6 APPENDIX

A Steady state

At steady state for all variables t= t+1, so the time subscript is removed.

TFP at steady state:
$A_e = 1$

From the Saver's Euler equation:

$$r = \frac{1}{\beta} + \delta - 1 \tag{29}$$

From the energy production function:

$$e = h_e \tag{30}$$

That together with the FOC of energy sector, leads to:

$$w = p_e \tag{31}$$

Knowing that, and dividing the two factor demands for energy (23) and for labor (24) by each other:

$$e_y = \frac{v}{1-\alpha-v} h_y \tag{32}$$

Making a guess on capital [28], all the other variables can be derived as a function of capital and the parameters.
From law of motion of capital:

$$i = \delta k \tag{33}$$

From the factor demand of capital:

$$y = rk/\alpha \tag{34}$$

[28]To make the guess on capital, it is used a simplified version of this model, which steady state can be fully solved analytically. Using the steady state value of capital in such model as a guess value here, allows to find numerically the steady state on Dynare

From the production function, substituting e_y as function of h_y:

$$h_y = (\frac{y}{k^{\alpha}(\frac{v}{1-\alpha-v})^{v}})^{\frac{1}{1-\alpha}} \tag{35}$$

Moreover, since it is assumed that $h = 1$:

$$h_e = 1 - h_y \tag{36}$$

Which also gives e since they are equal from (30); then from market clearing of energy it's obtained e_x.

From factor demand for energy:

$$p_e = \frac{vy}{e_y} \tag{37}$$

Knowing p_e, is also known w since they are equal from (31); then using equations (15) and (16):

$$p_S = (a_{S,c} + a_{S,e}(p_e(1+\tau_e))^{1-\varepsilon_x})^{\frac{1}{1-\varepsilon_x}} \tag{38}$$

$$p_H = (a_{H,c} + a_{H,e}(p_e(1+\tau_e))^{1-\varepsilon_x})^{\frac{1}{1-\varepsilon_x}} \tag{39}$$

From the good market clearing condition, can be found total consumption:

$$x = y - k\delta \tag{40}$$

The consumption of Hand-to-mouth is obtained from its budget constraint:

$$x_H = w/p_h \tag{41}$$

From the aggregation equation of consumption, once x_H is known, consumption of savers is given by:

$$(1-\lambda)x_S = x - \lambda x_H \tag{42}$$

Then, using demand function of energy and consumption good, for each agent:

$$e_S = (\frac{p_e(1+\tau_e)}{p_S})^{-\varepsilon_x} a_{S,e} x_S \tag{43}$$

$$c_S = (\frac{1}{p_s})^{-\varepsilon_x} a_{s,c} x_s \tag{44}$$

$$e_H = (\frac{p_e(1+tau_e)}{p_H})^{-\varepsilon_x} a_{H,e} x_H \tag{45}$$

$$c_H = (\frac{1}{p_H})^{-\varepsilon_x} a_{H,c} x_H \tag{46}$$

To conclude, steady state values of aggregate consumption of final good is given by the aggregation formula:

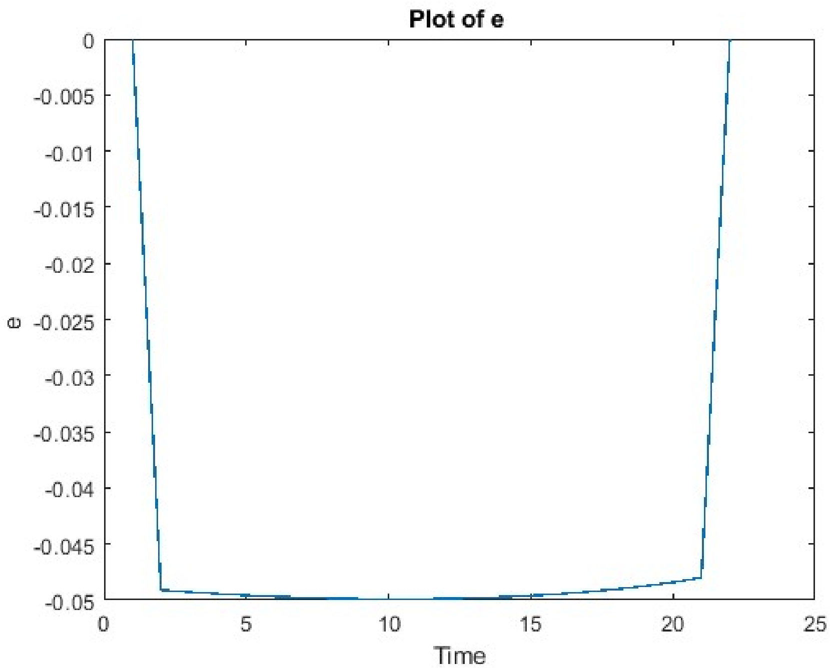
$$c = \lambda c_H + (1-\lambda) c_S \tag{47}$$

Finally, government public expenditure:

$$G = e_x \tau_e p_e \tag{48}$$

B Dynare Additional Figures

(a) Trajectory of energy supply after the negative TFP shock; Shown as deviation from steady state, normalized to zero



(b) Trajectory of energy price after the negative TFP shock; Shown as deviation from steady state, normalized to zero. TFP shock was calibrated to have approximately 50% increase in energy price

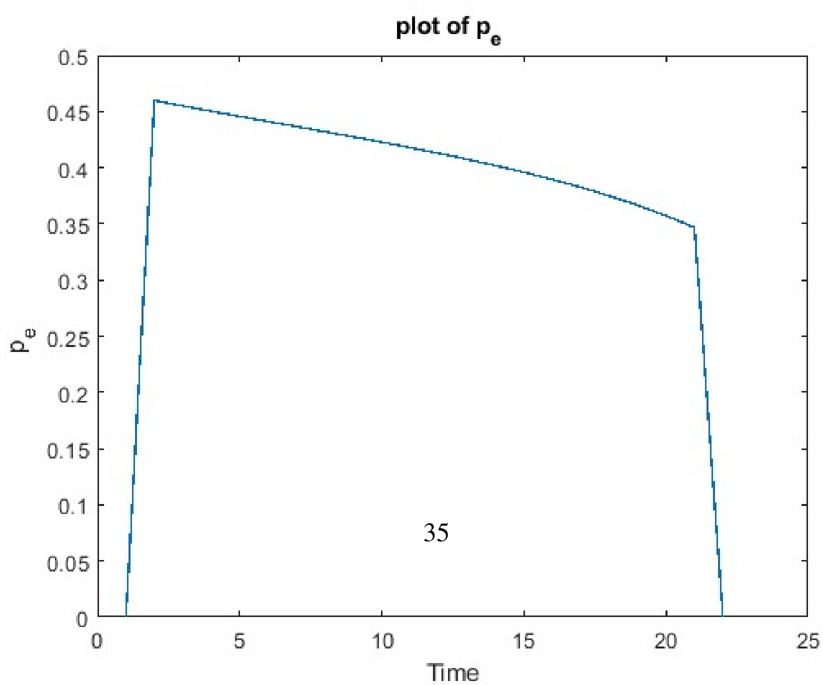
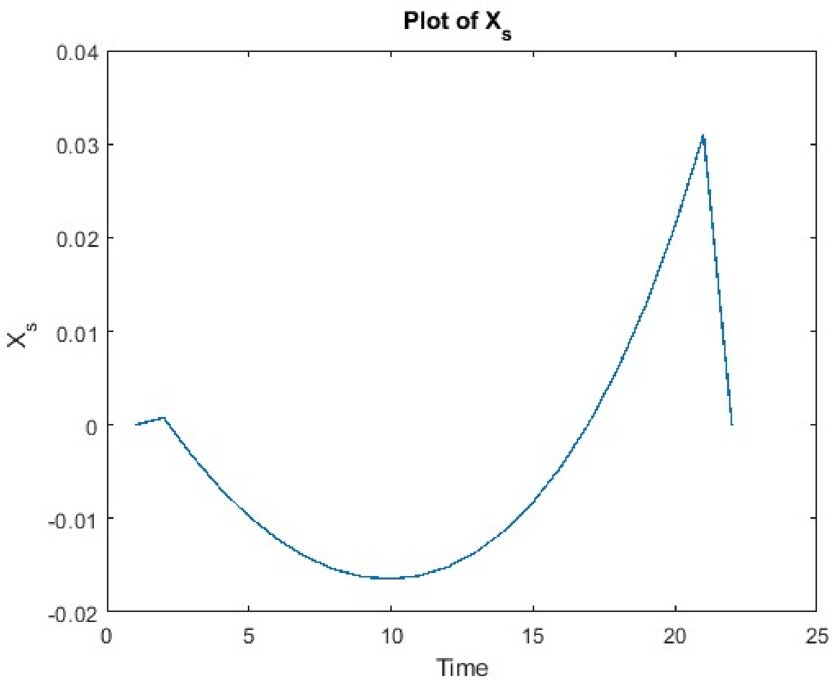


