

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:

$$r = \frac{1}{\beta} + \delta - 1 \quad (29)$$

From the energy production function:

$$e = h_e \quad (30)$$

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

$$w = p_e \quad (31)$$

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

$$e_y = \frac{\nu}{1 - \alpha - \nu} h_y \quad (32)$$

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:

$$i = \delta k \quad (33)$$

From the factor demand of capital:

$$y = rk/\alpha \quad (34)$$

²⁸To 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 :

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

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

$$h_e = 1 - h_y \quad (36)$$

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:

$$p_e = \frac{vy}{e_y} \quad (37)$$

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

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

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

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

$$x = y - k\delta \quad (40)$$

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

$$x_H = w/p_h \quad (41)$$

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

$$(1 - \lambda)x_S = x - \lambda x_H \quad (42)$$

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

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

$$c_S = \left(\frac{1}{p_S}\right)^{-\varepsilon_x} a_{S,c} x_S \quad (44)$$

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

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

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

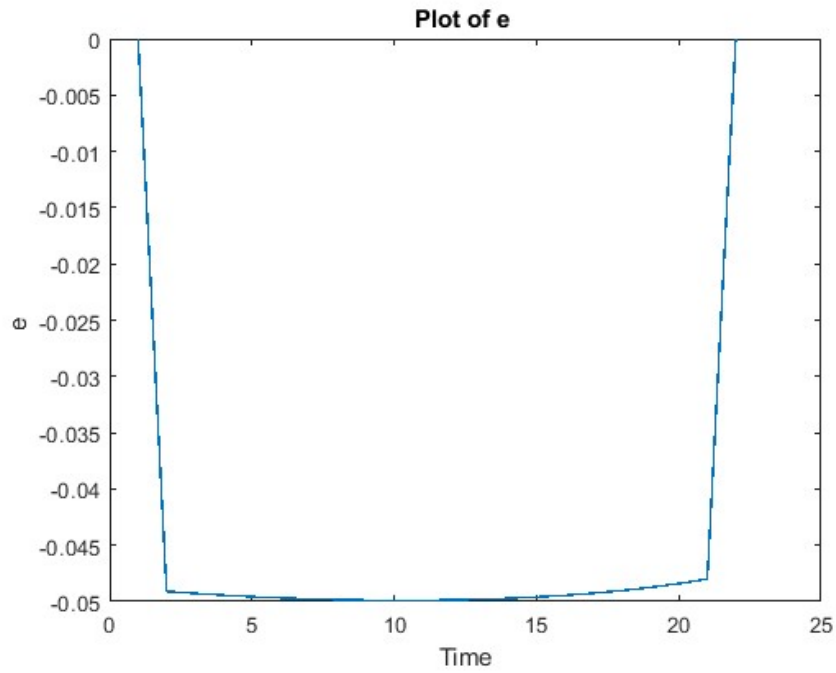
$$c = \lambda c_H + (1 - \lambda) c_S \quad (47)$$

Finally, government public expenditure:

$$G = e_x \tau_e p_e \quad (48)$$

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

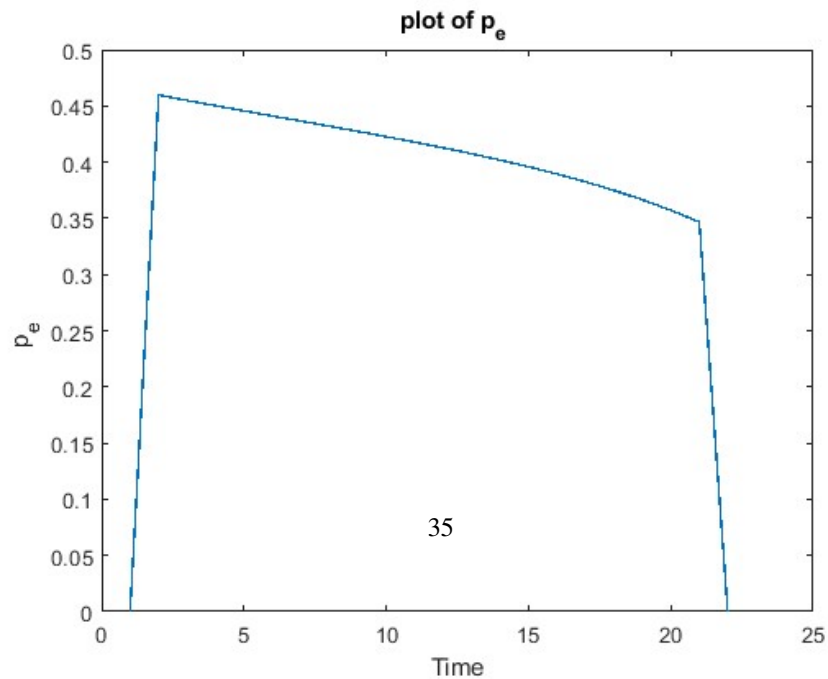
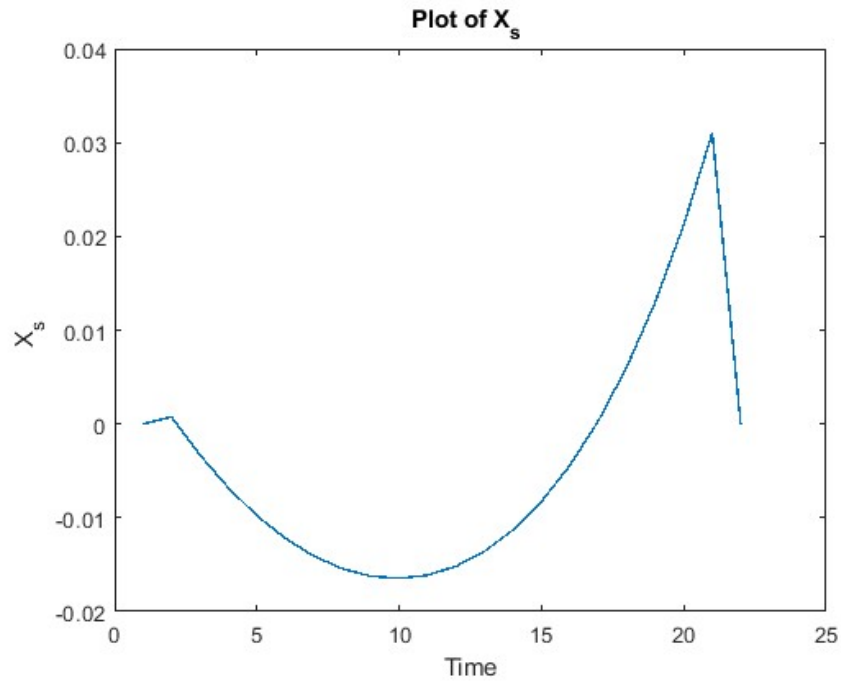


