demand shocks. The IO literature has questioned this traditional concept of IO multipliers by introducing 'net multiplier' concepts (Oosterhaven et al., 2003; Miller and Blair, 2009). Guerra and Sancho (2011) develop this argument further by assuming that the positive final demand shock needs to be compensated by some negative impulse that represents, for example, the financing of public expenditure. This argument is based on the idea that policy feedbacks might occur or that policy itself and therefore demand shocks might be endogenous. The macroeconomic literature has always emphasized the dependence of the fiscal multiplier on accompanying policy measures (monetary policy, public budget constraints) and it that sense always took into account endogenous feedbacks from policy on the outcome of demand shocks. Since the Great Recession (2008/2009), the main issue in macroeconomics was deriving states of the economy, where monetary policy was ineffective and fiscal policy multipliers would be potentially large (Eggertson, et al., 2019). Macroeconomists have also considered potential negative feedbacks from agents' (consumers and firms) behavior to positive demand shocks, which would dampen the multiplier. This discussion is based on theoretical concepts and stylized facts about state-dependent multipliers (Leeper et al., 2015; Oywang et al., 2013; Zuibary, 2014), i. e. multipliers that depend on the state of the economy in the boom-bust cycle. One main mechanism in explaining state dependent multipliers is the magnitude of the reaction of consumption to transitory income shocks (Gali et al., 2004). If all households have perfect foresight, 'Ricardian equivalence' holds and households do not increase consumption when current government spending increases their current income. Economic booms and busts are then characterized either by different shares of perfect foresight vs. 'hand to mouth' consumers (Auerbach and Gorodnichenko, 2012) or by different binding liquidity constraints for saver- and borrower-households (Eggertson and Krugman, 2012). In an IO framework, large demand shocks might - due to heterogenous income elasticities - also lead to important changes in the allocation of consumption and therefore in the aggregate multiplier of a demand shock.

Another line of research on state dependent multipliers that is followed in this paper, emphasizes the mechanism of the Philipps curve and of the labor market. The main idea is to attribute the observed heterogeneity in the reaction of consumers to government spending between booms and recessions to downward wage rigidity combined with a Philipps curve

(Shen and Yang, 2018). In recessions, positive demand shocks lead to less induced inflation, and to a larger extent induce quantity adjustment in employment and real income, which is the mechanism behind the multiplier. Due to nominal downward wage rigidity, the real wage rate decreases with positive demand shocks, leading to a labor market equilibrium at higher employment and a lower real wage rate. This argument is similar to the original concept of the 'employment function', laid down by Keynes (1936) in chapter 20. Gali (2013) also integrates this original Keynesian view of the labor market into a New Keynesian model and discusses the welfare effects of wage flexibility vs. wage rigidity.

In this paper, the Keynesian framework of chapter 20 of the General Theory is used to explain cyclical reactions of output and prices to demand shocks, thereby generating state-dependent multipliers. The main mechanism is price adjustment as a reaction to positive demand shocks. The state of the economy is defined by an indicator of capacity utilization that decides, if positive demand shocks mainly lead to positive price adjustments or mainly to real multiplier effects. The extension of the standard type II model proposed here incorporates direct feedbacks from quantities on output prices, as is the case in CGE models. The main difference to the CGE approach is that no strict macro-closure (fixed savings) that effectively rules out multipliers of positive demand shocks, is introduced. Equilibrium is not -as in the static CGE model - defined as the state of the economy in the base year of data, but can imply idle capacities, in which case positive demand shocks can lead to multiplier effects. If an economy works at full capacity, positive demand shocks mainly lead to positive price adjustments as in the CGE model.

Whereas the feedbacks from prices on goods and factor demand are taken into account in most macroeconomic IO models like the INFORUM-family models (Almon, 1991; Meade, 2013) or GINFORS (Meyer and Lutz, 2007; Meyer and Ahlert, 2017), the opposite mechanism (from quantities to prices) is usually not incorporated in a direct way. The main indirect channel of influence from quantities on prices in these models usually stems from the labor market (see also: Kratena, et al., 2017). When wage setting depends on the unemployment rate (the relation between actual and equilibrium unemployment), then positive demand shocks lead to positive price adjustment, driven from positive wage effects. However, in empirical modeling these wage curves are not perfectly suitable for capturing the differences in price dynamics between booms and recessions and the corresponding differences in multipliers of positive demand shocks. On the one hand, the small coefficient (about – 0.15) for the wage reaction with respect to unemployment corroborated by a large body of empirical analysis following the seminal work of Blanchflower and Oswald's (1994) 'wage curve' mainly explains cross sectional differences (e.g. regional) in wage levels and unemployment. In a dynamic specification, it does not necessarily lead to a significant acceleration in wage inflation and therefore also not to significant dynamic output price effects (Kratena, et al., 2017). On the other hand, even the small coefficient with respect to unemployment does not ensure downward wage rigidity in large recessions. The model might instead in such a case work similar to a CGE model with wage flexibility, limiting the potential of Keynesian mechanisms (effectiveness of fiscal policy) in a recession that depend on wage rigidity (Gali, 2013) or on a zero lower bound of inflation in slumps (Carlin and Soskice, 2018). Although a fully-fledged model needs to incorporate some wage setting schedule, the differences in price dynamics between booms and recessions seem to be captured in a more appropriate way by a Philipps curve mechanism. Furthermore, any wage setting schedule that wants to capture Keynesian mechanisms needs to guarantee downward wage rigidity, especially in large recessions. The main objective and achievement of this study is to suggest a direct state-dependent price effect of demand shocks that allows for multiplier effects of demand shocks in recessions, when wages are rigid (Shen and Yang, 2018). The mechanism used in this paper can be seen as the simplest possible Philipps curve, that does not incorporate all expectation and rigidity features that have been suggested in the recent literature (e.g. Gali and Gertler, 1998). In that sense, the recommendations of Vines and Wills (2018) as well as Carlin and Soskice (2018) from the 'rebuilding macroeconomic theory project' have been followed and the rational expectation concept has not been applied. Another recommendation followed from this project is the introduction of heterogenous agents in the form of a multi-sectoral framework, as proposed by Stiglitz (2018). A potential shortcoming of this study is that the functional relationship between price adjustment and capacity utilization has been calibrated *ad hoc* according to reasonable properties at minimum and maximum capacity utilization. This study does not provide any real empirical proof for the formal function used. A consistent solution to these shortcomings would consist of generally specifying the profit component in the price equations as a function of the capacity utilization, so that demand shocks would endogenously and simultaneously create the adequate price adjustments. The concept of heterogenous agents could also be further extended by introducing different household groups (income, income uncertainty, wealth, etc.), potentially leading to larger multiplier heterogeneity of demand shocks.

The model simulations for different states of the European economy and different model specifications reveal a significant variance of multipliers of a final demand shock. The shock is standardized as a 1% of GDP increase in gross fixed investment of the electricity sector. The total *nominal* demand shock is the sum of the direct and indirect output effects of the final demand shock and is split up into a final demand effect in constant prices and into price effects (increase in the profit coefficient per unit of output), depending on capacity utilization. A recession is defined as the sample minimum of capacity utilization (1995 - 2020) and a boom as the maximum. The same shock yields gross output impacts of 0.15% in a boom and at least 1,08% in a recession. The GDP multiplier is 0.15 in a boom and 1.15 to 1.33 in a recession, depending on induced changes in the marginal propensity of consumption. The most important result of this study is that the different reaction of private consumption to an external demand shock in booms and recessions (emphasized in the fiscal multiplier-debate) is actually driven by the interaction of the dynamics of nominal disposable income and of prices. The range of GDP multipliers between booms and recessions is in line with the existing literature (Shen and Yang, 2018; Auerbach and Gorodnichenko, 2012). The type II model specification and the CGE model specification represent margins of the range of Keynesian vs. neoclassical macroeconomic concepts. Their multipliers are therefore close to those at the margins of the state of the economy: the GDP multiplier of the type II model (1.36) is slightly larger than the 'recession multiplier' and the GDP multiplier of the CGE model is slightly smaller than the 'boom multiplier' (- 0.16). The GDP multiplier of the standard IO model is always smaller than unity (0.87) and significantly larger than the 'boom multiplier'.

The paper is organized as follows: Section 2 presents the quantity and price model of the macroeconomic IO model as well as the methodology of implementing demand shocks in booms and recessions. In section 3, the simulation results and multipliers for the case of boom and recession are presented, and in section 4 the results for alternative model specifications are shown and compared to the basic model. Finally, section 5 concludes.

2. The IO model with endogenous private consumption

The comparative-static macroeconomic IO model used in this study is based on the 2016 Supply/Use tables (source: EUROSTAT) for the EU28 countries and deals with the EU 28 as one single economy. Exports to the rest of the world are not explicitly modelled but held exogenously fixed, as are public consumption, gross fixed capital formation, import prices and the wage rate. Substitution between factors of production is not considered. Imports are determined via fixed import shares of users (intermediate and final). Private consumption is endogenous and defined as a function of real disposable income, i. e. nominal disposable income deflated by the consumer price. Nominal disposable income is partly made up by total wages and the part of profits (operating surplus and mixed income) that is distributed to households, to which one aggregate net tax rate is applied.

The matrices and vectors that constitute the database of the model are:

(i) the supply table (industries * goods) **V** with column sum equal to the vector of output by goods, **q**(**g**). The row sum of this matrix is defined as the vector of output by industries, **q,**
(ii) the domestic use table (goods * industries and goods * final demand components) $\mathbf{U}^d$ with row sum equal to the vector of output by goods, **q**(**g**), and
(iii) the imports use table (goods * industries and goods * final demand components) $\mathbf{U}^{im}$ with row sum equal to the vector of imports by goods, **im**.