Figure 7

(a) Trajectory of Savers total consumption after the negative TFP shock; Shown as deviation from steady state, normalized to zero



(b) Trajectory of Hand-to-mouth total consumption after the negative TFP shock; Shown as deviation from steady state, normalized to zero

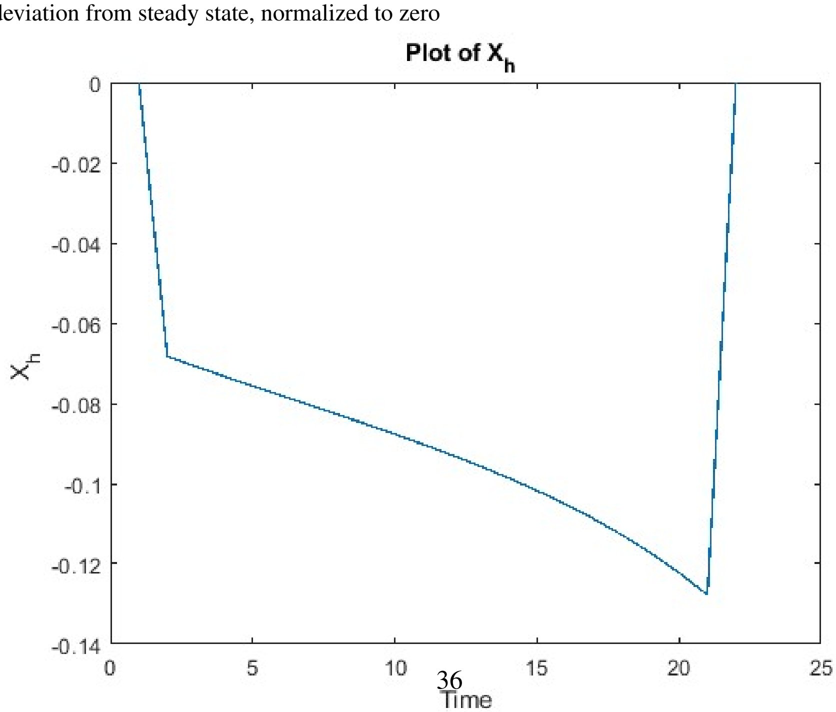
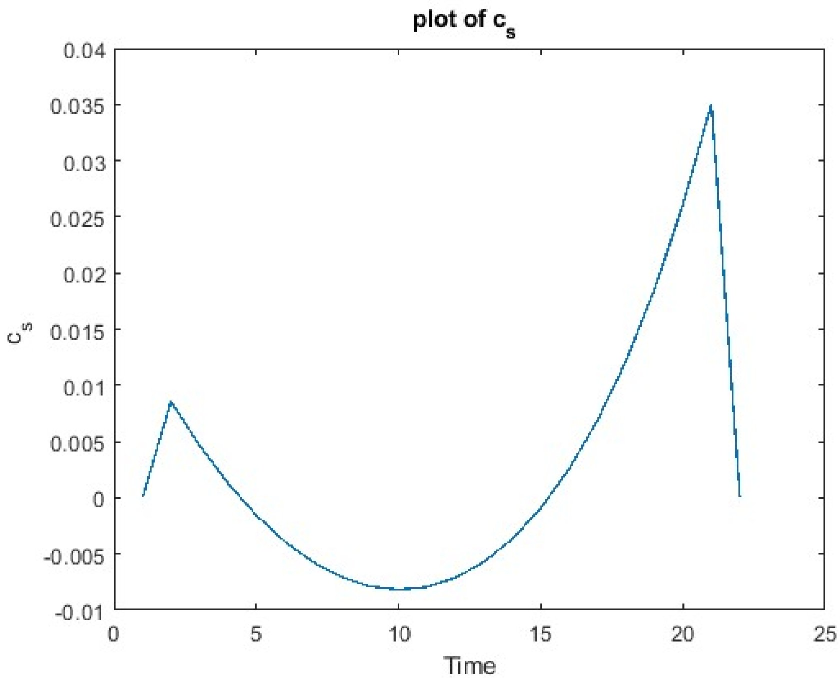


Figure 8: Comparison of total consumption trajectories between the two types of agents; Hand-to-mouth experienced a more severe drop in total consumption after the shock.

(a) Trajectory of Savers consumption of final good after the negative TFP shock; Shown as deviation from steady state, normalized to zero



(b) Trajectory of Hand-to-mouth consumption of final good after the negative TFP shock; Shown as deviation from steady state, normalized to zero

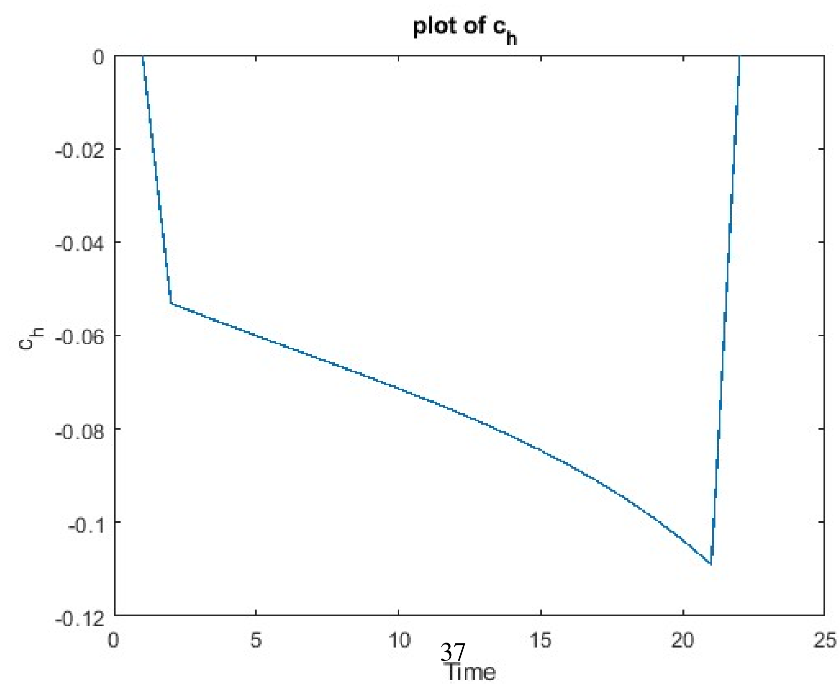
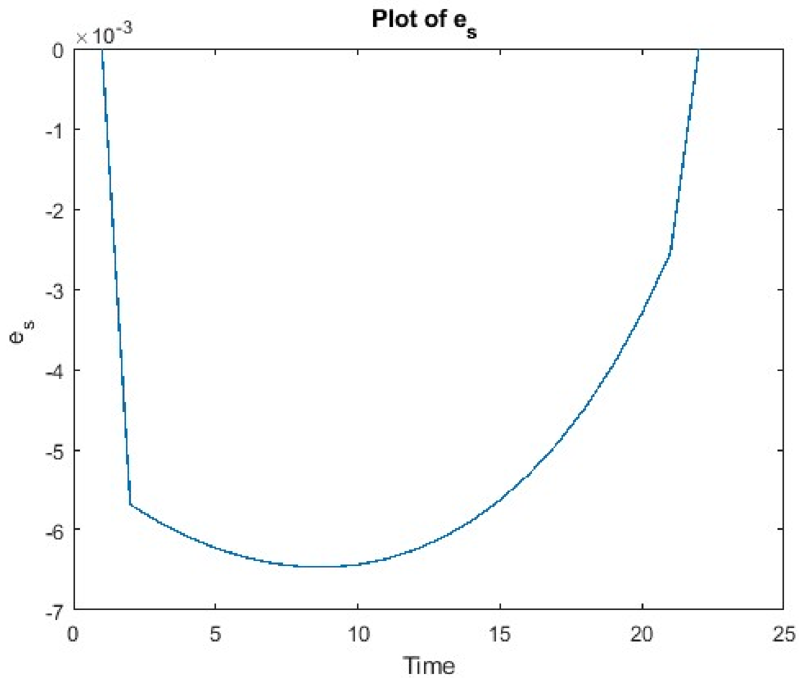


Figure 9: Comparison of final good consumption trajectories between the two types of agents; Hand-to-mouth experienced a more severe drop in final good consumption after the shock.