Figure 7

(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

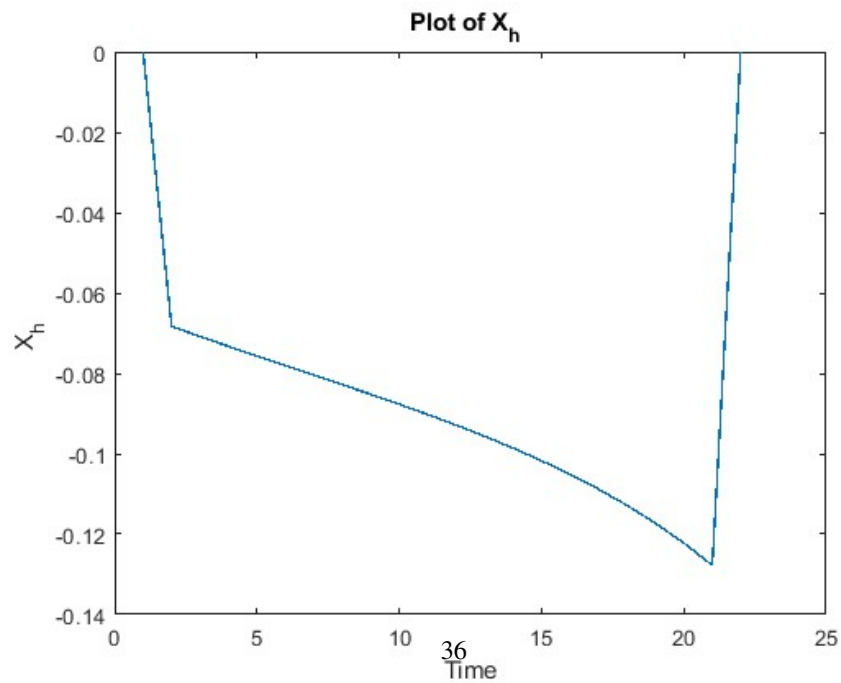
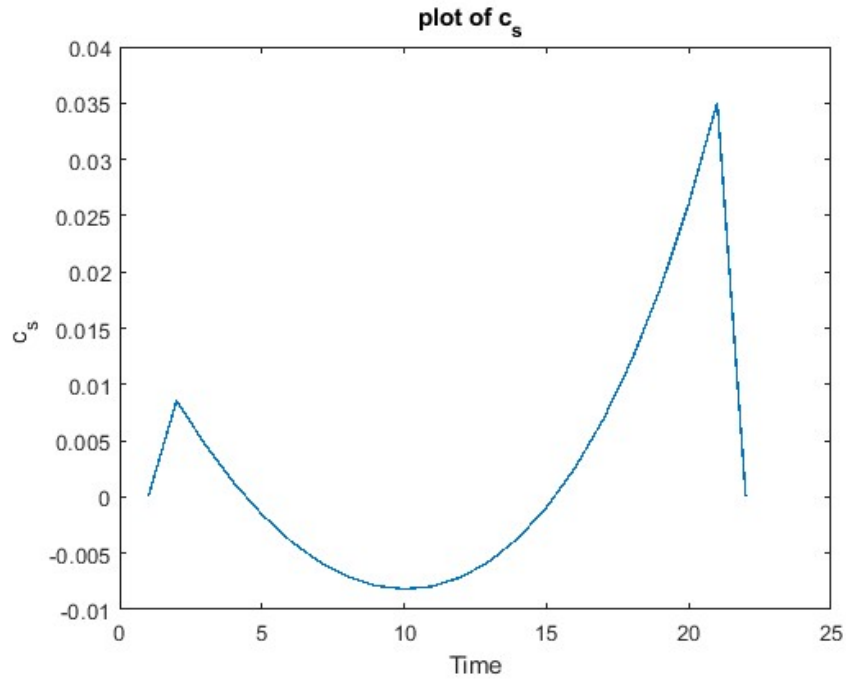


Figure 8: Comparison of total consumption trajectories between the two types of agents; Hand-to-mouth experienced a more severe drop in total consumption after the shock.

(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

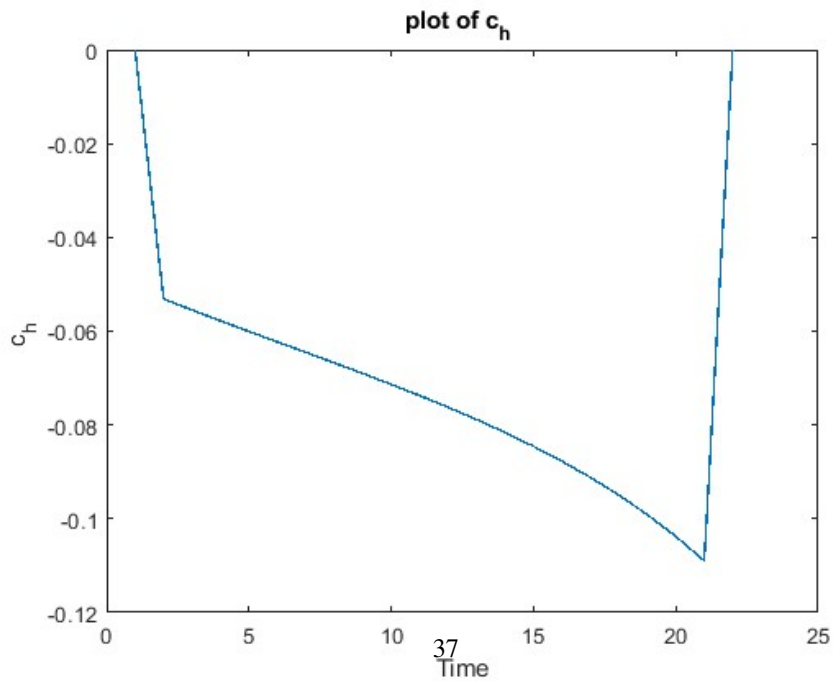
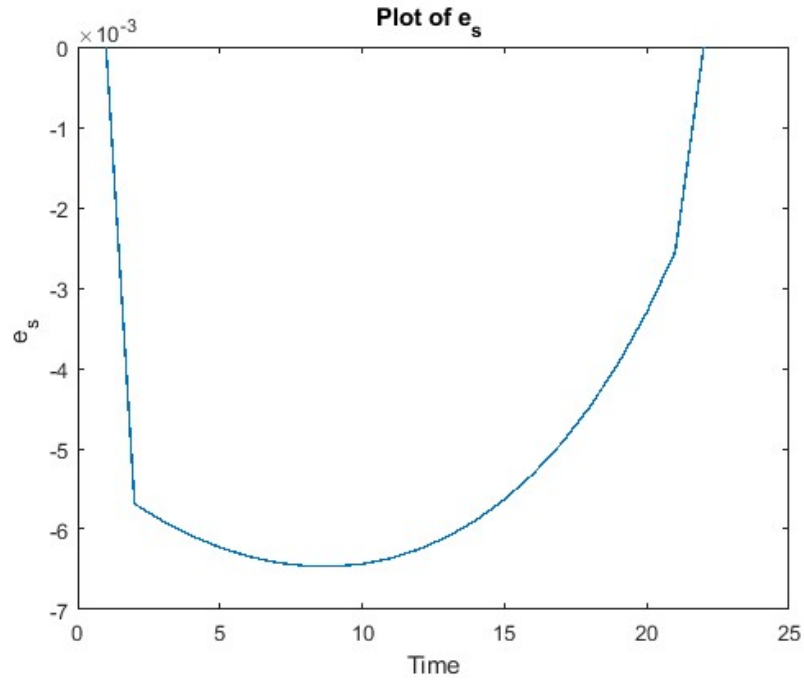