The vectors of final demand $\mathbf{f}^d$ and $\mathbf{f}^{im}$ comprise domestic (d) and imported (im) goods. The supply and use tables are converted into coefficients matrices for setting up the IO model. The 'market shares matrix' **D** is derived by dividing the matrix elements of **V** through the column sum, **q**(**g**). An element $q_{ji}/q(g)_i$ of this matrix **D** defines the participation of industry *j* in the production of good *i*. This matrix links the output by industries **q** to the output by goods **q**(**g**): **q** = **D q**(**g**). Note that applying the 'market shares matrix' **D** implies the assumption of 'industry technology', i.e. each good of an industry is produced with the same unique technology of this industry. The domestic 'technical coefficients matrix' $\mathbf{B}^d$ is derived by dividing the domestic intermediate use table $\mathbf{U}^d$ through the vector of total output by industries, **q**. The elements x^d_{ij}/q_j of $\mathbf{B}^d$ define the domestic input *i* in the production of one unit of industry *j*, therefore they determine domestic intermediate demand $\mathbf{x}^d$ as a function of output by industries **q**: $\mathbf{x}^d = \mathbf{B}^d\,\mathbf{q}$. Additionally, an imported 'technical coefficients matrix' $\mathbf{B}^{im}$ exists, that is derived from the import use matrix, $\mathbf{U}^{im}$. Final demand **f** is the sum of the following components: private consumption (**cp**), capital formation (**cf**), stock changes (**st**), exports (**ex**) and government consumption (**cg**): **f** = **cp** + **cf** + **st** + **ex** + **cg**. Total imports **im** are given by: $\mathbf{cp}^{im} + \mathbf{cf}^{im} + \mathbf{st}^{im} + \mathbf{ex}^{im} + \mathbf{cg}^{im} + \mathbf{x}^{im}$, where $\mathbf{x}^{im}$ is the imported intermediate demand ($\mathbf{x}^{im} = \mathbf{B}^{im}\,\mathbf{q}$). Total intermediate demand **x** is the sum $\mathbf{x}^d + \mathbf{x}^{im}$. Value added is defined as the sum of the following row vectors (industry dimension): (i) wages **W**, (ii) profit (gross operating surplus) **Π**, and (iii) net taxes in production, $\mathbf{T_q}$.

In the standard simple IO model, final demand and value added are the exogenous variables. In the model applied in this study, the final demand components are aggregated into two vectors: private consumption (**cp**) and other final demand (**f* = cf** + **st** + **ex** + **cg**). The latter is treated as exogenous, while the former is endogenous in terms of total consumption, *CP*. It is a function of real disposable household income *YD*/*PC*, which is made up of **W** and a share of **Π** (distributed profits). The consumer price *PC* is determined in the price model-part. In this price model, the coefficients of nominal value added-components per unit of real output are treated as exogenous: **w** for wages, **π** for profit and $\mathbf{t_q}$ for net taxes in production. The GDP identity holds from the demand (**GDP** = **q** – **x** = **f** – **im**) as well as from the income (**GDP** = **W** + **Π** + $\mathbf{T_q}$) side.

2.1. The quantity model

Given the definitions in the last section, the quantity model can be solved for output by industries and by goods. The final demand vector without private consumption (**f***) is exogenous and can be shocked in order to analyze multiplier effects. The consumer price *PC* is exogenous as well, from the perspective of the quantity model. Actually, this variable is determined in the price model and therefore constitutes the main feedback link from prices to demand in the model.

The two main equations of the quantity model are:

$$\mathbf{q} = \mathbf{D}\,\mathbf{q}(\mathbf{g}) \tag{1}$$

$$\mathbf{q}(\mathbf{g}) = \mathbf{B}^{\mathrm{d}}\mathbf{q} + \mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} \tag{2}$$

In (2) the domestic part of the final demand categories has been directly plugged in. That has been derived by subtracting the import components from **cp** and **f***. Substituting (1) into (2) gives the solution of the model that can be used to calculate multiplier effects of shocks in (real) domestic final demand, $\Delta\mathbf{f}^{*\mathrm{d}}$:

$$\mathbf{q}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\left(\mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} + \Delta\mathbf{f}^{*\mathrm{d}}\right) \tag{3}$$

In the base year, $\Delta\mathbf{f}^{*\mathrm{d}} = 0$. The vector of private consumption of domestic goods is the matrix product of the vector of quantity shares $\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}$ of domestic goods and total private consumption, *CP*:

$$\mathbf{cp}^{\mathrm{d}} = \mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}CP \tag{4}$$

The quantity shares comprise domestic and imported products, such that $\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}} + \mathbf{s}_{\mathrm{cp}}^{\mathrm{im}} = 1$ and are treated as exogenous. Given these quantity shares, the consumer price can be written as a function of the (row) vectors of domestic and import prices ($\mathbf{p}^{\mathrm{d}}$ and $\mathbf{p}^{\mathrm{im}}$):

$$PC = \mathbf{p}^{\mathrm{d}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}} + \mathbf{p}^{\mathrm{im}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{im}} \tag{5}$$

Total private consumption is endogenized in the same way as in a Social Accounting Matrix (SAM)-model (see: Miller and Blair, 2009). The difference is that the link between income generated in value added and the flows between the household sector and the other institutional sectors are not integrated into an extended matrix system, but are added to the equation system that is solved in loops (see: Kratena, 2017). Private consumption depends on real disposable income *YD*/*PC*, where *YD* is the sum of wages, **i**'**W**, the share (s_Y) of distributed profit **i**'**Π** (with **i**' as the transposed unity vector), government transfers Tr_g minus taxes, T_Y, and net foreign transfers, Tr_f. Defining the row vectors of value added-coefficients for wages as **w** and for profit with $\boldsymbol{\pi}$, and relating (Tr_g - T_Y) to ($\mathbf{i'W}$ + s_Y $\mathbf{i'\Pi}$) via a net income tax rate t_Y, nominal disposable income can be expressed in terms of the output vector:

$$YD = (\mathbf{wq} + s_Y \boldsymbol{\pi}\mathbf{q})(1 + t_Y) + Tr_f \tag{6}$$

Real disposable income then is a function of output and prices:

$$YD/PC = \left[(\mathbf{wq} + s_Y \boldsymbol{\pi}\mathbf{q})(1 + t_Y) + Tr_f\right] / \left[\mathbf{p}^{\mathrm{d}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}} + \mathbf{p}^{\mathrm{im}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{im}}\right] \tag{7}$$

The data for the components of *YD* have been taken from Sectoral Accounts within National Accounts of EUROSTAT. The share of profit that is redistributed to households and enters disposable income (s_Y), is set equal to 0.3 according to these data for the EU 28.

Total consumption of households is derived from a simple log-linear Keynesian consumption function of the type: $\ln CP = c_0 + c_1 \ln (YD/PC)$:

$$CP = C_0 (YD/PC)^{c_1} \tag{8}$$

where $C_0 = e^{c_0}$, and the marginal propensity of consumption (c_1) has been assumed with 0.7 for the benchmark case.

The total quantity model is then made up of the following equations that are solved as a recursive system:

$$\mathbf{q(g)} = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\left(\mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} + \Delta\mathbf{f}^{*\mathrm{d}}\right) \tag{3}$$

$$\mathbf{q} = \mathbf{D}\ \mathbf{q(g)} \tag{1}$$

$$YD/PC = \left[(\mathbf{wq} + s_Y \boldsymbol{\pi}\mathbf{q})(1 + t_Y) + Tr_f\right] / \left[\mathbf{p}^{\mathrm{d}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}} + \mathbf{p}^{\mathrm{im}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{im}}\right] \tag{7}$$

$$\mathbf{cp}^{\mathrm{d}} = \mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}\left(C_0 (YD/PC)^{c_1}\right) \tag{4a}$$

Final demand ($\mathbf{f}^*$) and final demand shocks ($\Delta\mathbf{f}^{*\mathrm{d}}$) as well as foreign transfers (Tr_f) are exogenous and consumption demand depends on the solution of the price model for domestic prices, $\mathbf{p}^{\mathrm{d}}$.

2.2. The price model

The price model is solved for domestic goods ($\mathbf{p}^{\mathrm{d}}$) and output prices (**p**), for given value added-coefficients of the base year ($\mathbf{w}$, $\boldsymbol{\pi}_0$, $\mathbf{t_q}$), and for exogenous import prices ($\mathbf{p}^{\mathrm{im}}$). Factor demand is defined by the fixed value added-coefficients according to the IO specification and no substitution between production factors is assumed. All vectors in the price model are row vectors. The ‘market shares matrix’ is used to transform output prices by industry into goods prices:

$$\mathbf{p}^{\mathrm{d}} = \mathbf{p}\ \mathbf{D} \tag{9}$$

$$\mathbf{p} = \mathbf{p}^{\mathrm{d}}\mathbf{B}^{\mathrm{d}} + \mathbf{p}^{\mathrm{im}}\mathbf{B}^{\mathrm{im}} + \mathbf{w} + \boldsymbol{\pi} + \mathbf{t}_{\mathrm{q}} \tag{10}$$

Substituting (10) into (9) gives the solution of the model that can be used to calculate price multiplier effects of shocks in import prices and value added-coefficients. The solution is written as:

$$\mathbf{p} = \left(\mathbf{p}^{\mathrm{im}}\mathbf{B}^{\mathrm{im}} + \mathbf{w} + \boldsymbol{\pi} + \mathbf{t}_{\mathrm{q}}\right)\left[\mathbf{I} - \mathbf{D}\mathbf{A}^{\mathrm{d}}\right]^{-1} \tag{11}$$

This solution exerts a feedback on the quantity model via the equation for the consumer price (5). The real demand shock ($\Delta\mathbf{f}^{*\mathrm{d}}$) in equation (3) is derived from a nominal demand shock that has demand and price effects on the economy, as laid down by Keynes (1936). Integrating the potential price effect of a nominal demand shock gives the following output price equation:

$$\mathbf{p} = \left(\mathbf{p}^{\mathrm{im}}\mathbf{B}^{\mathrm{im}} + \mathbf{w} + \boldsymbol{\pi}_0 + \mathbf{t}_{\mathrm{q}} + \Delta\mathbf{p}\right)\left[\mathbf{I} - \mathbf{D}\mathbf{A}^{\mathrm{d}}\right]^{-1} \tag{12}$$

In analogy to the quantity model, $\Delta\mathbf{p} = 0$ in the base year.

For given unit costs, that are determined by the terms $\mathbf{p}^{\mathrm{im}}\mathbf{B}^{\mathrm{im}}$, $\mathbf{w}$, and $\mathbf{t}_{\mathbf{q}}$, the additional price increase, triggered by a demand increase, accrues to profits that are the residual. Therefore, the profit-coefficient could also be written as $\boldsymbol{\pi} = \boldsymbol{\pi}_0 + \Delta\mathbf{p}$.