(a) Trajectory of Savers energy consumption after the negative TFP shock; Shown as deviation from steady state, normalized to zero



(b) Trajectory of Hand-to-mouth energy consumption after the negative TFP shock; Shown as deviation from steady state, normalized to zero

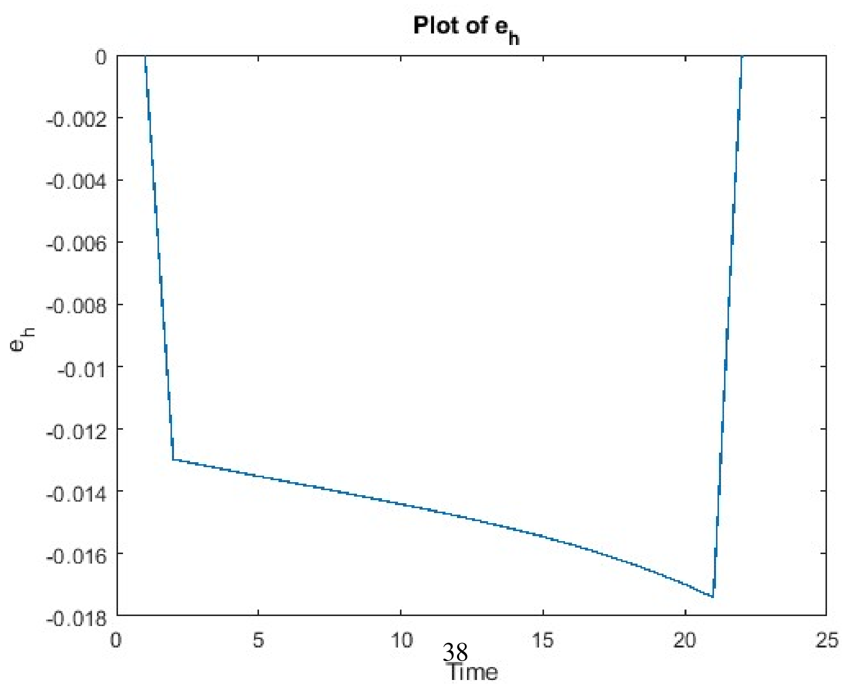


Figure 10: Comparison of energy consumption trajectories between the two types of agents; Hand-to-mouth experienced a more severe drop in energy consumption after the shock.

Figure 11: Comparison of Hand-to-mouth consumption of final good in the two scenarios: with VAT cut (red), without VAT cut (blue).The negative effect is less severe after VAT cut implementation

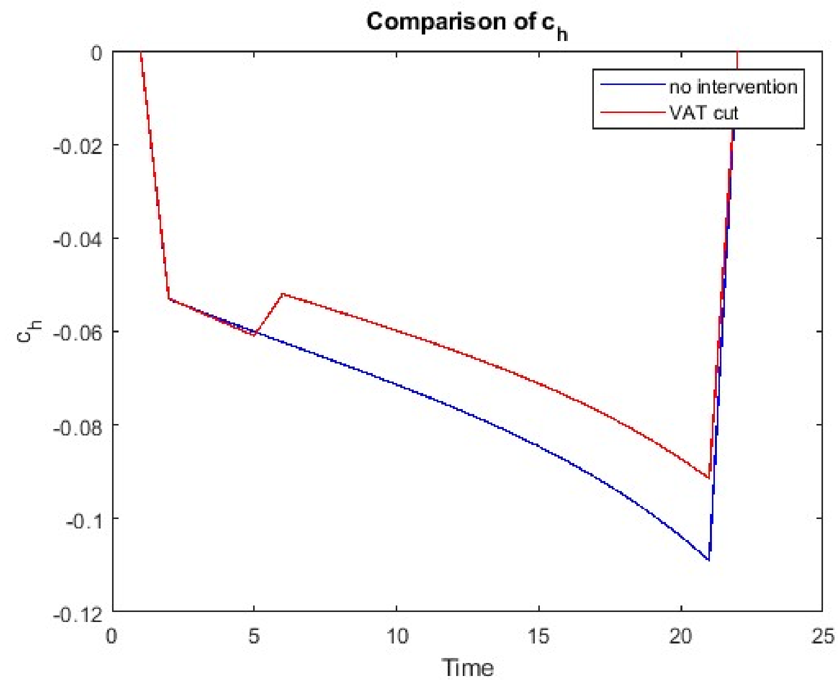


Figure 12: Comparison of Hand-to-mouth energy consumption in the two scenarios: with VAT cut (red), without VAT cut (blue). The negative effect is less severe after VAT cut implementation

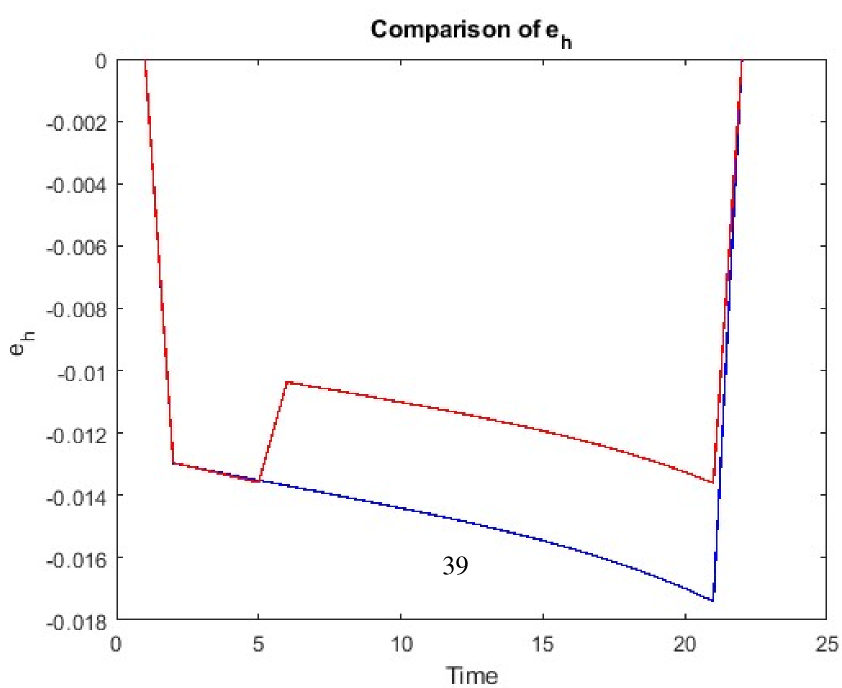


Figure 13: Comparison of Hand-to-mouth consumption in the two scenarios: with VAT cut (red), without VAT cut (blue). The negative effect is less severe after VAT cut implementation

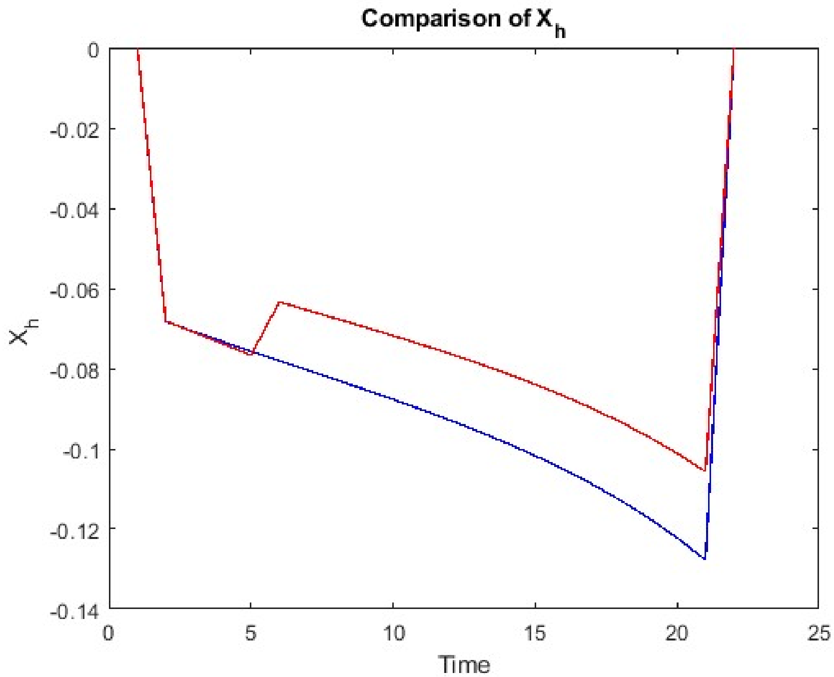
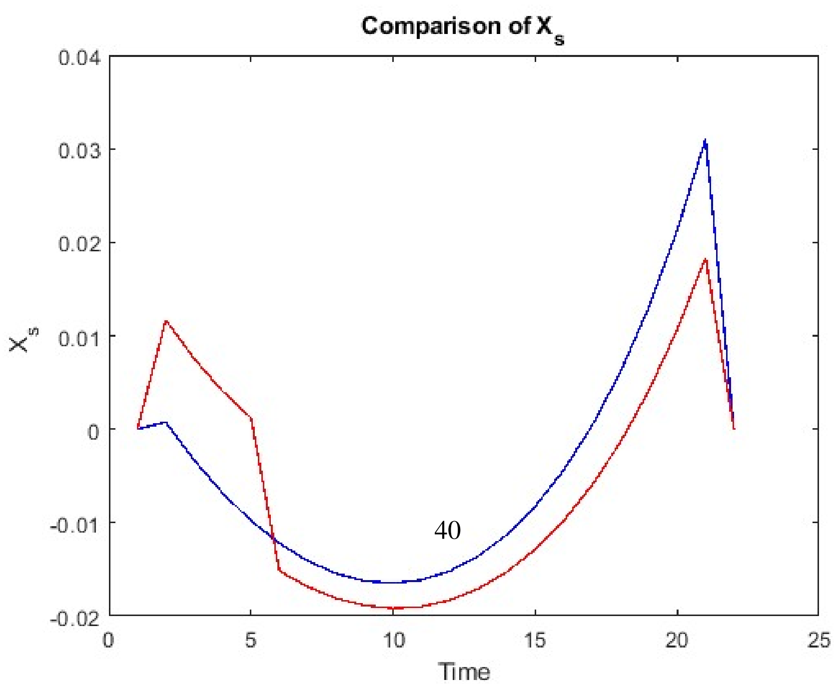


Figure 14: Comparison of Savers consumption in the two scenarios: with VAT cut (red), without VAT cut (blue). Savers increase more consumption initially, but also decrease more it after the VAT cut. This effect again is given by the substitution between savings, that increase and consumption that decreases.