Figure 9: Comparison of final good consumption trajectories between the two types of agents; Hand-to-mouth experienced a more severe drop in final good consumption after the shock.

(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

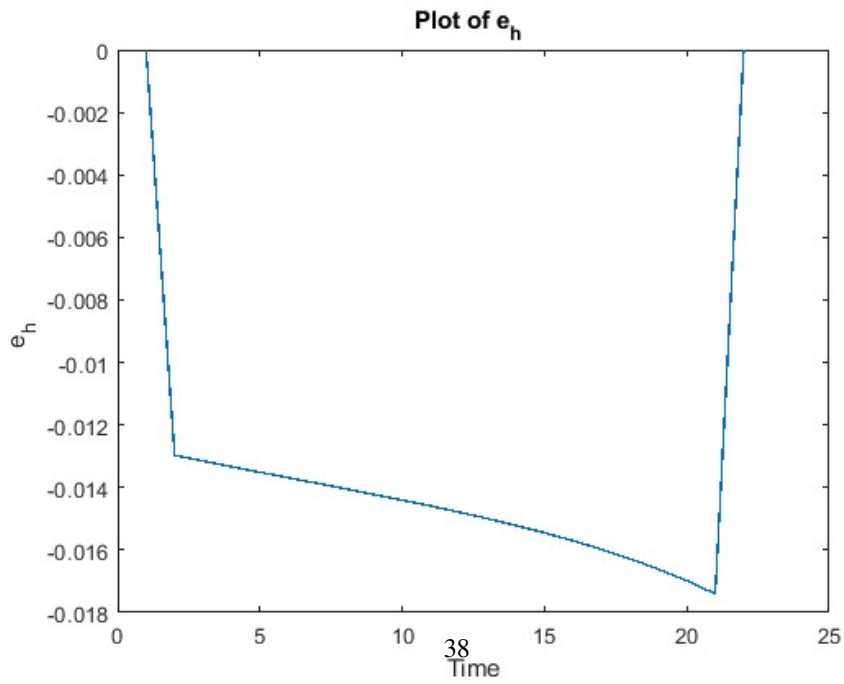


Figure 10: Comparison of energy consumption trajectories between the two types of agents; Hand-to-mouth experienced a more severe drop in energy consumption after the shock.

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

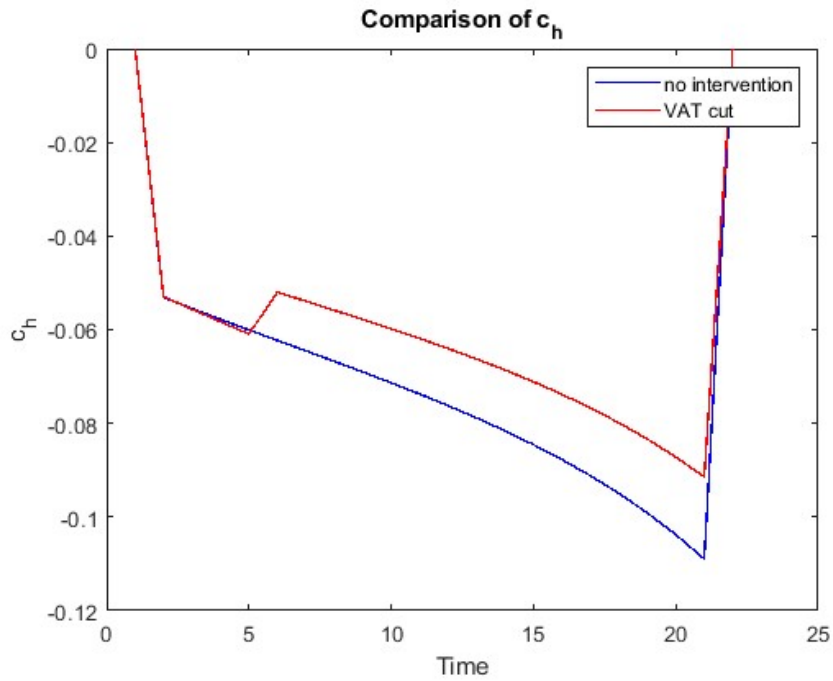


Figure 12: Comparison of Hand-to-mouth energy consumption in the two scenarios: with VAT cut (red), without VAT cut (blue). The negative effect is less severe after VAT cut implementation