2.3. Quantity and price effects of final demand shocks

In chapter 20, Keynes (1936) sets up the concept of an ‘employment function’ as an alternative to the neoclassical model of the labor market (see also: Gali, 2013). This alternative framework starts with the observation that union wage bargaining leading to nominal downward wage rigidity prevails in economic reality and therefore supply and demand of labor are not balanced by direct changes in the real wage rate, as the neoclassical theory suggests. With fixed nominal wage rates, the relationship between the employment level and the real wage rate is indirectly determined by prices and not directly in the labor market. In the Keynesian view, the employment level is a positive function of effective demand, that has an impact on output as well as on prices. The labor market equilibrium therefore is mainly determined by effective demand that in turn assigns a real wage rate to each employment level (Gali, 2013).

One basic idea in this concept is that any increase in *nominal* effective demand is partially absorbed by the production of additional output and partially by an increase in the price. Keynes (1936) in chapter 20 defines a demand elasticity of output and of prices to describe this double impact. The elasticities with respect to an increase in the *nominal* demand for good *i* are given with:

$$\varepsilon_{qq,i} = \frac{\Delta q(g)_i}{q(g)_i}\frac{qn(g)_i}{\Delta qn(g)_i} = \frac{dln(q(g)_i)}{dln(qn(g)_i)} \quad ; \qquad \varepsilon_{pq,i} = \frac{\Delta p_i^d}{p_i^d}\frac{qn(g)_i}{\Delta qn(g)_i} = \frac{dln(p_i^d)}{dln(qn(g)_i)} \tag{13}$$

A demand shock in terms of nominal goods output ($qn(g)_i$) partially translates into a real goods output effect ($q(g)_i$) and partially into a price effect for good i. Keynes (1936) emphasizes that both elasticities sum to unity ($\varepsilon_{qq,i}$ + $\varepsilon_{pq,i}$ = 1), as $qn(g)_i = p_i^d q(g)_i$. The relative magnitude of both elasticities depends on capacity utilization in each industry and therefore on the state of the economy. The average utilization of capacity in an industry is the mean of a distribution of utilization degrees. Across this distribution, at any time a certain number of firms is close to full capacity, while others might be at their minimum utilization. The whole schedule of the distribution shifts between a boom and a recession in the economy, thereby changing the mean of capacity utilization. At minimum utilization, firms are assumed to fully react with an expansion of production to demand increases. At maximum capacity utilization – that is still below 100% - some firms might still due to their capacity utilization prefer to expand output instead of raising prices. Note that in the IO price model applied here, firms do not face problems in adjusting their prices, which is different from the concept of the new Philipps curve (e.g.: Gali and Gertler, 1998). Therefore, the demand shock elasticities of output and prices can be simply specified as functions of capacity utilization. Data for capacity utilization for the EU 28 have been taken from the Business and Consumer Surveys of the European Commission. These surveys contain seasonally adjusted data for business indicators that have been checked by DG ECFIN. The focus in using the capacity utilization data from this source has been on manufacturing and some selected service industries. The latter either show very low levels of utilization (about 50%) throughout the whole period (1995 – 2020) or almost no variance in the indicator. From a theoretical point of view, the utilization of the capital stock is expected to represent a less restrictive boundary for production in service sectors. An alternative might be the application of a potential output concept for these sectors. Therefore, only a few service sectors have been included into the analysis (‘Land transport’, ‘Warehousing’, ‘Accommodation and food services’, ‘Real estate services’). Across 19 manufacturing sectors and over the sample period 1995 – 2020, the minimum capacity utilization found in the data is 72%, and the maximum is about 85%. For the selected service industries, the corresponding values are 86% and 91%. These limiting values have been taken as the starting point for the calibration of two different functions (for manufacturing and services) that link the demand shock elasticities of output and prices to the level of capacity utilization. As lined out above, at the minimum capacity utilization (72% for manufacturing and 86% for services), any demand increase is transformed into higher output, i.e. ε_{qq} = 1. At the other end of the historical capacity utilization distribution (85% and 91%) there is still a small part of firms that does not raise prices as a consequence of an increase in demand, but reacts via increasing output due to idle capacities. For manufacturing industries this part is 20% and for service industries 55%.

One unique function across industries has been specified for the demand shock elasticity of output:

$$\varepsilon_{qq} = \varepsilon_0 + \varepsilon_1(1 - u_K) \qquad ; \qquad \varepsilon_{pq} = 1 - \varepsilon_{qq} \tag{14}$$

Equation (14) has been calibrated taking into account the maximum and minimum values of the profit-coefficient $\boldsymbol{\pi}$ in the sample (1995 – 2017), based on EUKLEMS data together with the values for capacity utilization. This calibration procedure yields the parameter value for ε_1 = 6 for manufacturing sectors and ε_1 = 9 for service sectors. The constant has been chosen so that ε_{qq} is equal to unity at the minimum capacity utilization rate $u(K)$ of 72% for the average of the manufacturing industries and of 86% for the average of the service sectors.

Figure 1 describes the correlation between the demand shock elasticity of prices and capacity utilization for the manufacturing sector. The function can be described by the following points:

ε_{qq}	ε_{pq}	u_K
1	0	0.72
0.88	0.12	0.74
0.76	0.24	0.76
0.64	0.36	0.78
0.52	0.48	0.8
0.4	0.6	0.82
0.22	0.78	0.85

It must be emphasized here, that calibrating this function is only a first step and a second best-solution for modeling profit mark-ups on unit costs that depend on capacity utilization. The calibrated function though works in this modelling context and represents one option of considering that price adjustments to nominal demand shocks influence the multiplier.

Figure 2 shows the demand shock elasticity of prices for the 19 manufacturing industries at the two extreme points of capacity utilization (boom and recession) according to equation (14). That has been calculated by inserting the minimum and maximum values of u_K (1995 - 2020) in each manufacturing industry into equation (14). As Figure 2 reveals, in most industries the elasticity of output is unity in a recession. It also becomes quite obvious that the function calibrated in equation (14) yields significantly lower values for the elasticity of output in a boom.

>>>>>> Figure 1: Demand shock elasticity of prices and capacity utilization, manufacturing in EU 28>>>>>

>>>>>> Figure 2: Demand shock elasticity in boom and recession, manufacturing sectors in EU 28>>>>

As a next step, the macroeconomic concept of Keynes (1936) needs to be adapted for an IO model. In the concept of the IO model, one cannot define a *nominal* demand shock for domestic good *i* ($\Delta qn_{(g)i}$) as an exogenous demand shock. The change in nominal output is the result of the solution of the full model, taking into account all IO linkages. The only exogenous variable that actually can be shocked in the IO model framework is nominal final demand without consumption, $\mathbf{fn^*}$. Taking into consideration that part of $\mathbf{fn^*}$ (depending on the goods affected) consists of imports ($\mathbf{fn}^{*\mathrm{im}}$), subtracting these imports from the shock converts it into a *nominal* shock to final demand for domestic goods, $\Delta\mathbf{fn}^{*\mathrm{d}}$ (imports stemming from intermediate demand are considered in the solution of the model).

In the next step, one can separate the indirect effects due to IO linkages driven by this demand shock from the induced effects, due to the income/consumption loop. The effects from IO linkages are instantaneous and are necessary inputs for the industries to deliver to those final uses that have been shocked. The induced effects can be seen as adhered to that and taking place after production, when incomes are finally spent. This is a rather simplifying assumption for the purpose of this study. The literature on disaggregation of IO models in time (e.g. Donaghy, et al., 2007, and Avelino, 2017) has shown that some industries produce in advance of the demand and others only after receiving demand signals. Nevertheless, in the context of this study it is only relevant to distinguish between instantaneous 'first round' IO linkages and 'second round' income/consumption effects.

Following this reasoning, the Leontief inverse is used to convert the *nominal* final demand shock for domestic goods, $\Delta\mathbf{fn}^{*\mathrm{d}}$ into a 'first round' *nominal* demand shock as defined in equation (13):

$$\Delta\mathbf{qn}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\Delta\mathbf{fn}^{*\mathrm{d}} \tag{15}$$

This *nominal* demand shock vector then leads to 'first round' price effects, depending on capacity utilization as specified in (14):

$$\Delta\mathbf{p}^{\mathrm{d}} = \mathbf{p}_0^{\mathrm{d}}\hat{\mathbf{E}}_{\mathrm{pq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})} \quad ; \quad \Delta\mathbf{p} = \Delta\mathbf{p}^{\mathrm{d}}\,\mathbf{D}^{-1} \tag{16}$$

In (16), $\hat{\mathbf{E}}_{\mathrm{pq}}$ is a diagonal matrix of the demand shock elasticities of prices $\varepsilon_{pq,i}$, $\Delta\widehat{\mathbf{QN}(\mathbf{g})}$ is a diagonal matrix of elements $\mathrm{dln}(qn(g)_i)$, and $\mathbf{p}_0^{\mathrm{d}}$ is the goods price in the base year data (i.e. without any demand shock). The 'first round' price effects by goods in vector $\Delta\mathbf{p}^{\mathrm{d}}$ are then converted into output 'first round' price effects, $\Delta\mathbf{p}$, with the 'market shares' matrix **D**. The output price effect is added to the profit term, so that this term becomes: $\boldsymbol{\pi} = \boldsymbol{\pi}_0 + \mathbf{p}_0^{\mathrm{d}}\hat{\mathbf{E}}_{\mathrm{pq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}$. Equally, the 'first round' goods price in the case of a demand shock simulation can be written as:

$$\mathbf{p}^{*\mathrm{d}} = \left(\mathbf{p}_0^{\mathrm{d}} + \mathbf{p}_0^{\mathrm{d}}\hat{\mathbf{E}}_{\mathrm{pq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\right) \tag{17}$$

The feedback from the changes in the price system on real disposable income is twofold. The higher profit term increases nominal disposable income with a share of 0.3 and the higher consumer price simultaneously reduces real disposable income.