C Calibration of Intertemporal Elasticity of Savers

The intertemporal elasticity of substitution is a crucial parameter in general equilibrium models. However, there isn't a general agreement on the estimation of this parameter. [29]. Therefore the calibration of IES should be taken carefully. For this reason, this section will examine different IES value choices and their effects on the outcome of the model. In the baseline model elasticity of substitution of Savers[30] is set equal to 1, which is a quite standard value macroeconomic literature[31]. Here instead, it is considered a smaller value for σ, set equal to 0.5. This implies a higher elasticity of substitution ($1/\sigma = 2$). Results can be seen in Figures 15 and 16. A higher elasticity of substitution implies that Savers react more to changes in the interest rate. Therefore, when r decreased after the shock they reduce more savings and substitute them with consumption. This implies that, compared with the baseline scenario, because of this stronger substitution effect, total consumption of Savers initially increases more after the shock. Nevertheless, conclusions on the unequal impact on households still hold. The same exercise can be done for a lower elasticity, setting sigma equal to 10, so that IES is 0.1. In this case, Savers react less to the decrease in the interest rate, so their consumption decreases after the shock. However, the impact is still shared unequally with Hand-to-mouth agents, that are hit harder by the shock. Figures 17 and 18 report these results.

[29]Tomáš Havránek, Measuring Intertemporal Substitution: The Importance of Method Choices and Selective Reporting, Journal of the European Economic Association, Volume 13, Issue 6, 1 December 2015, Pages 1180–1204

[30]Notice that this parameter is not relevant for Hand-to-mouth since they don't face intertemporal problem and cannot save

[31]Kanzig(2022)

Figure 15: Saver investments with higher IES (equal to 2)

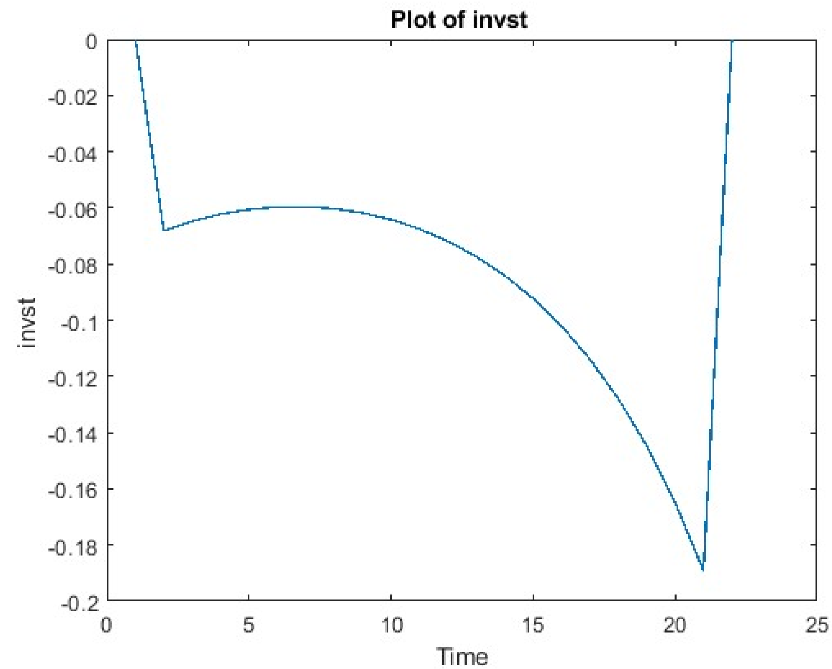


Figure 16: Savers consumption with higher IES (equal to 2)

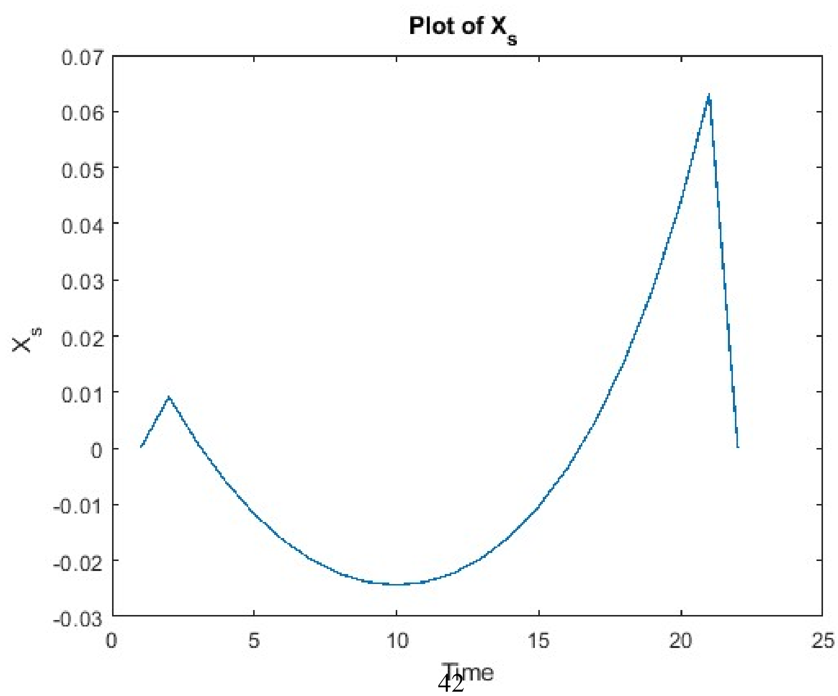


Figure 17: Savers investments with lower IES (equal to 0.1)

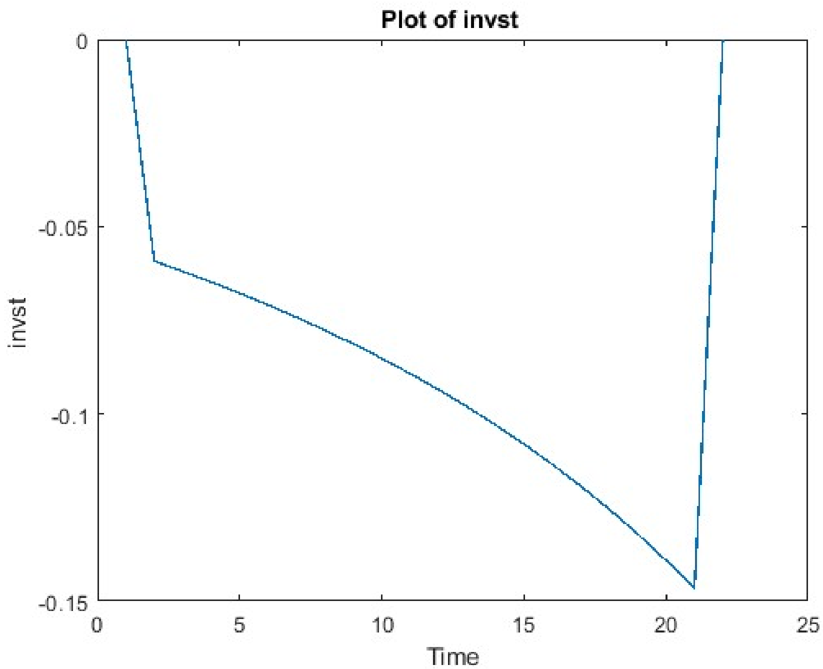
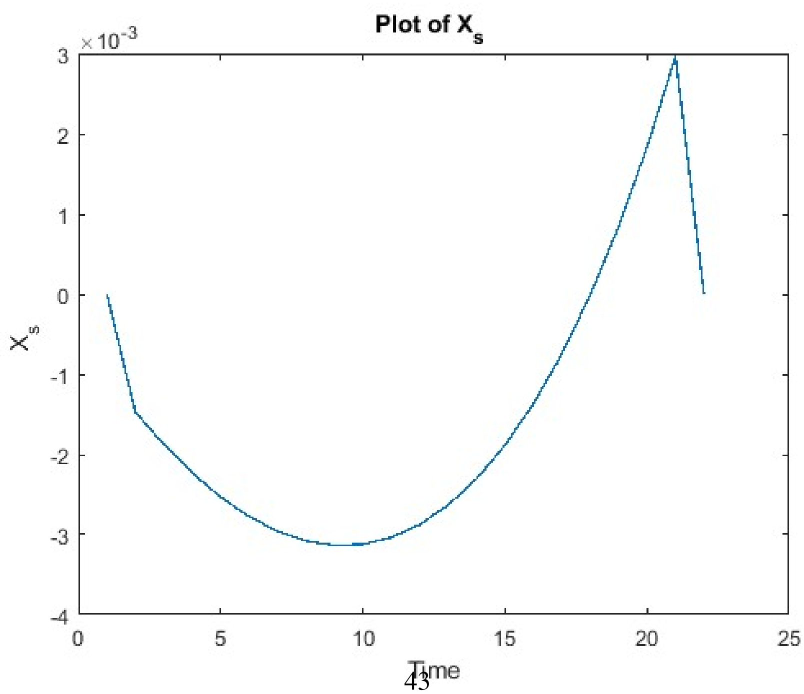