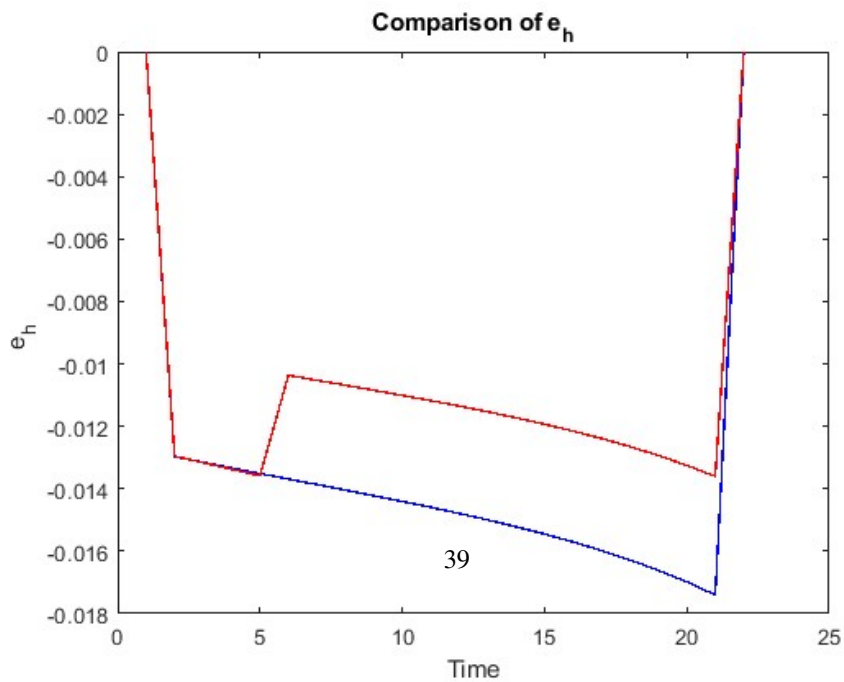


Figure 13: Comparison of Hand-to-mouth consumption in the two scenarios: with VAT cut (red), without VAT cut (blue). The negative effect is less severe after VAT cut implementation

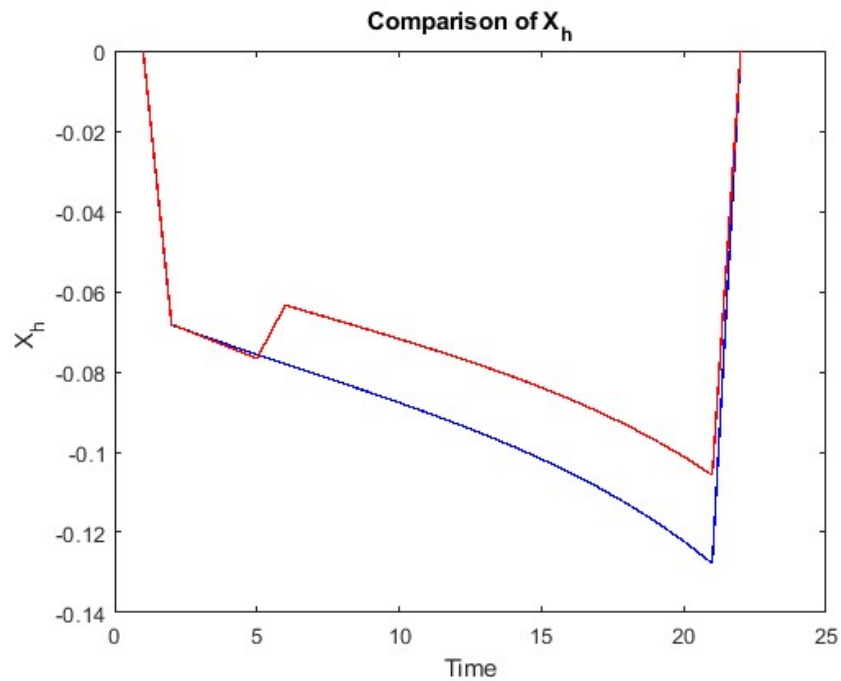
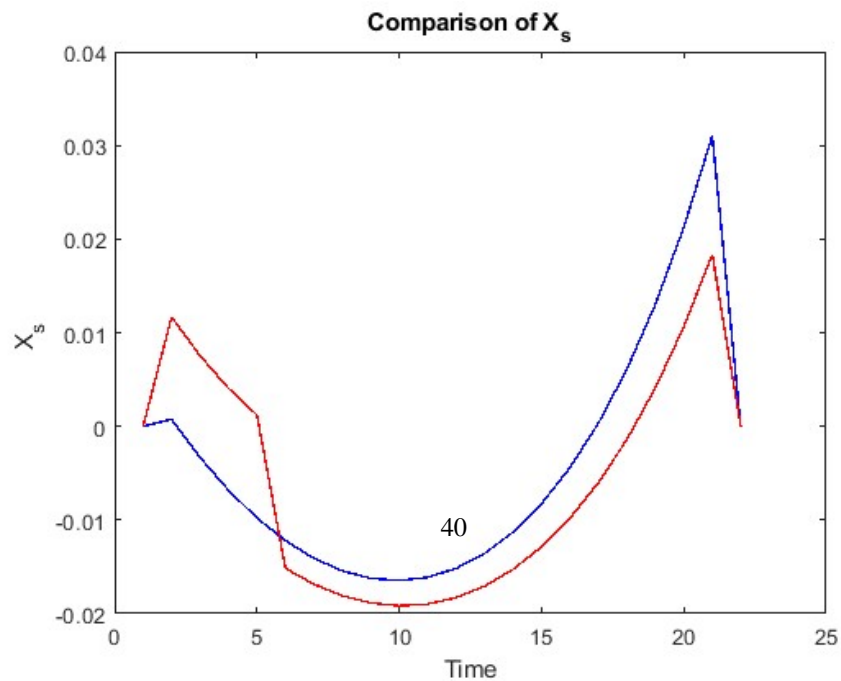


Figure 14: Comparison of Savers consumption in the two scenarios: with VAT cut (red), without VAT cut (blue). Savers increase more consumption initially, but also decrease more it after the VAT cut. This effect again is given by the substitution between savings, that increase and consumption that decreases.



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 Savers³⁰ is set equal to 1, which is a quite standard value macroeconomic literature³¹. 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.

²⁹Tomáš 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

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

³¹Kanzig(2022)