In analogy to the calculation of 'first round' price effects by combining equations (15) and (17), the potential 'first round' output effects can be calculated applying the matrix of output elasticities $\hat{\mathbf{E}}_{\mathrm{qq}}$ and taking into account that $\Delta\mathbf{f}^{*\mathrm{d}} = [\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}]\Delta\mathbf{q}$:

$$\Delta\mathbf{f}^{*\mathrm{d}} = [\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}]\left(\hat{\mathbf{E}}_{\mathrm{qq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\mathbf{q}\right) \tag{18}$$

This procedure directly follows from $\varepsilon_{qq,i} + \varepsilon_{pq,i} = 1$, which in turn guarantees that $\mathrm{dln}(qn(g)_i) = \mathrm{dln}(p^d{}_i) + \mathrm{dln}(q(g)_i)$ consistent with the original concept of the elasticities, as defined in chapter 20 of Keynes (1936). Both shocks from equation (16) and (18) can then be implemented into the full model and the impact of the demand shock can be assessed from the solution of the model. The solution of the price model can be derived in a stand-alone version, comprising the following equations:

$$\Delta\mathbf{p} = [\mathbf{p}_0^{\mathbf{d}}\hat{\mathbf{E}}_{\mathrm{pq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}]\mathbf{D}^{-1} \tag{16a}$$

$$\mathbf{p} = \left(\mathbf{p}^{\mathrm{im}}\mathbf{B}^{\mathrm{im}} + \mathbf{w} + \boldsymbol{\pi}_0 + \mathbf{t}_{\mathrm{q}} + \Delta\mathbf{p}\right)[\mathbf{I} - \mathbf{D}\mathbf{A}^{\mathrm{d}}]^{-1} \tag{12}$$

$$\mathbf{p}^{\mathrm{d}} = \mathbf{p}\,\mathbf{D} \tag{9}$$

$$PC = \mathbf{p}^{\mathrm{d}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}} + \mathbf{p}^{\mathrm{im}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{im}} \tag{5}$$

In this part, a *nominal* final demand shock for domestic goods ($\Delta\mathbf{fn}^{*\mathrm{d}}$) has in a first step been converted into a *nominal* total demand shock according to $\Delta\mathbf{qn}(\mathbf{g}) = [\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}]^{-1}\Delta\mathbf{fn}^{*\mathrm{d}}$. That yields a 'first round' change in prices ($\Delta\mathbf{p}$ and $\Delta\mathbf{p}^{\mathrm{d}}$) and a 'first round' change in output ($\Delta\mathbf{q}$), where the latter is converted into a *real* final demand shock ($\Delta\mathbf{f}^{*\mathrm{d}} = [\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}]\Delta\mathbf{q}$), as shown in equation (18). Note that the price changes are only 'first round' and do not represent an equilibrium. The new vector of domestic prices is determined in the solution of the full price model (comprising equation (12) and (9)) and interacts with the quantity model via *YD*/*PC*, where *PC* is derived from this solution of the price model. This new consumer price and the *real* demand shock are both introduced into the quantity model that comprises the following equations:

$$\Delta\mathbf{f}^{*\mathrm{d}} = [\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}]\left(\hat{\mathbf{E}}_{\mathrm{qq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\mathbf{q}\right) \tag{18}$$

$$\mathbf{q}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\left(\mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} + \Delta\mathbf{f}^{*\mathrm{d}}\right) \qquad (3)$$

$$\mathbf{q} = \mathbf{D}\,\mathbf{q}(\mathbf{g}) \qquad (1)$$

$$YD/PC = \left[\left(\mathbf{wq} + s_Y\left(\boldsymbol{\pi}_{\mathbf{0}} + \mathbf{p}_0^{\mathrm{d}}\hat{\mathbf{E}}_{\mathrm{pq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\right)\mathbf{q}\right)(1 + t_Y) + Tr_f\right]/PC \qquad (7a)$$

$$\mathbf{cp}^{\mathrm{d}} = \mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}\left(C_0 (YD/PC)^{c_1}\right) \qquad (4a)$$

Note that due to the term $s_Y\left(\boldsymbol{\pi}_{\mathbf{0}} + \mathbf{p}_0^{\mathrm{d}}\hat{\mathbf{E}}_{\mathrm{pq}}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\right)$ in the definition of disposable income, induced price effects from the demand shock also have a positive influence on income, though the negative via *PC* dominates. There is one recursive loop in this part of the model, working via the income/consumption feedbacks of the quantity model, i.e. the standard type II model -loop. This part is solved as an equation system applying an iterative procedure and finally yields the full multiplier of the shock.

3. Multipliers in booms and recessions

The model has been used for simulations of a 1% of GDP shock of gross fixed capital formation (GFCF) of the electricity sector. Investment in this sector has been a key element of recovery programs and national investment strategies (decarbonization) after recent crises. In the model presented above, the GFCF vector is part of exogenous final demand ($\mathbf{f}^{*\mathrm{d}}$). It represents the total demand for investment goods from all industries. The double entry information on investment by industry and by good is described in investment matrices, that are officially only available for a small number of EU countries. For this study, the column ‘Electricity, gas, steam and hot water’ of the investment matrix 2014 for Austria (source: Statistics Austria) has been applied for splitting up the 1% of GDP investment of this sector across all goods. The second step in preparing the adequate demand shock vector consisted of applying the import shares by good of the GFCF vector in the EU 28 SUT (2016). That yields the domestic part of the vector and results in a slight reduction of the demand shock to 0.87% of GDP. The final step is converting the final demand shock for domestic goods ($\Delta\mathbf{fn}^{*\mathrm{d}}$) into the total demand shock: $\Delta\mathbf{qn}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\Delta\mathbf{fn}^{*\mathrm{d}}$. A small number of goods makes up for about 65% of this vector: ‘Basic metals’, ‘Fabricated metals’, ‘Electrical equipment’ (16%), ‘Machinery and equipment’, ‘Repair and installation of machinery’ (10%), ‘Construction’ (12%), ‘Wholesale trade’, ‘Computer programming’, and ‘Architectural and engineering services’.

Table 1 and Figure 3 reveal the considerable difference of induced price effects from this demand shock calculated with equation (16a) in boom and recession. For those primary and service industries, for which no elasticity function (equation (14)) has been calibrated, the average values of the elasticity of prices ε_{pq} across sectors for boom and recession have been plugged in. These average elasticity values amount to 0.088 at minimum capacity utilization and 0.812 at maximum capacity utilization and together with the values from equation (14) yield full matrices $\hat{\mathbf{E}}_{\mathrm{pq}}$ and $\hat{\mathbf{E}}_{\mathrm{qq}}$ for equations (16a) and (18) without any zero elements. In general, at maximum capacity (i.e. in a boom), a large part of the shock is absorbed by price increases in most industries and $\Delta\mathbf{f}^{*\mathrm{d}}$ is very small.

>>>>>> *Table 1: Price effect (in %) of the demand shock in boom and recession, manufacturing sectors in EU 28*>>>>>>>

>>>>>> *Figure 3: Price effect (in %) of the demand shock in boom and recession, manufacturing sectors in EU 28*>>>>>>

The effects $\Delta\mathbf{p}$ and $\Delta\mathbf{f}^{*\mathrm{d}}$ have been introduced into the model comprising equations (1), (3), (4a), (5), (7a), (9), (12), (16a) and (18). In Table 2 and Figure 4 the most important macroeconomic effects of the simulations for both states of the economy can be observed. The variables shown are those that are crucial for understanding the model mechanisms which lead to the significant differences in results for the two states of the economy. The first striking result is that nominal disposable income is almost affected in the same magnitude in both situations. In a boom, the price effects result in higher profits, of which 30% accrues to disposable income. This aspect is overseen in some Keynesian models (e.g. Carlin and Soskice, 2018 and Ravn and Sterk, 2016), that work with the Kaleckian feature that all profits are saved and consumption stems from wages. The impact on real disposable income (deflated by the consumer price) is considerably different in both states due to large differences in the consumer price effect that is almost zero in the case of a recession. That leads to almost a double impact of the same demand shock on private consumption in the case of a recession. In that sense, the model outlined here corroborates the results of Shen and Vang (2017), namely that different price dynamics are the cause for different consumption reactions in booms and recessions. This is an alternative view to the line of research that motivates the differences in consumption reaction with differences in household behavior (expectations) and in the financial environment between booms and busts (Auerbach and Gorodnichenko, 2012; Eggertson and Krugman, 2012). The impact on final demand, GDP and gross output is almost double in the case of a recession. Another result of Shen and Vang (2017) is also confirmed by the results in Table 2 and Figure 4, namely the difference in the impact on the real wage rate. As nominal wages have not been changed in the model simulations here, the negative of the change in the consumer price is equal to the change in the real wage rate. Shen and Vang (2017) derive a decrease in the real wage rate with a government spending shock in expansions and an increase in recessions. This result is not exactly matched here, as there is also a small decrease in the real wage rate (- 0.11%) in the case of recession, which is much smaller than the same effect in a boom (- 0.87%), though. Different signs in impact are obtained in the total real income effects. In the case of a boom, the high impact on prices dominates the positive income effect from an expansion in output and real income decreases.

>>>>>> *Table 2: Macroeconomic effects (in %) of the demand shock in boom and recession* >>>>>>

>>>>>> *Figure 4: Macroeconomic effects (in %) of the demand shock in boom and recession* >>>>>

The differences in the macroeconomic results are also visible in the sectoral effects on gross output (Figure 5). In general, in all manufacturing sectors, gross output is much more stimulated in the case of a recession than in a boom. Figure 5 also shows the direct effects of the demand shock, calculated by dividing the elements of the *nominal* domestic demand shock vector ($\Delta\mathbf{fn}^{*\mathrm{d}}$, before any price effects are induced) by the elements of goods output ($\mathbf{q}(\mathbf{g})$). These direct effects are concentrated in the two investment goods industries 'Electrical equipment' and 'Repair and installation of machinery' and are slightly larger than the final output effects in the recession case. This is due to capacity constraints for some firms in these industries, even in a recession as measured here (minimum capacity utilization in historical data). In other industries that have a high share in the direct effects of the demand shock ('Computer/electronic products', 'Machinery and equipment', 'Construction', 'Computer programming', 'Architectural and engineering services'), the final output effect in a recession is higher than the direct effect, partly by IO linkages and partly by induced consumption. The final output effects in a boom are very low compared to the effects in a recession as well as compared to the direct effects, i.e. the capacity constraints actually inhibit the expansion of output and trigger the price effects.

>>>>>> *Figure 5: Output effects (in %) of the demand shock in boom and recession, selected industries in EU 28*>>>>

4. Multipliers in different model specifications

In order to put the macroeconomic impacts as well as the resulting multipliers in perspective, the results of the modelling approach have been compared with alternative model specifications. The model set up in this study can be seen as an alternative to (i) the standard IO model, (ii) the standard type II model, and (iii) the standard CGE model.