Figure 18: Savers consumption with lower IES (equal to 0.1)



D Descriptive statistics for variable contracts

As explained in paragraph 4.2.2, for variable contracts ACTIF+ and ACTIF+ PRO, starting from November 2021 there were multiple price observations per month. This was because Luminus, as many other providers, to respond to energy crises started to change the markup component of the indexation formula to increase the price. Initially, to have a better picture of current prices, were selected the most recent markup ones. However, as can be seen in Figure 19, this led to a divergence between the treatment and the control group trends. The reason for the divergence is explained by looking at Table 7, which report prices of the updated markup version for those months, for both firm and households. Comparing the first two columns can be seen that in the last months firm's prices decreased when household's prices increased. And the cause of this divergence is explicit looking at columns three and four, that report markup values. There can be seen that markups were changed in different directions for the two client categories. This implies firms are not a good control group for those months. To solve this issue for the analysis will be selected variable contracts that kept the markup unchanged. This ensures to have a good control group but at the cost of losing information on the markup change.

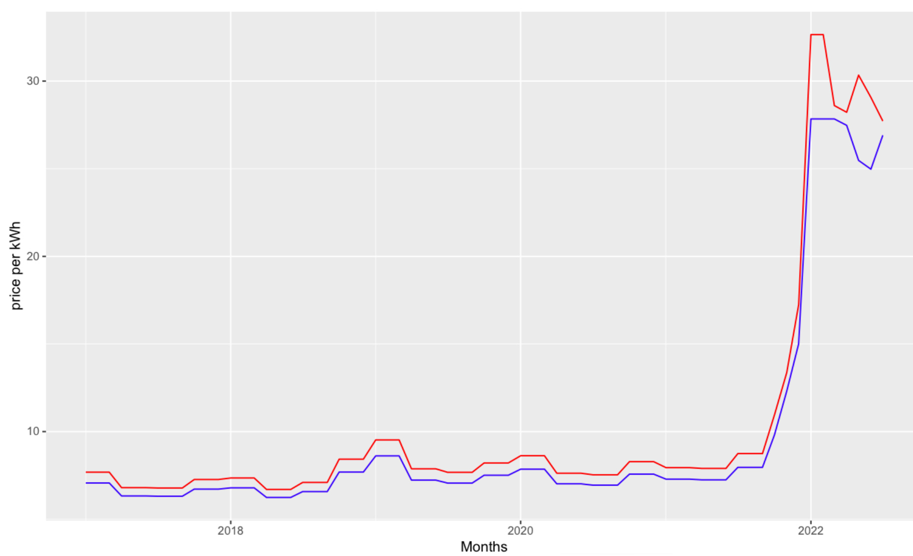


Figure 19: Luminus variable contract price per kWh, in its version for household (red) and firms (blue)

Table 7: Prices per kWh and markup

Month	Firm Price (€cent/kWh)	Household Price (€cent/kWh)	Firm Markup	Household Markup
2021-10-01	9.803059	10.941786	2.34500	1.70000
2021-09-01	7.961310	8.747710	2.34500	1.70000
2021-08-01	7.961310	8.747710	2.34500	1.70000
2021-07-01	7.961310	8.747710	2.34500	1.70000
2021-06-01	7.247814	7.897723	2.34500	1.70000
2021-05-01	7.247814	7.897723	2.34500	1.70000
2021-04-01	7.247814	7.897723	2.34500	1.70000
2021-03-01	7.286415	7.943707	2.34500	1.70000
2021-02-01	7.286415	7.943707	2.34500	1.70000
2021-01-01	7.286415	7.943707	2.34500	1.70000
2021-11-01	12.303059	13.361786	4.84500	3.70000
2021-12-01	15.003059	17.233786	7.54500	6.90000
2022-04-01	27.476160	28.222648	14.34400	13.68950
2022-03-01	27.842135	28.604776	14.34400	13.68950
2022-02-01	27.842135	32.652622	14.34400	13.68950
2022-01-01	27.842135	32.652622	14.34400	13.68950
2022-05-01	25.476180	30.342648	12.34402	15.68950
2022-06-01	24.976180	29.070648	11.84402	14.48950
2022-07-01	26.910132	27.721775	13.34402	12.78952

E Difference in Difference regression

The linear regression implemented in paragraphs 4.4 and 4.5 required a transformation of the standard DiD treatment regressor, to measure directly the pass-through from the estimated coefficient. This section, explains in what consisted the transformation and shows the results of the standard DiD regression (without transformation). It will be done for the VAT cut of 2022 but the same method applies to the 2014 VAT cut.
In standard DiD the linear regression model for this analysis looks as follows:

$$Ln(P)_{ijt} = \beta_0 + \beta_1 HH_j + \beta_2 VAT_{cut22} + \beta_3 HH_j VAT_{cut22} + \varepsilon_{ijt} \tag{1}$$

In the DiD specification, there are two dummies: the first identifies the treatment group (households), and the second identifies the treatment period (after March 2022). The third regressor is the product of the two dummies, the so-called treatment coefficient, which identifies the treatment (VAT cut) effect on the dependent variable (prices). Therefore, in this model, the coefficient β_3 is not a measure of the pass-through, but only of the difference between household and firm prices after the implementation of the cut. Table 8 reports results of this regression

Table 8: Coefficients

	Estimate	Std. Error	t value	p-value
(Intercept)	2.02907	0.02607	77.817	$< 2 \times e^{-16}$ ***
HH	0.19013	0.03688	5.156	$4.95 \times e^{-7}$ ***
VAT_{cut}	1.08641	0.09545	11.382	$< 2 \times e^{-16}$ ***
$VAT_{cut} \times$HH	-0.20225	0.13499	-1.498	0.135

These results show that the treatment coefficient is negative, as expected since the VAT cut reduced prices. Coherently with the transformed regression results, the treatment coefficient is not significant. This means that there is no significant effect of the treatment on the dependent variable. The other coefficients are significant and positive. HH has a positive effect on prices, which is true since HH prices are always higher than firms' prices. VAT_{cut} coefficient is also positive, and this represents the fact that being in the VAT cut period means higher firms' prices due to the energy crisis.

Can be interesting to check the dif-in-dif specification relevance, by running a simple difference regression, so without considering a control group. Results are reported in Table 9.

Without considering firm prices as a control group, and simply looking at the effect

Table 9: Coefficients

	Estimate	Std. Error	t value	p-value
(Intercept)	2.16256	0.02224	97.237	$< 2 \times e^{-16}$ ***
$VAT_{cut} \times$HH	0.94081	0.11513	8.171	$1.25 \times e^{-14}$ ***

of VAT cut on household prices, the treatment coefficient is significant. However, not considering the control group implies that the treatment coefficient is positive. Indeed, looking only at household prices trends, being in the month of VAT cut corresponds to higher energy prices, due to the energy crisis effect. So, simple difference analysis is not a good method to account for the effect of pass-through, since it does not take into account the increasing trend of prices of that period.