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

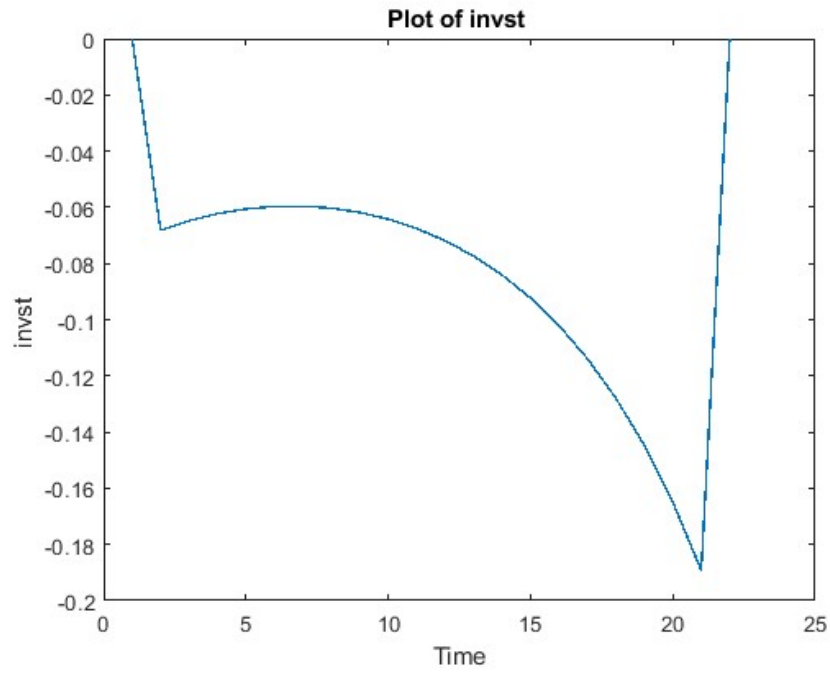


Figure 16: Savers consumption with higher IES (equal to 2)

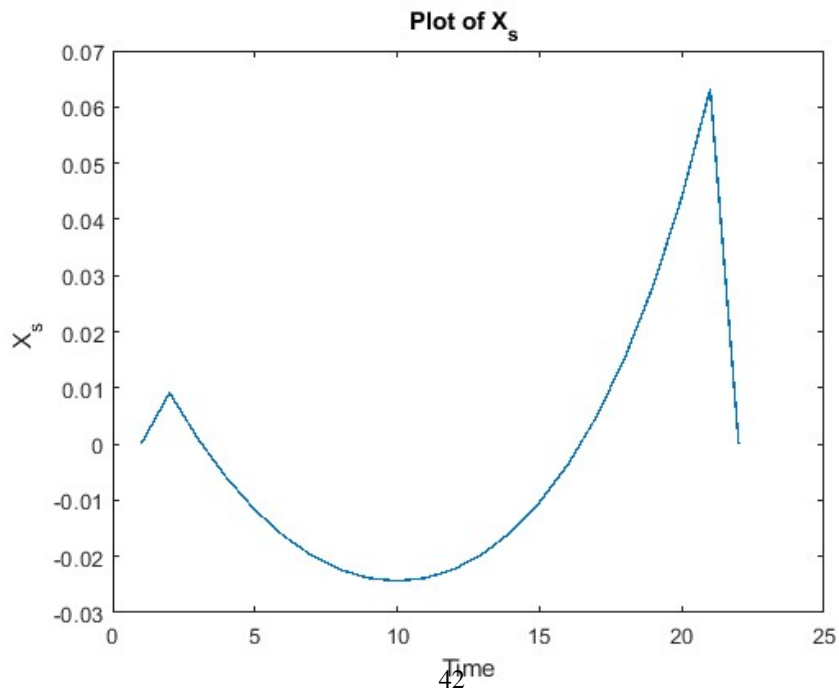


Figure 17: Savers investments with lower IES (equal to 0.1)

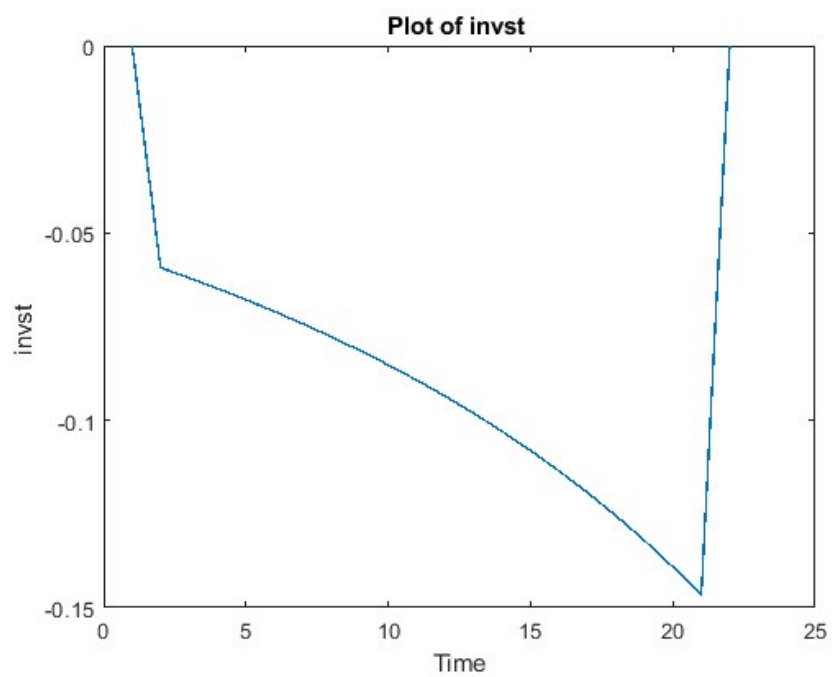
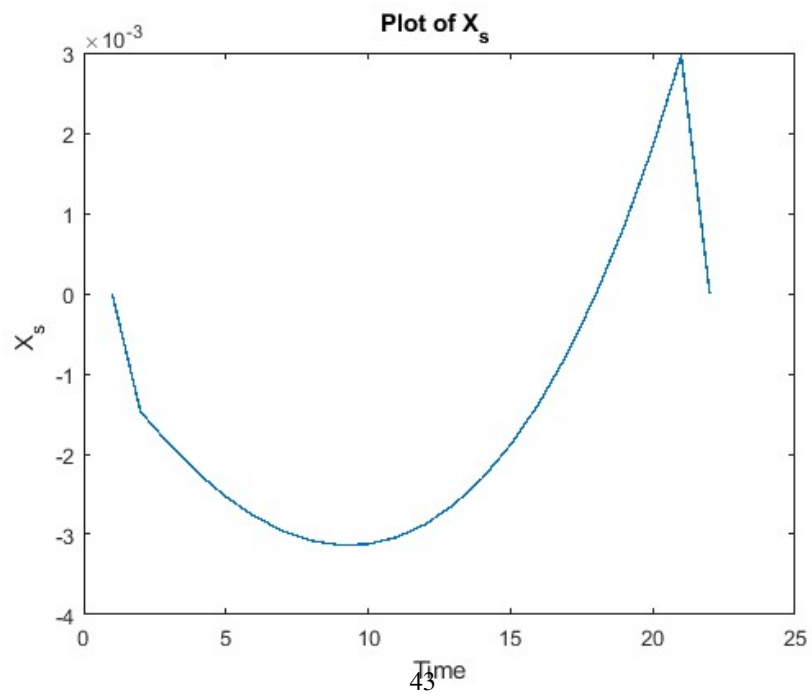


Figure 18: Savers consumption with lower IES (equal to 0.1)



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.