Common to specifications (i) and (ii) is that no difference between nominal and real demand shocks exists and no interaction between the price and the quantity model takes place. In the standard IO model, no income/consumption multiplier prevails and the additional final demand shock in terms of domestic goods equals the induced value added. In an open economy, part of the final demand shock will always consist of imports, so that the GDP multiplier in the standard IO model will always be below unity. The gross output multiplier in the standard IO model is larger than unity due to the IO linkages. In the type II-model the IO linkages are complemented by an income/consumption loop, so that a GDP multiplier is larger than unity. Usually, in type II-models, the consumption reaction to income is described by fixed average coefficients, in analogy to the technical coefficients in production. In order to be comparable, the type II-model specified here incorporates the same consumption function (equation (4a)) as the basic model in this study. It can be expected that the type II-model yields a maximum multiplier effect, as only positive feedback mechanisms of the final demand shock are included and no negative feedback either from the price side nor from the policy environment (as in the case of the 'net multiplier') is considered. One can attempt to entangle the perspective of different states of the economy (boom and recession) with different model specifications in a systemic way (Table 3). That should be useful for understanding the comparison of results. The basic model has been used for simulations of the demand shock in a recession and in a boom and the results have been presented in the last section. The type II-model and the standard IO model can both be characterized as representing a situation with no price feedbacks which is the analogue to the recession case. The type II-model additionally takes a positive consumption/income loop after a demand shock into account.

In the standard CGE model, the macroeconomic closure rule (investment equals savings) restricts the multiplier of an exogenous investment demand shock and the new demand crowds out existing investment, as investment is fixed either by the amount of savings or directly exogenous (Burfisher, 2017). Robinson (2006) has demonstrated that it is the macro-closure rule that decides about the multiplier impact from a model, everything else (functional forms, parameter values) equal. This same idea is followed here and the CGE model specification is imposed within the structure of the basic model. In principle, the macro-closure rule of fixed investment can be imposed in different ways in a static CGE model (Burfisher, 2017 and Robinson, 2006). Several mechanisms in the solution algorithm of the model drive the adjustment towards the equilibrium that is defined by the closure rule. One mechanism is the tâtonnement process that balances supply and demand and finds the equilibrium price for all goods. The other mechanism in order to adjust investment is the same tâtonnement mechanism at the factor market for capital. The factor market for capital is not modelled here, the interest rate plays no role and the capital stock is inherited from the past and can be utilized to a certain degree. Therefore, a simple closure rule of fixed investment is used to be introduced in the basic model of this study, namely the tâtonnement process between supply and demand for all goods, imposing the supply/demand equilibrium of the basecase. That can be translated in the functioning of the basic model as a full capacity utilization, so that any exogenous demand shock represents excess demand and the elasticity of prices to output changes (ε_{pq}) for all sectors is always unity. The CGE model specification therefore represents the situation of a boom (Table 3) in the extreme fashion of pure price feedbacks from demand shocks. Besides that, the model structure is the same as in the basic model and incorporates the same consumption function.

Another option for different model specifications is sensitivity analysis with respect to core parameters. In the model simulations presented above, the difference in the consumption reaction is driven by the difference in income and price effects. One could assume that - as the literature about fiscal multipliers and consumption does - a recession is also different from a boom in terms of consumption reactions to transitory income shocks induced by the demand shock. This can be due to increased unemployment probability, tighter liquidity constraints and, in general, higher income uncertainty, especially in the case of a large recession. The sensitivity analysis is carried out for the case of a recession and uses the same elasticities of prices to demand shocks, as well as the basic model structure with the same consumption function. The only difference is a higher marginal consumption reaction to the transitory income shock triggered by the exogenous demand shock (Table 3).

>>>>>*Table 3: Model features: States of the economy and model specifications*>>>>>

The standard IO model can be formulated in terms of the quantity model only, as no price feedbacks from the final demand shock prevail. Equation (18b) states that in this case the real final demand shock simply equals the nominal final demand shock. The IO quantity model is comprised in equations (3) and (1).

$$\Delta\mathbf{f}^{*\mathrm{d}} = \Delta\mathbf{fn}^{*\mathrm{d}} \tag{18b}$$

$$\mathbf{q}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\left(\mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} + \Delta\mathbf{f}^{*\mathrm{d}}\right) \tag{3}$$

$$\mathbf{q} = \mathbf{D}\,\mathbf{q}(\mathbf{g}) \tag{1}$$

In the case of the type II-model the final demand shock is also defined by equation (18b). The IO quantity model (equations (3) and (1)) is complemented by the definition of disposable income and the consumption vector, both without price feedback.

$$\Delta\mathbf{f}^{*\mathrm{d}} = \Delta\mathbf{fn}^{*\mathrm{d}} \tag{18b}$$

$$\mathbf{q}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\left(\mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} + \Delta\mathbf{f}^{*\mathrm{d}}\right) \tag{3}$$

$$\mathbf{q} = \mathbf{D}\,\mathbf{q}(\mathbf{g}) \tag{1}$$

$$YD = \left[(\mathbf{wq} + s_Y\boldsymbol{\pi}_\mathbf{0}\mathbf{q})(1 + t_Y) + Tr_f\right] \tag{7b}$$

$$\mathbf{cp}^{\mathrm{d}} = \mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}(C_0(YD)^{c_1}) \tag{4b}$$

The CGE model has the same structure as the basic model, but the elasticity of prices in all industries to demand shocks equals unity, so that matrix $\hat{\mathbf{E}}_{\mathrm{pq}}$ becomes the unity matrix $\mathbf{I}$. Therefore, equations (16a) and (7a) can be converted into (16b) and (7b) by substituting the product $\mathbf{p}_\mathbf{0}^\mathbf{d}\hat{\mathbf{E}}_{\mathrm{pq}}$ simply by the base-year price vector, $\mathbf{p}_\mathbf{0}^\mathbf{d}$. That is equivalent to 'first round' price effects that are equal to the 'first round' output effects in $\Delta\mathbf{QN}(\mathbf{g})$. As sectoral output $\mathbf{q}$ is given in the CGE model by the capacity constraint, additional final demand $\Delta\mathbf{f}^{*\mathrm{d}}$ needs to crowd out other investment. This is not explicitly shown here, but instead the shock has no direct impact ($\Delta\mathbf{f}^{*\mathrm{d}} = 0$):

Prices:

$$\Delta\mathbf{p} = \left[\mathbf{p}_\mathbf{0}^\mathbf{d}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\right]\mathbf{D}^{-\mathbf{1}} \tag{16b}$$

$$\mathbf{p} = \left(\mathbf{p}^{\mathrm{im}}\mathbf{B}^{\mathrm{im}} + \mathbf{w} + \boldsymbol{\pi}_0 + \mathbf{t}_{\mathrm{q}} + \Delta\mathbf{p}\right)\left[\mathbf{I} - \mathbf{DA}^{\mathrm{d}}\right]^{-1} \tag{12}$$

$$\mathbf{p}^{\mathrm{d}} = \mathbf{p}\,\mathbf{D} \tag{9}$$

$$PC = \mathbf{p}^{\mathrm{d}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{d}} + \mathbf{p}^{\mathrm{im}}\mathbf{s}_{\mathrm{cp}}^{\mathrm{im}} \tag{5}$$

Quantities:

$$\Delta\mathbf{f}^{*\mathrm{d}} = 0 \tag{18b}$$

$$\mathbf{q}(\mathbf{g}) = \left[\mathbf{I} - \mathbf{A}^{\mathrm{d}}\mathbf{D}\right]^{-1}\left(\mathbf{cp}^{\mathrm{d}} + \mathbf{f}^{*\mathrm{d}} + \Delta\mathbf{f}^{*\mathrm{d}}\right) \tag{3}$$

$$\mathbf{q} = \mathbf{D}\,\mathbf{q}(\mathbf{g}) \tag{1}$$

$$YD/PC = \left[\left(\mathbf{wq} + s_Y\left(\boldsymbol{\pi}_\mathbf{0} + \mathbf{p}_\mathbf{0}^\mathbf{d}\,\Delta\widehat{\mathbf{QN}(\mathbf{g})}\right)\mathbf{q}\right)(1 + t_Y) + Tr_f\right]/PC \tag{7b}$$

$$\mathbf{cp}^{\mathrm{d}} = \mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}(C_0(YD/PC)^{c_1}) \tag{4a}$$

The sensitivity analysis only differs from the basic model by assuming that the marginal propensity of consumption (*mpc*) out of disposable income generated as a consequence of the final demand shock (c_2) is equal to 0.9, whereas c_1 = 0.7 applies to the base-year real income (YD_0/PC_0):

$$\mathbf{cp}^{\mathrm{d}} = \mathbf{s}_{\mathrm{cp}}^{\mathrm{d}}(C_0(YD_0/PC_0)^{c_1}(YD/PC - YD_0/PC_0)^{c_2}) \tag{4c}$$

The basic model with this alternative consumption function consists of equations (1), (3), (4c), (5), (7a), (9), (12), (16a) and (18).

Table 4 and Figure 6 compare the basic model results for a recession with the two extreme specifications of the type II-Model and the CGE model. The specification of the type II model could be thought of as a 'Keynesian equilibrium' as defined in Carlin and Soskice (2018), where the zero lower bound of the interest rate is binding and inflation is stable at zero as well. The CGE model is exactly the opposite case, where all firms in all industries are in a full capacity utilization equilibrium. The macroeconomic outcomes clearly confirm these views, showing the expected results for output and prices.

The result from the last section, that higher prices due to a higher profit term have a counterpart in disposable income is also found in these alternative model specifications. The impact on nominal disposable income is still about 0.7% in the CGE model specification, though no new wage income is generated in that case. As in the case of a boom, the high consumer price effect – more than 1% in the CGE model – drives a negative real income effect and, as a consequence, a negative consumption impact. Final demand is in total negatively affected in the CGE model, as the nominal final demand shock is fully compensated by price effects and the private consumption effect is negative. The price effects of excess demand in this specification therefore not only crowd out the additional investment form the demand shock, but additionally also some private consumption. That leads to an overall slightly negative GDP impact in the CGE model, whereas in the type II-model it is slightly higher (1.15%) than in the recession case. The type II-model case shows high nominal income effects, which – as no price feedbacks are at work – directly translate into real income effects. The profit term impact on disposable income is therefore completely absent in this model specification, all income is generated in the form of wages and is spent to a large part on consumption, driving the high multiplier impact. In the case of a recession, from the small consumer price effect (0.11%), one can conclude that the profit term impact on disposable income is also very small, though not zero as in the case of the type II-model

>>>>> *Table 4: Macroeconomic effects (in %) of the demand shock: Recession vs. different model specifications*>>>>>

>>>>> *Figure 6: Macroeconomic effects (in %) of the demand shock: Recession vs. different model specifications*>>>>>

Table 5 and Figure 7 show all results in terms of output effects and multipliers of different states of the economy and different model specifications. The multipliers are all defined as the result in the corresponding variable (GDP or gross output) in relation to the *nominal* final demand shock for domestic goods (which is about 0.87% of GDP after subtracting imports from the total investment vector in the first place).