To measure directly the pass-through of the tax cut, the treatment regressor was transformed following Hindriks and Serse (2022). The transformed specification reads as follows:

$$Ln(P)_{ijt} = \beta_0 + \beta_1 HH_j + \beta_2 VAT_{cut22} + \beta_3 ln(1+\tau) + \varepsilon_{ijt} \tag{2}$$

The coefficient of $ln(1+\tau)$ is a measure of the pass-through, indeed:

$$\beta_3 = \frac{dLN(P)}{dLN(1+\tau)} = \frac{\Delta P/P}{\Delta\tau/1+\tau} \tag{3}$$

F Dynare and Matlab codes

```
%VAT cut scenario

var
y      %production
k      %capital
x      %tot consumption
c_h    %consumption of final good of Hand-to-mouth
c_s    % consumption of final good Savers
e_h    %consumption of energy good of H
e_s    %consumption of energy good of S
X_h    % H total consumption
X_s    % S totalconsumption
invst  % investments
r      % interest rate
w      % wage
h_e    % labor demand in energy sector
h_y    % labor demand in production sector
e_y    %energy used in production sector
e_x    % energy used in consumption (tot)
c      %total consumption of final good
e      % energy supply
p_e    % price of energy
p_s    % price of saver consumption bundle
p_h    %price of H consumption bundle
G      %public expenditure
;

%exogeneous variables

varexo
A     % productivity shock
tau_e %tax on energy consumption
;

%parameters

parameters aalpha bbeta ddelta ssigma A_ss r_ss k_ss invst_ss  y_ss
 x_ss X_h_ss h X_s_ss w_ss v epsilon_x lambda a_s_c a_s_e a_h_c a_h_e
e_y_ss e_x_ss e_s_ss e_h_ss c_h_ss c_s_ss h_e_ss h_y_ss p_e_ss c_ss
 p_s_ss p_h_ss ;
```

```
aalpha = 0.30;   % return of capital
v= 0.085;        %return of energy
bbeta = 0.96;    % discount factor
ddelta = 0.025;  % depreciation rate
ssigma = 1;      % elasticity of consumption
lambda = 0.25;   % share of hand to mouth
epsilon_x = 0.21;% elasticity between energy and non energy good
a_s_e = 0.071;   % income share spent in energy S
a_s_c = 1- a_s_e;% income share spent in final good S
a_h_e = 0.103;   % income share spent in energy H
a_h_c = 1- a_h_e;% income share spent in final good H
h=1;             % labor supply

%steady state formulas (derived analyitically)

tau_e_ss = 0.21;
A_ss = 1;
r_ss = (1/bbeta)-1+ddelta;
k_ss = 3.53288;  % guess on capital
y_ss= r_ss*k_ss/aalpha ;
h_y_ss = (y_ss/(k_ss^(aalpha)*(v/(1-aalpha-v))^v))^(1/(1-aalpha));
invst_ss = (ddelta)*k_ss;
h_e_ss = 1-h_y_ss;
e_ss = h_e_ss;
e_y_ss = v/(1-aalpha-v)*h_y_ss ;
p_e_ss = v*y_ss/e_y_ss;
w_ss = p_e_ss;
x_ss = y_ss-invst_ss;
p_h_ss = (a_h_c + a_h_e*(p_e_ss*(1+tau_e_ss))^(1-epsilon_x))^(1/(1-epsilon_x));
p_s_ss = (a_s_c + a_s_e*(p_e_ss*(1+tau_e_ss))^(1-epsilon_x))^(1/(1-epsilon_x));
X_h_ss = w_ss/p_h_ss;
X_s_ss =(x_ss - lambda*X_h_ss)/(1-lambda) ;
c_s_ss = (1/p_s_ss)^(-epsilon_x)*a_s_c*X_s_ss;
c_h_ss = (1/p_h_ss)^(-epsilon_x)*a_h_c*X_h_ss;
e_s_ss = (p_e_ss*(1+tau_e_ss)/p_s_ss)^(-epsilon_x)*X_s_ss*a_s_e;
e_h_ss = (p_e_ss*(1+tau_e_ss)/p_h_ss)^(-epsilon_x)*X_h_ss*a_h_e;
e_x_ss = (1-lambda)*e_s_ss + lambda*e_h_ss;
c_ss = c_s_ss*(1-lambda) + c_h_ss*lambda;
G_ss = tau_e_ss*e_x_ss*p_e_ss;


% Model

model;
%euler equation Saver
   p_s*X_s^(-ssigma) = p_s(+1)*X_s(+1)^(-ssigma)*bbeta*(1+r(+1)-ddelta);
```

```
%budget constraint Hand to mouth
p_h*X_h = w;

%Total Consumption H
X_h = (a_h_c^(1/epsilon_x)*c_h^((epsilon_x-1)/epsilon_x)+
a_h_e^(1/epsilon_x)*e_h^((epsilon_x-1)/epsilon_x))^(epsilon_x/(epsilon_x-1));

%Total Consumption S
X_s = (a_s_c^(1/epsilon_x)*c_s^((epsilon_x-1)/epsilon_x) +
 a_s_e^(1/epsilon_x)*e_s^((epsilon_x-1)/epsilon_x))^(epsilon_x/(epsilon_x-1));

% consumption constraints
%p_s*X_s = c_s + p_e(1+ tau_e)*e_s;
%p_h*X_h = c_h + p_e(1+tau_e)*e_h;

% energy consumption of two agents
e_s = (p_e*(1+tau_e)/p_s)^(-epsilon_x)*X_s*a_s_e;

e_h = (p_e*(1+tau_e)/p_h)^(-epsilon_x)*X_h*a_h_e;

% Prices of consumption bundles of two agents
%p_s = ((a_s_c + a_s_e*(p_e*(1+tau_e))^(1-epsilon_x))^(1/(1-epsilon_x));
%p_h = ((a_h_c + a_h_e*(p_e*(1+tau_e))^(1-epsilon_x))^(1/(1-epsilon_x));

% final good consumption of two agents
c_s = (1/p_s)^(-epsilon_x)*a_s_c*X_s;

c_h = (1/p_h)^(-epsilon_x)*a_h_c*X_h;



% law of motion capital
    k = (1-ddelta)*k(-1)+invst;

%resource constraint
   G+ invst = y-x;
%market clearing consitions
h = h_y + h_e; %labor market

e = e_y + e_x; %energy market

%Variable aggregation
e_x = e_s*(1-lambda) + e_h*lambda; % aggregate energy consumption

c = c_s*(1-lambda) + c_h*lambda;   %aggregate good consumption consumption