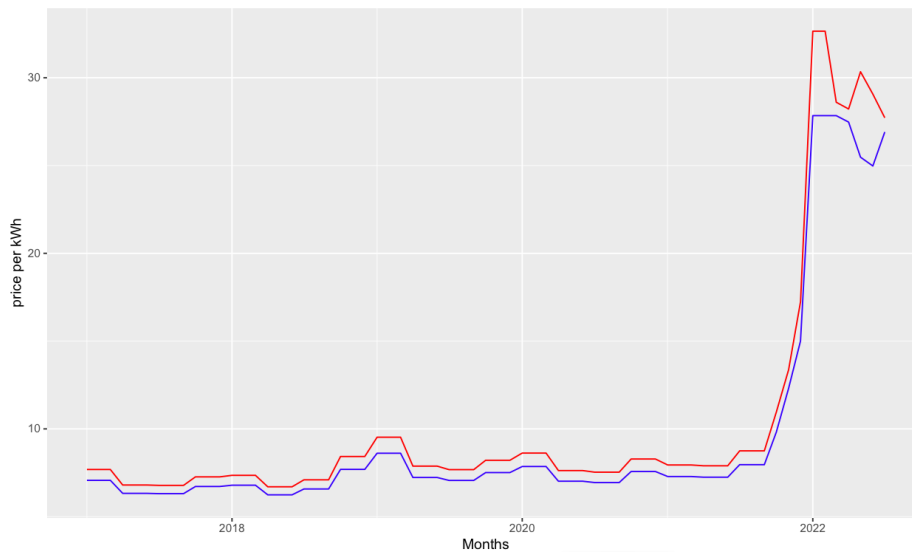


Figure 19: Luminus variable contract price per kWh, in its version for household (red) and firms (blue)

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:

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

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:

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

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

$$\beta_3 = \frac{d\ln(P)}{d\ln(1 + \tau)} = \frac{\Delta P/P}{\Delta \tau / (1 + \tau)} \quad (3)$$

F Dynare and Matlab codes

```
1  %VAT cut scenario
2
3  var
4  y      %production
5  k      %capital
6  x      %tot consumption
7  c_h    %consumption of final good of Hand-to-mouth
8  c_s    % consumption of final good Savers
9  e_h    %consumption of energy good of H
10 e_s    %consumption of energy good of S
11 X_h    % H total consumption
12 X_s    % S totalconsumption
13 invst  % investments
14 r      % interest rate
15 w      % wage
16 h_e    % labor demand in energy sector
17 h_y    % labor demand in production sector
18 e_y    %energy used in production sector
19 e_x    % energy used in consumption (tot)
20 c      %total consumption of final good
21 e      % energy supply
22 p_e    % price of energy
23 p_s    % price of saver consumption bundle
24 p_h    %price of H consumption bundle
25 G      %public expenditure
26 ;
27
28 %exogeneous variables
29
30 varexo
31 A      % productivity shock
32 tau_e  %tax on energy consumption
33 ;
34
35 %parameters
36
37 parameters aalpha bbeta ddelta ssigma A_ss r_ss k_ss invst_ss y_ss
38 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
39 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
40 p_s_ss p_h_ss ;
41
42
43
```

```

44 aalpha = 0.30; % return of capital
45 v= 0.085; %return of energy
46 bbeta = 0.96; % discount factor
47 ddelta = 0.025; % depreciation rate
48 ssigma = 1; % elasticity of consumption
49 lambda = 0.25; % share of hand to mouth
50 epsilon_x = 0.21;% elasticity between energy and non energy good
51 a_s_e = 0.071; % income share spent in energy S
52 a_s_c = 1- a_s_e;% income share spent in final good S
53 a_h_e = 0.103; % income share spent in energy H
54 a_h_c = 1- a_h_e;% income share spent in final good H
55 h=1; % labor supply
56
57 %steady state formulas (derived analytically)
58
59 tau_e_ss = 0.21;
60 A_ss = 1;
61 r_ss = (1/bbeta)-1+ddelta;
62 k_ss = 3.53288; % guess on capital
63 y_ss= r_ss*k_ss/aalpha ;
64 h_y_ss = (y_ss/(k_ss^(aalpha)*(v/(1-aalpha-v))^v))^(1/(1-aalpha));
65 invst_ss = (ddelta)*k_ss;
66 h_e_ss = 1-h_y_ss;
67 e_ss = h_e_ss;
68 e_y_ss = v/(1-aalpha-v)*h_y_ss ;
69 p_e_ss = v*y_ss/e_y_ss;
70 w_ss = p_e_ss;
71 x_ss = y_ss-invst_ss;
72 p_h_ss = (a_h_c + a_h_e*(p_e_ss*(1+tau_e_ss))^(1-epsilon_x))^(1/(1-epsilon_x));
73 p_s_ss = (a_s_c + a_s_e*(p_e_ss*(1+tau_e_ss))^(1-epsilon_x))^(1/(1-epsilon_x));
74 X_h_ss = w_ss/p_h_ss;
75 X_s_ss =(x_ss - lambda*X_h_ss)/(1-lambda) ;
76 c_s_ss = (1/p_s_ss)^(-epsilon_x)*a_s_c*X_s_ss;
77 c_h_ss = (1/p_h_ss)^(-epsilon_x)*a_h_c*X_h_ss;
78 e_s_ss = (p_e_ss*(1+tau_e_ss)/p_s_ss)^(-epsilon_x)*X_s_ss*a_s_e;
79 e_h_ss = (p_e_ss*(1+tau_e_ss)/p_h_ss)^(-epsilon_x)*X_h_ss*a_h_e;
80 e_x_ss = (1-lambda)*e_s_ss + lambda*e_h_ss;
81 c_ss = c_s_ss*(1-lambda) + c_h_ss*lambda;
82 G_ss = tau_e_ss*e_x_ss*p_e_ss;
83
84
85 % Model
86
87 model;
88 %euler equation Saver
89 p_s*X_s^(-ssigma) = p_s(+1)*X_s(+1)^(-ssigma)*bbeta*(1+r(+1)-ddelta);