The highest values for multipliers are derived from the type II-model and from the basic model in a recession with the high marginal propensity of consumption (c_2 = 0.9) for transitory income changes. The GDP multiplier in these two model specifications is about 1.4 and the gross output multiplier is about 3. Using the standard type II-model for impact analysis is – according to these results – therefore only justified in a recession and when high consumption reactions to transitory income shocks can be expected. Otherwise the type II-model heavily overestimates the multiplier effects from demand shocks. The CGE model and the basic model in a boom both yield GDP multipliers close to zero, and a gross output multiplier between -0.3 (CGE) and 0.35. The range of GDP multipliers of all model specifications and different states of the economy therefore is between zero and 1.4, which is very much in line with the literature. Auerbach and Gorodnichenko (2012) conclude a range between 0.5 and 1.5 from their quantitative calibrated model and Shen and Vang (2017) between 0.57 and 1.7. These macroeconomic studies apply other techniques (SVAR) for deriving multipliers and consider other channels for crowding out effects through monetary policy.

The standard IO model results show a GDP multiplier of 0.9 and a gross output multiplier of 2. The bias of using the standard IO model for multiplier analysis instead of the basic model of this study therefore may act in both directions. Using the standard IO model in a situation of a recession may result in a slight underestimation of multiplier effects, whereas using it in a situation of a boom leads to a considerable overestimation of impacts.

>>>>>> *Table 5: Macroeconomic effects (in %) and multipliers of the demand shock in different states of the economy and with different model specifications* >>>>

>>>>>> *Figure 7: Multipliers of the demand shock in different states of the economy and with different model specifications* >>>>

Although at the aggregate level only a small difference in the output impact between the basic model in a recession (gross output impact: 1.08%) and the standard IO model (gross output impact: 0.86%) can be observed, the results by industry reveal important differences in both directions (Figure 8). Figure 5 shows that in the two investment goods industries that are mainly directly affected by the demand shock ('Electrical equipment', 'Repair and installation of machinery'), the direct effects exceed the final output effects. This is not the case in the standard IO model, as no capacity constraints are at work, so that the final output effects are higher than the direct effects in these industries. In sectors that are either strongly directly affected by the demand shock or via IO linkages, the output effects in the recession case are similar to those in the standard IO model and considerably higher than the direct effects. Relatively small output effects are observed across many industries in the recession case ('Food/beverages/tobacco', 'Textile/wearing apparel', 'Pharmaceutical products', 'Motor vehicles', 'Furniture', 'Accommodation and food services', 'Motion pictures/broadcasting', 'Creative arts, entertainment', 'Sporting services and recreation', 'Other personal services') , where the output effects from the standard IO model are almost zero. These are induced by higher real income and consumption and therefore absent in the case of the standard IO model.

>>>>>> *Figure 8: Output effects (in %) of the demand shock in recession and standard IO model, selected industries in EU 28* >>>>

5. Conclusions

The objective of this paper was establishing a simple comparative-static macroeconomic IO model with price feedbacks, that allows for large multiplier effects of demand shocks in recessions and small multipliers in booms (Shen and Yang, 2018). The same multiplier heterogeneity is also demonstrated with different model specifications (standard IO, type II, CGE). The main mechanisms in the methodology are cyclical reactions of output and prices to demand shocks, postulated by Keynes (1936) in chapter 20 ('employment function'). This can be seen as a simple surrogate for a Philipps curve without an explicit treatment of expectation formation. The interplay between rigid wage rates and flexible prices that react to demand shocks simultaneously determines nominal income and the consumer price. Demand shocks on the one hand create additional disposable income from wages and partly also from profits, and on the other hand also raise prices, depending on the state of the economy. The profit component of disposable income turns out to be important and has been overlooked in some Keynesian models (e. g. Carlin and Soskice, 2018). A main result of model simulations for a 1% of GDP investment shock is that the difference in reaction of private consumption to this stimulus between recessions and booms can be fully attributed to this interplay between nominal income and the consumer price. This result is fully in line with Shen and Yang (2018) and presents an alternative explanation for heterogeneity in consumption reactions to most of the fiscal multiplier literature (e.g. Auerbach and Gorodnichenko, 2012). These studies attribute differences in consumption response to changes in the composition of consumer types (‘Ricardian equivalence’ vs. ‘hand-to-mouth’).

The basic macroeconomic IO model gives a GDP multiplier of 0.15 and a gross output multiplier of 0.35 from demand shocks in a boom. The GDP multiplier in a recession is between 1.2 and 1.3 and the gross output multiplier between 2.6 and 2.9, depending on the severeness of the recession in terms of income uncertainty and liquidity constraints (marginal propensity of consumption out of transitory income). These results are in line with the macroeconomic literature on state-dependent multipliers. The standard IO model results show a GDP multiplier of 0.87 and a gross output multiplier of 2.05. Using the standard IO model leads to a slight underestimation of multipliers in a recession, and to a considerable overestimation of impacts in a boom. The standard type II-multiplier model without price feedbacks for multiplier analysis most probably overestimates the multiplier, except in severe recessions. A CGE model specification yields small negative multipliers, as the price effects from excess demand not only crowd out the investment stimulus, but also some private consumption. The impacts across industries not only depend on relative capacity constraints, but also on the induced consumption effects, which are high in the recession case and in the type II-Model and absent in the standard IO model.

Though the methodology and the applications serve to derive state-dependent multipliers in a macroeconomic IO model, there are important shortcomings and scope for further development of the method. First, in the current model version, the shocks need to be introduced in a step-wise procedure in the model and the mechanisms do not work simultaneously. The postulated relationship between price adjustment and capacity utilization is based on a calibrated function that fulfills certain desired properties and matches extreme values in sample data (1995 – 2020). The concept needs to be further developed in the direction of econometric mark-up price equations with an explicit expectation formation mechanism as in the concept of the new Philipps curve (Gali and Gertler, 1998; Shen and Yang, 2018) and an explicit and empirically sound elasticity of the mark-up with respect to capacity utilization. The model also simply assumes downward wage rigidity by not dealing with wage formation and the labor market. A labor market module needs to be added where downward wage rigidity can be explicitly modeled. Another important extension that intrudes itself is heterogeneity across households. As Kim et al. (2015) have shown, differentiating groups of households with different behavior and consumption structures serves to explain large changes in the structure of the economy. In the setting of the model presented here, one would expect that also the aggregate short-run multipliers would be more diverse with demand shocks affect different household groups in a different way.

References

Auerbach, A. J. and Y. Gorodnichenko (2012) Measuring the output responses to fiscal policy, *American Economic Journal: Economic Policy* 4(2), 1 – 27.

Avelino, A. F. (2017) Disaggregating input–output tables in time: the temporal input–output framework, *Economic Systems Research*, 29(3), 313 – 334.

Blanchflower D.G., Oswald, A.J. (1994) The wage curve. Cambridge, Massachusetts, *MIT Press*.

Burfisher, M. E. (2017) Introduction to computable general equilibrium models, *Cambridge University Press*, Cambridge 2017.

Carlin, W. and D. Soskice (2018) Stagnant productivity and low unemployment: stuck in a Keynesian equilibrium, *Oxford Review of Economic Policy*, 34(1–2), 169 – 194.

Clopper, A. (1991) The INFORUM approach to interindustry modeling, *Economic Systems Research*, 3, (1), 1-7.

Donaghy, K. P., N. Balta-Ozkan, G. J. D. Hewings (2007) Modeling unexpected events in temporally disaggregated econometric input–output models of regional economies, *Economic Systems Research*, 19(2), 125 – 145.

Eggertson, G. B. and P. Krugman (2012) Debt deleveraging, and the liquidity trap: A Fisher-Minsky-Koo approach, *Quarterly Journal of Economics* 127, 1- 45.

Eggertsson, G. B., N. R. Mehrotra, and J. A. Robbins (2019) A model of secular stagnation: Theory and quantitative evaluation, *American Economic Journal: Macroeconomics*, 11(1), January 2019, 1 – 48.

Gali, J., M. Gertler (1998) Inflation dynamics: A structural econometric analysis, *Journal of Monetary Economics*, 44 (2), October 1999, 195 – 222.

Gali, J., J. D. López-Salido, and J. Valles (2004) Understanding the effects of government spending on consumption, *European Central Bank Working Paper Series* No. 339, April 2004.

Gali, J. (2013) Notes for a new guide to Keynes (I): Wages, aggregate demand, and employment, *Journal of the European Economic Association*, 11 (5), October 2013, 973-1003.

Guerra, A. I. and F. Sancho (2011) Budget-constrained expenditure multipliers, *Applied Economics Letters*, 18, 1259 – 1262.

Keynes, J. M. (1936) The general theory of employment, interest and money, *MacMillan*, London, 1936.

Kim K., K. Kratena, G.J.D. Hewings (2015) The extended econometric input–output model with heterogenous household demand system, *Economic Systems Research*, 27 (2), 257-285.

Kratena, K., (2017) General equilibrium analysis, in: T. ten Raa (ed.), Handbook of Input-Output Analysis, *Edward Elgar*, Cheltenham 2017.

Kratena, K., G. Streicher, S. Salotti, M. Sommer, and J. Valderas Jaramillo (2017) FIDELIO 2: Overview and theoretical foundations of the second version of the fully interregional dynamic econometric long-term input-output model for the EU27. *JRC Technical Report JRC105900*, EUR 28503 EN, Sevilla, 2017 (doi:10.2760/313390)

Leeper, E. M., N. Traum, and T. B. Walker (2015) Clearing up the fiscal multiplier morass: Prior and posterior analysis, *NBER Working Paper Series*, # 21433.

Meade, D. (2013) The Inforum LIFT model: Technical documentation, November 2013, College Park, MD.

Meyer, B., C. Lutz, C (2007) The GINFORS model: Model overview and evaluation (available at: http://www.petre.org.uk/pdf/sept08/petrE_WP3%202%20Ginfors.pdf).

Meyer, B., G. Ahlert (2017), Imperfect markets and the properties of macro-economic-environmental models as tools for policy evaluation. *Ecological Economics*, 155, 809-87.