```

```
x = (1-lambda)*X_s + lambda*X_h;  % aggregate consumption


%production sector

y = k(-1)^(aalpha)*e_y^v*h_y^(1-aalpha-v);             %production function

r = aalpha*k(-1)^(aalpha-1)*e_y^v*h_y^(1-aalpha-v);    %demand of capital

w= k(-1)^(aalpha)*e_y^v*h_y^(-aalpha-v)*(1-aalpha-v);  %demand of labor

p_e= v*k(-1)^aalpha*e_y^(v-1)*h_y^(1-aalpha-v);        %demand of energy



%energy sector
e = A*h_e; %energy production function

e = w*h_e/p_e;  %energy supply

%government
G = tau_e*e_x*p_e;

end;

initval;
A=A_ss;
tau_e = tau_e_ss;
r = r_ss;
k=k_ss;
e = e_ss;
h_e= h_e_ss;
h_y= h_y_ss;
p_e = p_e_ss;
invst = invst_ss;
y= y_ss;
x =x_ss;
X_s = X_s_ss;
X_h = X_h_ss;
w = w_ss;
e_y = e_y_ss;
e_x  = e_x_ss;
c_h = c_h_ss;
c_s = c_s_ss;
e_h = e_h_ss;
e_s = e_s_ss;
```

```
p_h = p_h_ss;
p_s = p_s_ss;
c = c_ss;
end;


resid(1);
steady;
check;


shocks;

% no intervention scenario: only TFP shock; VAT cut scenario: both shocks

var A; %TFP negative shock
periods 1:20;
values 0.65;
var tau_e; %VAT cut policy shock
periods 5:20;
values 0.06;
end;

simul(periods=20); %deterministic simulation

rplot A;
rplot p_e;
rplot tau_e;
```

```

dynare adj_noint


%Normalise around steady state

c_h_norm1 = c_h - c_h(1);
c_s_norm1 = c_s - c_s(1);
p_e_norm1 = p_e - p_e(1);
r_norm1 = r - r(1);
k_norm1=k - k(1);
e_norm1 = e - e(1);
h_e_norm1= h_e - h_e(1);
h_y_norm1= h_y - h_y(1);
```

```
invst_norm1 = invst - invst(1);
y_norm1= y - y(1);
x_norm1 =x - x(1);
X_s_norm1 = X_s- X_s(1);
X_h_norm1 = X_h- X_h(1);
w_norm1 = w - w(1);
e_y_norm1 = e_y - e_y(1);
e_x_norm1  = e_x- e_x(1);
e_h_norm1 = e_h-e_h(1);
e_s_norm1 = e_s-e_s(1);
p_h_norm1 = p_h-p_h(1);
p_s_norm1 = p_s-p_s(1);
c_norm1 = c-c(1);

%plot c_h
time = 1:numel(c_h_norm1);  % Time axis

figure;
plot(time, c_h_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('c_h ');
title('plot of c_h ');

%plot c_s
time = 1:numel(c_s_norm1);  % Time axis

figure;
plot(time, c_s_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('c_s ');
title('plot of c_s ')


%plot p_e
time = 1:numel(p_e_norm1);  % Time axis
figure;
plot(time, p_e_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('p_e ');
title('plot of p_e ');

% Plot r_norm
figure;
plot(time, r_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('r ');
```

```
title('Plot of r ');

% Plot k_norm
figure;
plot(time, k_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('k ');
title('Plot of k ');

% Plot e_norm
figure;
plot(time, e_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('e ');
title('Plot of e ');


% Plot invst_norm
figure;
plot(time, invst_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('invst ');
title('Plot of invst ');


% Plot X_s_norm
figure;
plot(time, X_s_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('X_s ');
title('Plot of X_s ');

% Plot X_h_norm
figure;
plot(time, X_h_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('X_h ');
title('Plot of X_h ');


% Plot e_h_norm
figure;
plot(time, e_h_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('e_h ');
title('Plot of e_h ');
```

```
% Plot e_s_norm
figure;
plot(time, e_s_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('e_s ');
title('Plot of e_s ');



% Plot e_s_norm
figure;
plot(time, e_s_norm1, 'LineWidth', 1);
xlabel('Time');
ylabel('e_s ');
title('Plot of e_s ');
```

```
dynare gove_adj


%Normalise
c_h_norm2 = c_h - c_h(1);
c_s_norm2 = c_s - c_s(1);
p_e_norm2 = p_e - p_e(1);
r_norm2 = r - r(1);
k_norm2=k - k(1);
e_norm2 = e - e(1);
h_e_norm2= h_e - h_e(1);
h_y_norm2= h_y - h_y(1);
invst_norm2 = invst - invst(1);
y_norm2= y - y(1);
x_norm2=x - x(1);
X_s_norm2 = X_s- X_s(1);
X_h_norm2 = X_h- X_h(1);
w_norm2 = w - w(1);
e_y_norm2 = e_y - e_y(1);
e_x_norm2  = e_x- e_x(1);
e_h_norm2 = e_h-e_h(1);
e_s_norm2 = e_s-e_s(1);
p_h_norm2 = p_h-p_h(1);
```

```
p_s_norm2 = p_s-p_s(1);
c_norm2 = c-c(1);


%COMPARISON OF TWO SCENARIO/ VAT CUT VS NO INTERVENTION

time = 1:numel(c_h_norm1);  % Time axis
figure;
subplot(4, 5, 1);
plot(time, c_h_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, c_h_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('c_h');
title('Comparison of c_h');
legend('no intervention', 'VAT cut');


% Plot c_s_norm
subplot(4, 5, 2);
plot(time, c_s_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, c_s_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('c_s ');
title('Comparison of c_s');

% Plot p_e_norm
subplot(4, 5, 3);
plot(time, p_e_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, p_e_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('p_e ');
title('Comparison of p_e');

% Plot r_norm
subplot(4, 5, 4);
plot(time, r_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, r_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
```

```
ylabel('r ');
title('Comparison of r');

% Plot k_norm
subplot(4, 5, 5);
plot(time, k_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, k_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('k ');
title('Comparison of k');

% Plot e_norm
subplot(4, 5, 6);
plot(time, e_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, e_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('e ');
title('Comparison of e');

% Plot h_e_norm
subplot(4, 5, 7);
plot(time, h_e_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, h_e_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('h_e ');
title('Comparison of h_e');

% Plot h_y_norm
subplot(4, 5, 8);
plot(time, h_y_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, h_y_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('h_y ');
title('Comparison of h_y');

% Plot invst_norm
subplot(4, 5, 9);
plot(time, invst_norm1, 'LineWidth', 1, 'Color', 'b');
```

```
hold on;
plot(time, invst_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('invst ');
title('Comparison of invst');

% Plot y_norm
subplot(4, 5, 10);
plot(time, y_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, y_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('y ');
title('Comparison of y');

% Plot x_norm
subplot(4, 5, 11);
plot(time, x_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, x_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('x ');
title('Comparison of x');

% Plot X_s_norm
subplot(4, 5, 12);
plot(time, X_s_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, X_s_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('X_s ');
title('Comparison of X_s');

% Plot X_h_norm
subplot(4, 5, 13);
plot(time, X_h_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, X_h_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('X_h ');
title('Comparison of X_h');
```

```
% Plot w_norm
subplot(4, 5, 14);
plot(time, w_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, w_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('w ');
title('Comparison of w');

% Plot e_y_norm
subplot(4, 5, 15);
plot(time, e_y_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, e_y_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('e_y ');
title('Comparison of e_y');

% Plot e_x_norm
subplot(4, 5, 16);
plot(time, e_x_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, e_x_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('e_x ');
title('Comparison of e_x');

% Plot e_h_norm
subplot(4, 5, 17);
plot(time, e_h_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, e_h_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('e_h ');
title('Comparison of e_h');

% Plot e_s_norm
subplot(4, 5, 18);
plot(time, e_s_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, e_s_norm2, 'LineWidth', 1, 'Color', 'r');
```

```
hold off;
xlabel('Time');
ylabel('e_s ');
title('Comparison of e_s');

% Plot p_h_norm
subplot(4, 5, 19);
plot(time, p_h_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, p_h_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('p_h ');
title('Comparison of p_h');

% Plot p_s_norm
subplot(4, 5, 20);
plot(time, p_s_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, p_s_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('p_s ');
title('Comparison of p_s');


%zoom on what relevant in comparison
time = 1:numel(c_h_norm1);  % Time axis

plot(time, X_h_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, X_h_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('X_h ');
title('Comparison of X_h');


plot(time, c_h_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, c_h_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('c_h');
title('Comparison of c_h');
legend('no intervention', 'VAT cut');
```

```
% Plot c_s_norm
plot(time, c_s_norm1, 'LineWidth', 1, 'Color', 'b');
hold on;
plot(time, c_s_norm2, 'LineWidth', 1, 'Color', 'r');
hold off;
xlabel('Time');
ylabel('c_s ');
title('Comparison of c_s');
```

G R codes

```
#replication of Hindriks and Serse on VAT cut 2014


library(readxl)
library(dplyr)
Price_data_sorted <- read_excel("~/Desktop/Price_data_sorted.xlsx",
                                sheet = "REPLICATION",
                               col_types = c("text",
                                          "text", "text", "numeric", "date",
                                          "text", "text", "text", "numeric",
                                          "numeric", "text", "date", "numeric",
                                         "numeric", "text", "text", "numeric",
                                        "numeric", "text", "numeric", "numeric",
                                        "numeric", "numeric", "numeric",
                                        "numeric", "numeric", "numeric",
                                        "numeric", "numeric", "numeric",
                                        "numeric", "numeric", "numeric",
                                        "text", "text", "text", "numeric",
                                        "numeric", "numeric", "numeric",
                                         "numeric", "numeric", "numeric",
                                       "numeric", "numeric", "numeric",
                                        "numeric", "numeric", "numeric",
                                         "numeric", "numeric", "numeric",
                                         "numeric", "numeric", "numeric",
                                         "numeric", "numeric", "numeric",
                                          "numeric", "numeric", "numeric",
                                          "numeric", "numeric", "numeric",
                                               "numeric"))



df_1 <- data.frame(Price_data_sorted)


#SELECT DATA
#consider only consumption of energy contract data
df_1 <- subset(df_1, type_contract == "Afname")

#take only contract price data in brussel
#(price per kWh does not change in other regions)
df_1 <- subset(df_1, region == "BXL")
```

```
#to use it when studying only variable contracts
#df_1 <- subset(df_1, type_product == "Variabel")


#TAKE ONLY HINDRIKS and SERSE SAMPLE (2014-2016)
df_1 <- subset(df_1, as.Date(Month)<= as.Date("2016-12-01"))


# create dataset for the regression
df_split <- split(df_1, f= df_1$Professioneel.Particulier)

# add 1 to vat rate column
df_split <- within(df_split, Particulier$vat_rate <- Particulier$vat_rate+1)
#compute vat inclusive prices for household only
df_split <- within(df_split, Particulier$price.kWh...21 <-
                     Particulier$price.kWh...21*Particulier$vat_rate)
#make vat rate for firm equal to 1
df_split <- within(df_split, Professioneel$vat_rate <- Professioneel$vat_rate/0.21)


df_adj <- rbind(df_split$Particulier, df_split$Professioneel)


#tao regressors
df_reg <- within(df_adj, vat_rate <- log(vat_rate)) #regressor ln(1+tao)

# price for dependent variable ln(price)

df_reg <- within(df_adj, price.kWh...21 <- log(price.kWh...21))

#Create dummy variables

# dummy for client type; household=1 and firm =0
df_reg <- within(df_reg, Professioneel.Particulier<-
                   ifelse(Professioneel.Particulier == "Particulier", 1, 0))




# Create dummy for the VAT cut equal to 1 during VAT cut period

df_reg <- within(df_reg, Month <- ifelse(as.Date(Month)>=as.Date("2014-03-01")
                                   & as.Date(Month)>=as.Date("2015-08-01"), 1, 0))

#method 1 standard DiD
#multiplicate dummies to get coefficient
#df_reg <- within(df_reg, vat_rate <- Month*Professioneel.Particulier)
```

```
# method 2 modification of standard DiD implemented by H&S:  ln(1+tao)

# Regression Model

model <- lm(price.kWh...21~ Professioneel.Particulier  + Month + vat_rate, df_reg)



#simple difference regression
modelsimple <-  lm(price.kWh...21~ vat_rate, df_reg)



summary(model)
summary(modelsimple)


#avarages for plot fixed and variable trends
avg_t <- aggregate(df_split$Particulier$price.kWh...21,
                   list(df_split$Particulier$Month), FUN = mean)
avg_c <- aggregate(df_split$Professioneel$price.kWh...21,
                   list(df_split$Professioneel$Month), FUN = mean)


#plot prices to check parallel trend
library(lubridate)
library(ggplot2)
library(scales)

library(colorspace)
p1 <- ggplot() +
  geom_line(data = avg_t, aes(x = Group.1, y = x , color = "household")) +
  geom_line(data = avg_c, aes(x = Group.1, y = x, color = "firm")) +

  scale_colour_manual(name="Line Color",
                      values=c(household = "red", firm="blue", vatcut= "black"))+
  xlab('Months') +
  ylab('Avarage price per kWh')

p1

# create a plot the zoom on VAT cut

avgt_z <- subset(avg_t, as.Date(Group.1)>= as.Date("2014-03-01")
                 & as.Date(Group.1)<= as.Date("2015-08-01"))
```

```
avgc_z <- subset(avg_c, as.Date(Group.1)>= as.Date("2014-03-01")
                 & as.Date(Group.1)<= as.Date("2015-08-01"))


zoom <- ggplot() +
  geom_line(data = avgt_z, aes(x = Group.1, y = x), color = "red") +
  geom_line(data = avgc_z, aes(x = Group.1, y = x), color = "blue") +
  xlab('Months') +
  ylab('price per kWh')

zoom
```

```
# only luminus contract; only brussel, 01/2017 - 07/2022
#fixed and variable contracts, first together and than separate


library(readxl)
library(dplyr)
Price_data_sorted <- read_excel("~/Desktop/Price_data_sorted.xlsx",
                                sheet = "VATCUT2022",
                                col_types = c("text",
                                              "text", "text", "numeric", "date",
                                              "text", "text", "text", "numeric",
                                           "numeric", "text", "date", "numeric",
                                           "numeric", "text", "text", "numeric",
                                       "numeric", "text", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "text", "text", "text", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric", "numeric", "numeric",
                                              "numeric"))