```

```

90
91 %budget constraint Hand to mouth
92 p_h*X_h = w;
93
94 %Total Consumption H
95 X_h = (a_h_c^(1/epsilon_x)*c_h^((epsilon_x-1)/epsilon_x)+
96 a_h_e^(1/epsilon_x)*e_h^((epsilon_x-1)/epsilon_x))^(epsilon_x/(epsilon_x-1));
97
98 %Total Consumption S
99 X_s = (a_s_c^(1/epsilon_x)*c_s^((epsilon_x-1)/epsilon_x) +
100 a_s_e^(1/epsilon_x)*e_s^((epsilon_x-1)/epsilon_x))^(epsilon_x/(epsilon_x-1));
101
102 % consumption constraints
103 p_s*X_s = c_s + p_e*(1+tau_e)*e_s;
104 p_h*X_h = c_h + p_e*(1+tau_e)*e_h;
105
106 % energy consumption of two agents
107 e_s = (p_e*(1+tau_e)/p_s)^(-epsilon_x)*X_s*a_s_e;
108
109 e_h = (p_e*(1+tau_e)/p_h)^(-epsilon_x)*X_h*a_h_e;
110
111 % Prices of consumption bundles of two agents
112 p_s = ((a_s_c + a_s_e*(p_e*(1+tau_e))^(1-epsilon_x))^(1/(1-epsilon_x)));
113 p_h = ((a_h_c + a_h_e*(p_e*(1+tau_e))^(1-epsilon_x))^(1/(1-epsilon_x)));
114
115 % final good consumption of two agents
116 c_s = (1/p_s)^(-epsilon_x)*a_s_c*X_s;
117
118 c_h = (1/p_h)^(-epsilon_x)*a_h_c*X_h;
119
120
121 % law of motion capital
122 k = (1-delta)*k(-1)+invst;
123
124 %resource constraint
125 G+ invst = y-x;
126 %market clearing consitions
127 h = h_y + h_e; %labor market
128
129 e = e_y + e_x; %energy market
130
131 %Variable aggregation
132 e_x = e_s*(1-lambda) + e_h*lambda; % aggregate energy consumption
133
134 c = c_s*(1-lambda) + c_h*lambda; %aggregate good consumption consumption
135

```

```

136 x = (1-lambda)*X_s + lambda*X_h; % aggregate consumption
137
138
139 %production sector
140
141 y = k^(-1)^(aalpha)*e_y^v*h_y^(1-aalpha-v); %production function
142
143 r = aalpha*k^(-1)^(aalpha-1)*e_y^v*h_y^(1-aalpha-v); %demand of capital
144
145 w = k^(-1)^(aalpha)*e_y^v*h_y^(-aalpha-v)*(1-aalpha-v); %demand of labor
146
147 p_e = v*k^(-1)^aalpha*e_y^(v-1)*h_y^(1-aalpha-v); %demand of energy
148
149
150
151 %energy sector
152 e = A*h_e; %energy production function
153
154 e = w*h_e/p_e; %energy supply
155
156 %government
157 G = tau_e*e_x*p_e;
158
159 end;
160
161 initval;
162 A=A_ss;
163 tau_e = tau_e_ss;
164 r = r_ss;
165 k=k_ss;
166 e = e_ss;
167 h_e= h_e_ss;
168 h_y= h_y_ss;
169 p_e = p_e_ss;
170 invst = invst_ss;
171 y= y_ss;
172 x =x_ss;
173 X_s = X_s_ss;
174 X_h = X_h_ss;
175 w = w_ss;
176 e_y = e_y_ss;
177 e_x = e_x_ss;
178 c_h = c_h_ss;
179 c_s = c_s_ss;
180 e_h = e_h_ss;
181 e_s = e_s_ss;

```

```

182 p_h = p_h_ss;
183 p_s = p_s_ss;
184 c = c_ss;
185 end;
186
187
188 resid(1);
189 steady;
190 check;
191
192
193 shocks;
194
195 % no intervention scenario: only TFP shock; VAT cut scenario: both shocks
196
197 var A; %TFP negative shock
198 periods 1:20;
199 values 0.65;
200 var tau_e; %VAT cut policy shock
201 periods 5:20;
202 values 0.06;
203 end;
204
205 simul(periods=20); %deterministic simulation
206
207 rplot A;
208 rplot p_e;
209 rplot tau_e;

```

```

1
2 dynare adj_noint
3
4
5 %Normalise around steady state
6
7 c_h_norm1 = c_h - c_h(1);
8 c_s_norm1 = c_s - c_s(1);
9 p_e_norm1 = p_e - p_e(1);
10 r_norm1 = r - r(1);
11 k_norm1=k - k(1);
12 e_norm1 = e - e(1);
13 h_e_norm1= h_e - h_e(1);
14 h_y_norm1= h_y - h_y(1);

```

```

15  invst_norm1 = invst - invst(1);
16  y_norm1 = y - y(1);
17  x_norm1 = x - x(1);
18  X_s_norm1 = X_s - X_s(1);
19  X_h_norm1 = X_h - X_h(1);
20  w_norm1 = w - w(1);
21  e_y_norm1 = e_y - e_y(1);
22  e_x_norm1 = e_x - e_x(1);
23  e_h_norm1 = e_h - e_h(1);
24  e_s_norm1 = e_s - e_s(1);
25  p_h_norm1 = p_h - p_h(1);
26  p_s_norm1 = p_s - p_s(1);
27  c_norm1 = c - c(1);
28
29  %plot c_h
30  time = 1:numel(c_h_norm1); % Time axis
31
32  figure;
33  plot(time, c_h_norm1, 'LineWidth', 1);
34  xlabel('Time');
35  ylabel('c_h ');
36  title('plot of c_h ');
37
38  %plot c_s
39  time = 1:numel(c_s_norm1); % Time axis
40
41  figure;
42  plot(time, c_s_norm1, 'LineWidth', 1);
43  xlabel('Time');
44  ylabel('c_s ');
45  title('plot of c_s ');
46
47
48  %plot p_e
49  time = 1:numel(p_e_norm1); % Time axis
50  figure;
51  plot(time, p_e_norm1, 'LineWidth', 1);
52  xlabel('Time');
53  ylabel('p_e ');
54  title('plot of p_e ');
55
56  % Plot r_norm
57  figure;
58  plot(time, r_norm1, 'LineWidth', 1);
59  xlabel('Time');
60  ylabel('r ');