Miller, R. E. and P. D. Blair (2009) Input-output analysis. Foundations and extensions. 2nd edidtion, *Cambridge University Press*, New York, 2009.

Oosterhaven, J., E. C. Van der Knijff, and G. J. Eding (2003) Estimating interregional economic impacts: An evaluation of nonsurvey, semisurvey, and fall-survey methods, *Environment and Planning*, A 35(1), 5 – 18.

Oywang, M. T., V. A. Ramey, and S. Zubairy (2013) Are government spending multipliers greater during periods of slack? Evidence from twentieth-century historical data , *American Economic Review: Papers & Proceedings* 103(3), 129 – 134.

Ravn, M., and V. Sterk (2016) Macroeconomic Fluctuations with HANK & SAM: An Analytical Approach, *Discussion Papers-Centre for Macroeconomics* (CFM), 1633.

Robinson, S. (2006), Macro models and multipliers: Leontief, Stone, Keynes, and CGE models, in: A. de Janvry and R. Kanbur, eds., *Poverty, Inequality and Development: Essays in Honor of Erik Thorbecke*, New York: Springer Science, 2006, 205-232.

Shen, W., S-C. S. Vang (2017) Downward nominal wage rigidity & state-dependent government spending multipliers, *Journal of Monetary Economics*, 98, October 2018, 11 – 26.

Stiglitz, J. (2018) Where modern macroeconomics went wrong, *Oxford Review of Economic Policy*, 34(1–2), 70 – 106.

Vines, D. and S. Wills (2018) The rebuilding macroeconomic theory project: an analytical assessment, *Oxford Review of Economic Policy*, 34(1–2), 1 – 42.

Zubairy, S. (2014) On fiscal multipliers: estimates from a medium scale DSGE model, *International Economic Review*, 55(1), 169 – 195.

Figure 1: Demand shock elasticity of prices and capacity utilization, manufacturing in EU 28

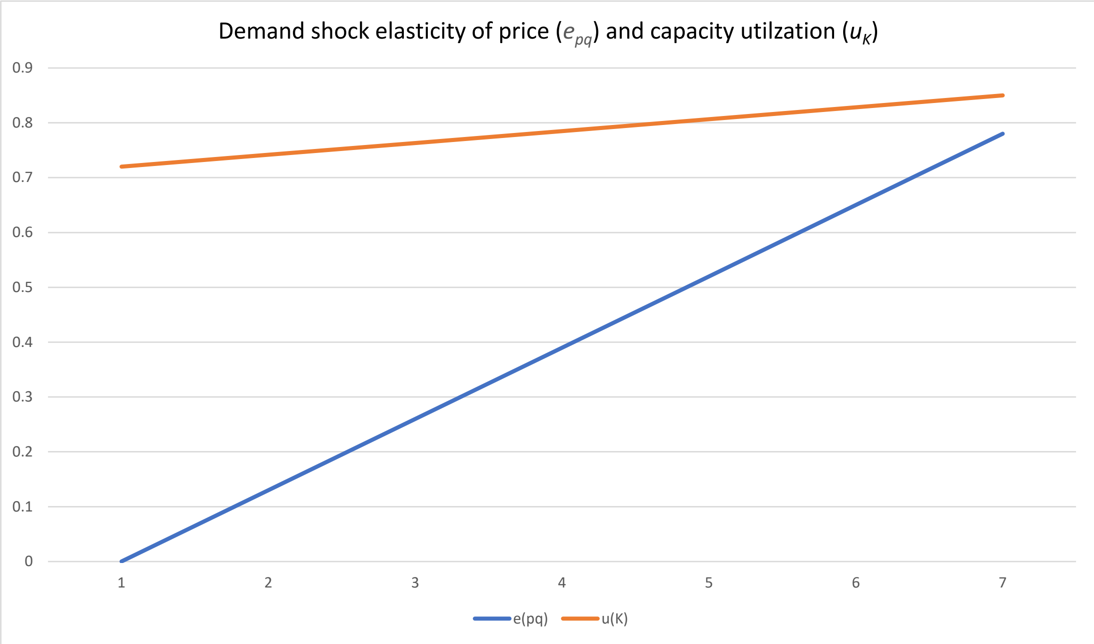

Figure 2: Demand shock elasticity of output in boom and recession, manufacturing sectors in EU 28

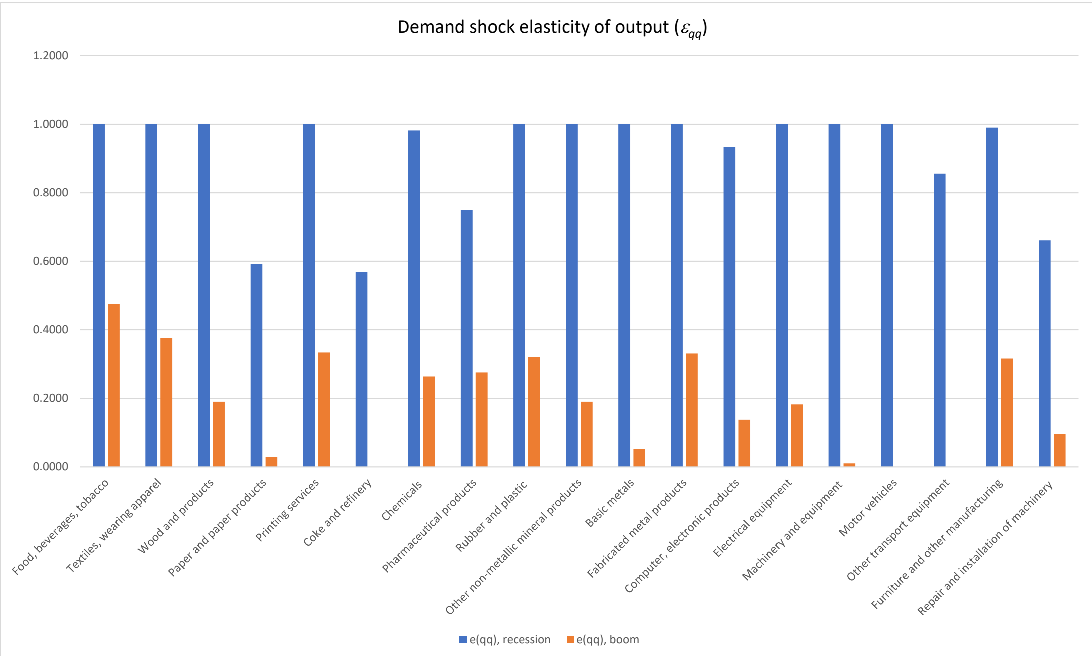

Table 1: Price effect (in %) of the demand shock in boom and recession, manufacturing sectors in EU 28

	recession	boom
Food, beverages, tobacco	0.00%	0.04%
Textiles, wearing apparel	0.00%	0.11%
Wood and products	0.00%	1.32%
Paper and paper products	0.23%	0.54%
Printing services	0.00%	0.40%
Coke and refinery	0.16%	0.36%
Chemicals	0.01%	0.45%
Pharmaceutical products	0.01%	0.03%
Rubber and plastic	0.00%	0.94%
Other non-metallic mineral products	0.00%	1.39%
Basic metals	0.00%	2.56%
Fabricated metal products	0.00%	1.29%
Computer, electronic products	0.19%	2.51%
Electrical equipment	0.00%	11.82%
Machinery and equipment	0.00%	1.65%
Motor vehicles	0.00%	0.35%
Other transport equipment	0.05%	0.35%
Furniture and other manufacturing	0.00%	0.21%
Repair and installation of machinery	2.99%	7.99%

Figure 3: Price effect (in %) of the demand shock in boom and recession, manufacturing sectors in EU 28

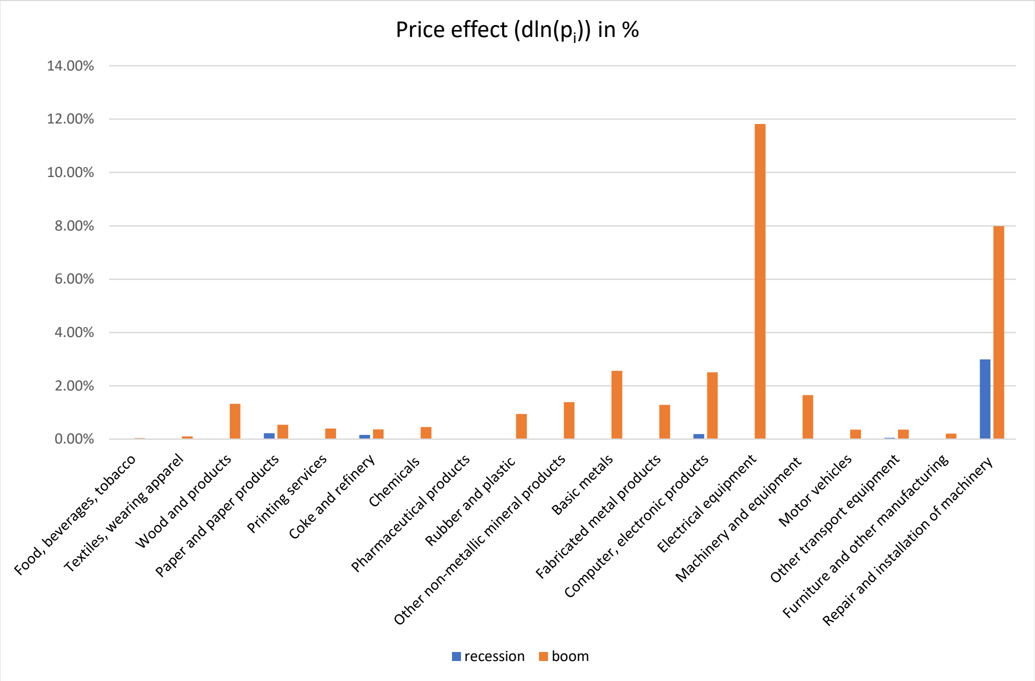

Table 2: Macroeconomic effects (in %) of the demand shock in boom and recession

	recession	boom
Disposable income	1.08%	0.77%
Cons. Price	0.11%	0.84%
Disposable income/Cons. Price	0.97%	-0.06%
Private consumption	0.68%	-0.04%
Final demand	0.99%	0.13%
GDP	0.97%	0.13%
Gross output	1.08%	0.15%