```

```r


df <- data.frame(Price_data_sorted)

#selectt only period of interest for 2022 VATcut
df <- subset(df, as.Date(Month) > as.Date("2016-12-01") & as.Date(Month)
             <= as.Date("2022-07-01"))

#take only consumption contracts
df_1 <- subset(df, type_contract == "Afname")


#try to check with only fixed/variable contracts
#df_1 <- subset(df_1, type_product == "Variabel")

#SELECT DATA
#take only variable contract for each month that was  offered from 01-2013;
#otherwise is following different products
df_spl <- split(df_1, f = df_1$type_product)
df_s <- subset(df_spl$Variabel, as.Date(date_from) == as.Date("2013-01-01"))

df_1 <- rbind(df_s, df_spl$Vast)


# change dataset for the regression
df_split <- split(df_1, f= df_1$Professioneel.Particulier)

# add 1 to vat rate column
df_split <- within(df_split, Particulier$vat_rate <- Particulier$vat_rate+1)

#compute vat inclusive prices for household only
df_split <- within(df_split, Particulier$price.kWh...21 <-
                     Particulier$price.kWh...21*Particulier$vat_rate)

#make vat rate for firm equal to 1
df_split <- within(df_split, Professioneel$vat_rate <- Professioneel$vat_rate/0.21)


#compute avarage price of firm and of household
avgt <- mean(df_split$Particulier$price.kWh...21)
avgc <-mean(df_split$Professioneel$price.kWh...21)
sde_t <- sd(df_split$Particulier$price.kWh...21)
sde_c <- sd(df_split$Professioneel$price.kWh...21)


df_adj <- rbind(df_split$Particulier, df_split$Professioneel)
```

```r

#descriptive statistics

df_s <- split(df_adj, f=df_adj$type_product)
avgvar <- mean(df_s$Variabel$price.kWh...21)
avgfix <- mean(df_s$Vast$price.kWh...21)
sdevar <- sd(df_s$Variabel$price.kWh...21)
sdefix <- sd(df_s$Vast$price.kWh...21)

#tao regressors
df_reg <- within(df_adj, vat_rate <- log(vat_rate)) #regressor ln(1+tao)

# price for dependent variable ln(price)

df_reg <- within(df_adj, price.kWh...21 <- log(price.kWh...21))e

#Create dummy variables

# dummy for client type; household=1 and firm =0

df_reg <- within(df_reg, Professioneel.Particulier<-
                   ifelse(Professioneel.Particulier == "Particulier", 1, 0))

# Create dummy for the VAT cut


df_reg <- within(df_reg, Month <-
                   ifelse(as.Date(Month)>=as.Date("2022-03-01"), 1, 0))

#method 1 standard DiD
#multiplicate dummies to get coefficient
#df_reg <- within(df_reg, vat_rate <- Month*Professioneel.Particulier)


#method 2 use the transformed regressor to measure directlt PT: ln(1+tao)

# Regression Model

model <- lm(price.kWh...21~ Professioneel.Particulier  + Month + vat_rate, df_reg)



#simple difference regression
modelsimple <-  lm(price.kWh...21~ vat_rate, df_reg)


```

```
summary(model)
summary(modelsimple)

#robustness check - compute robust standard errors
library(sandwich)
robust_se <- vcovHC(model, type = "HC3")

coefficients <- coef(model)
se <- sqrt(diag(robust_se))

# Combine coefficients and standard errors into a data frame
results <- data.frame(coef = coefficients, se = se)

# Print the results
print(results)

#plot prices to check for parallel trend
library(lubridate)
library(ggplot2)
library(scales)

library(colorspace)


df_t <- data.frame(df_split$Particulier$price.kWh...21,
                   df_split$Particulier$Month)
df_c <- data.frame(df_split$Professioneel$price.kWh...21,
                   df_split$Professioneel$Month)

tc <- data.frame(df_c, df_t)

p <- ggplot() +
  geom_line(data = df_t, aes(x = df_split.Particulier.Month,
                             y = df_split.Particulier.price.kWh...21),
                              color = "red") +
  geom_line(data = df_c, aes(x = df_split.Professioneel.Month,
                             y = df_split.Professioneel.price.kWh...21),
                               color = "blue") +
  xlab('Months') +
  ylab('price per kWh')

p


# create a plot the zoom on VAT cut
```

```r
t_z <- subset(df_t, as.Date(df_split$Particulier$Month)>= as.Date("2022-01-01"))
c_z <- subset(df_c, as.Date(df_split$Professioneel$Month)>= as.Date("2022-01-01"))


zoom <- ggplot() +
  geom_line(data = t_z, aes(x = df_split.Particulier.Month,
                            y = df_split.Particulier.price.kWh...21),
                           color = "red") +
  geom_line(data = c_z, aes(x = df_split.Professioneel.Month,
                            y = df_split.Professioneel.price.kWh...21),
                            color = "blue") +
  xlab('Months') +
  ylab('price per kWh')

zoom

#avarages for plot fixed and variable
avg_t <- aggregate(df_split$Particulier$price.kWh...21,
                   list(df_split$Particulier$Month), FUN = mean)
avg_c <- aggregate(df_split$Professioneel$price.kWh...21,
                   list(df_split$Professioneel$Month), FUN = mean)


p1 <- ggplot() +
  geom_line(data = avg_t, aes(x = Group.1, y = x , color = "household")) +
  geom_line(data = avg_c, aes(x = Group.1, y = x, color = "firm")) +

 scale_colour_manual(name="Line Color",
   values=c(household = "red", firm="blue", vatcut= "black"))+
  xlab('Months') +
  ylab('Avarage price per kWh')

p1

# create a plot the zoom on VAT cut

avgt_z <- subset(avg_t, as.Date(Group.1)>= as.Date("2022-01-01"))
avgc_z <- subset(avg_c, as.Date(Group.1)>= as.Date("2022-01-01"))


zoom <- ggplot() +
  geom_line(data = avgt_z, aes(x = Group.1, y = x), color = "red") +
  geom_line(data = avgc_z, aes(x = Group.1, y = x), color = "blue") +
  xlab('Months') +
  ylab('price per kWh')

```

```
zoom
```