Figure 4: Macroeconomic effects (in %) of the demand shock in boom and recession

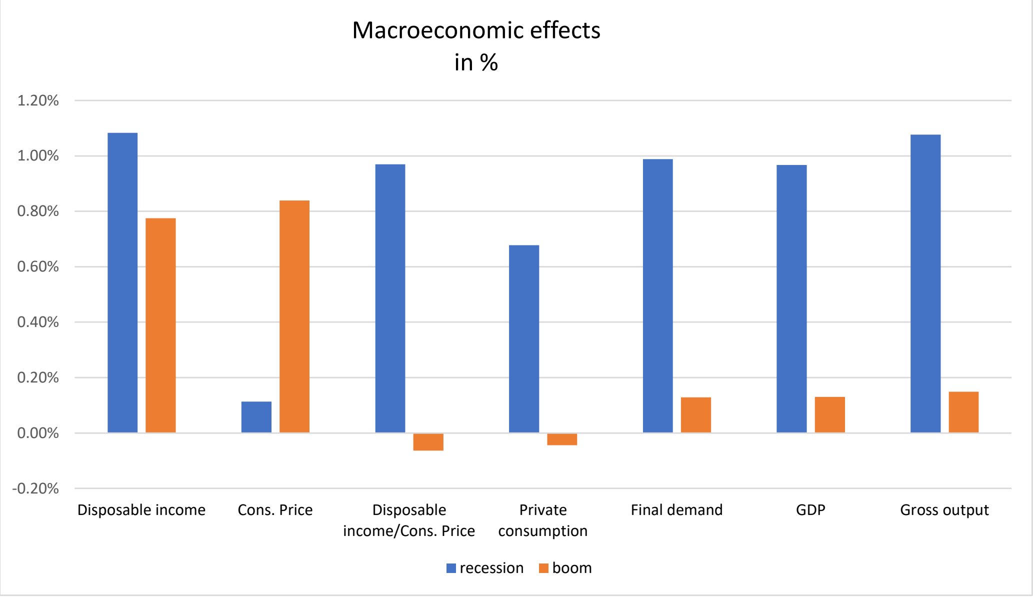

Figure 5: Output effects (in %) of the demand shock in boom and recession, selected industries in EU 28

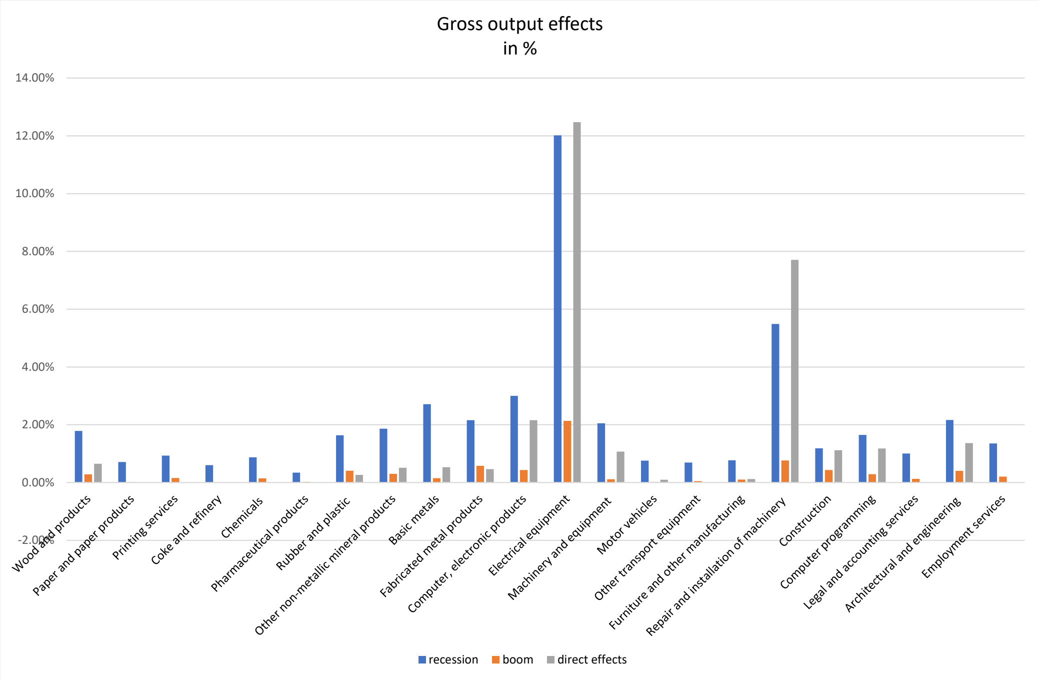

Table 3: Model features: States of the economy and model specifications

				Basic model
Recession	Basic model	Standard IO	Type II	mpc = 0.9
		no price feedback	no price feedback	
		no consumption reaction	consumption reaction	high consumption reaction
Boom	Basic model			CGE
				only price feedback
				consumption reaction

Table 4: Macroeconomic effects (in %) of the demand shock: Recession vs. different model specifications

	recession	Type II	CGE
Disposable income	1.08%	1.24%	0.66%
Cons. Price	0.11%	0.00%	1.07%
Disposable income/Cons. Price	0.97%	1.24%	-0.40%
Private consumption	0.68%	0.87%	-0.28%
Final demand	0.99%	1.17%	-0.14%
GDP	0.97%	1.15%	-0.13%
Gross output	1.08%	1.27%	-0.13%

Figure 6: Macroeconomic effects (in %) of the demand shock: Recession vs. different model specifications

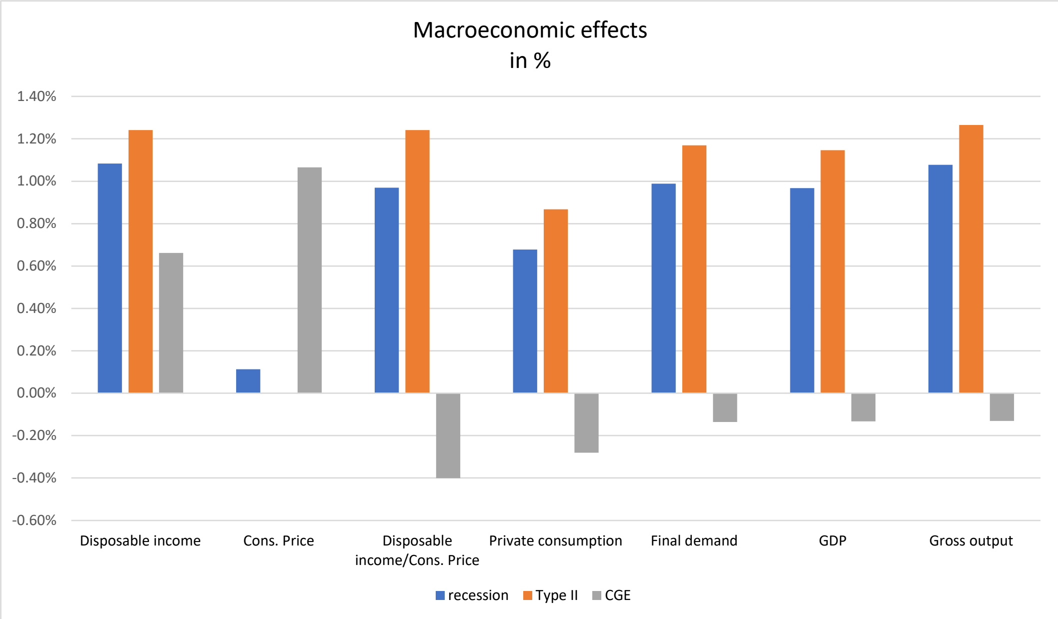

Table 5: Macroeconomic effects (in %) and multipliers of the demand shock in different states of the economy and with different model specifications

					recession	
	Type II	IO	CGE	recession	mpc = 0.9	boom
GDP impact	1.15%	0.74%	-0.13%	0.97%	1.12%	0.13%
Gross output impact	1.27%	0.86%	-0.13%	1.08%	1.23%	0.15%
GDP multiplier	1.36	0.87	-0.16	1.15	1.33	0.15
Output multiplier	3.01	2.05	-0.31	2.56	2.93	0.35

Figure 7: Multipliers of the demand shock in different states of the economy and with different model specifications

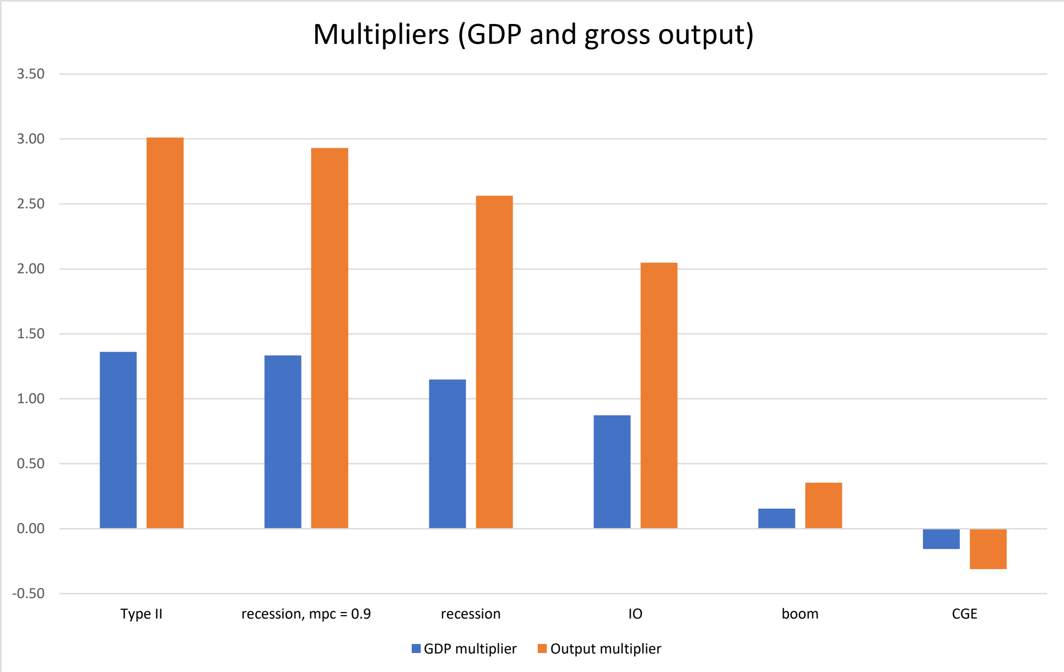

Figure 8: Output effects (in %) of the demand shock in recession and standard IO model, selected industries in EU 28