```

```

61 title('Plot of r ');
62
63 % Plot k_norm
64 figure;
65 plot(time, k_norm1, 'LineWidth', 1);
66 xlabel('Time');
67 ylabel('k ');
68 title('Plot of k ');
69
70 % Plot e_norm
71 figure;
72 plot(time, e_norm1, 'LineWidth', 1);
73 xlabel('Time');
74 ylabel('e ');
75 title('Plot of e ');
76
77
78 % Plot invst_norm
79 figure;
80 plot(time, invst_norm1, 'LineWidth', 1);
81 xlabel('Time');
82 ylabel('invst ');
83 title('Plot of invst ');
84
85
86 % Plot X_s_norm
87 figure;
88 plot(time, X_s_norm1, 'LineWidth', 1);
89 xlabel('Time');
90 ylabel('X_s ');
91 title('Plot of X_s ');
92
93 % Plot X_h_norm
94 figure;
95 plot(time, X_h_norm1, 'LineWidth', 1);
96 xlabel('Time');
97 ylabel('X_h ');
98 title('Plot of X_h ');
99
100
101 % Plot e_h_norm
102 figure;
103 plot(time, e_h_norm1, 'LineWidth', 1);
104 xlabel('Time');
105 ylabel('e_h ');
106 title('Plot of e_h ');

```

```

107
108
109 % Plot e_s_norm
110 figure;
111 plot(time, e_s_norm1, 'LineWidth', 1);
112 xlabel('Time');
113 ylabel('e_s ');
114 title('Plot of e_s ');
115
116
117
118 % Plot e_s_norm
119 figure;
120 plot(time, e_s_norm1, 'LineWidth', 1);
121 xlabel('Time');
122 ylabel('e_s ');
123 title('Plot of e_s ');
124

```

```

1
2 dynare gove_adj
3
4
5 %Normalise
6 c_h_norm2 = c_h - c_h(1);
7 c_s_norm2 = c_s - c_s(1);
8 p_e_norm2 = p_e - p_e(1);
9 r_norm2 = r - r(1);
10 k_norm2=k - k(1);
11 e_norm2 = e - e(1);
12 h_e_norm2= h_e - h_e(1);
13 h_y_norm2= h_y - h_y(1);
14 invst_norm2 = invst - invst(1);
15 y_norm2= y - y(1);
16 x_norm2=x - x(1);
17 X_s_norm2 = X_s- X_s(1);
18 X_h_norm2 = X_h- X_h(1);
19 w_norm2 = w - w(1);
20 e_y_norm2 = e_y - e_y(1);
21 e_x_norm2 = e_x- e_x(1);
22 e_h_norm2 = e_h-e_h(1);
23 e_s_norm2 = e_s-e_s(1);
24 p_h_norm2 = p_h-p_h(1);

```

```

25 p_s_norm2 = p_s-p_s(1);
26 c_norm2 = c-c(1);
27
28
29 %COMPARISON OF TWO SCENARIO/ VAT CUT VS NO INTERVENTION
30
31 time = 1:numel(c_h_norm1); % Time axis
32 figure;
33 subplot(4, 5, 1);
34 plot(time, c_h_norm1, 'LineWidth', 1, 'Color', 'b');
35 hold on;
36 plot(time, c_h_norm2, 'LineWidth', 1, 'Color', 'r');
37 hold off;
38 xlabel('Time');
39 ylabel('c_h');
40 title('Comparison of c_h');
41 legend('no intervention', 'VAT cut');
42
43
44 % Plot c_s_norm
45 subplot(4, 5, 2);
46 plot(time, c_s_norm1, 'LineWidth', 1, 'Color', 'b');
47 hold on;
48 plot(time, c_s_norm2, 'LineWidth', 1, 'Color', 'r');
49 hold off;
50 xlabel('Time');
51 ylabel('c_s ');
52 title('Comparison of c_s');
53
54 % Plot p_e_norm
55 subplot(4, 5, 3);
56 plot(time, p_e_norm1, 'LineWidth', 1, 'Color', 'b');
57 hold on;
58 plot(time, p_e_norm2, 'LineWidth', 1, 'Color', 'r');
59 hold off;
60 xlabel('Time');
61 ylabel('p_e ');
62 title('Comparison of p_e');
63
64 % Plot r_norm
65 subplot(4, 5, 4);
66 plot(time, r_norm1, 'LineWidth', 1, 'Color', 'b');
67 hold on;
68 plot(time, r_norm2, 'LineWidth', 1, 'Color', 'r');
69 hold off;
70 xlabel('Time');

```

```

71 ylabel('r ');
72 title('Comparison of r');
73
74 % Plot k_norm
75 subplot(4, 5, 5);
76 plot(time, k_norm1, 'LineWidth', 1, 'Color', 'b');
77 hold on;
78 plot(time, k_norm2, 'LineWidth', 1, 'Color', 'r');
79 hold off;
80 xlabel('Time');
81 ylabel('k ');
82 title('Comparison of k');
83
84 % Plot e_norm
85 subplot(4, 5, 6);
86 plot(time, e_norm1, 'LineWidth', 1, 'Color', 'b');
87 hold on;
88 plot(time, e_norm2, 'LineWidth', 1, 'Color', 'r');
89 hold off;
90 xlabel('Time');
91 ylabel('e ');
92 title('Comparison of e');
93
94 % Plot h_e_norm
95 subplot(4, 5, 7);
96 plot(time, h_e_norm1, 'LineWidth', 1, 'Color', 'b');
97 hold on;
98 plot(time, h_e_norm2, 'LineWidth', 1, 'Color', 'r');
99 hold off;
100 xlabel('Time');
101 ylabel('h_e ');
102 title('Comparison of h_e');
103
104 % Plot h_y_norm
105 subplot(4, 5, 8);
106 plot(time, h_y_norm1, 'LineWidth', 1, 'Color', 'b');
107 hold on;
108 plot(time, h_y_norm2, 'LineWidth', 1, 'Color', 'r');
109 hold off;
110 xlabel('Time');
111 ylabel('h_y ');
112 title('Comparison of h_y');
113
114 % Plot invst_norm
115 subplot(4, 5, 9);
116 plot(time, invst_norm1, 'LineWidth', 1, 'Color', 'b');

```

```

117 hold on;
118 plot(time, invst_norm2, 'LineWidth', 1, 'Color', 'r');
119 hold off;
120 xlabel('Time');
121 ylabel('invst ');
122 title('Comparison of invst');
123
124 % Plot y_norm
125 subplot(4, 5, 10);
126 plot(time, y_norm1, 'LineWidth', 1, 'Color', 'b');
127 hold on;
128 plot(time, y_norm2, 'LineWidth', 1, 'Color', 'r');
129 hold off;
130 xlabel('Time');
131 ylabel('y ');
132 title('Comparison of y');
133
134 % Plot x_norm
135 subplot(4, 5, 11);
136 plot(time, x_norm1, 'LineWidth', 1, 'Color', 'b');
137 hold on;
138 plot(time, x_norm2, 'LineWidth', 1, 'Color', 'r');
139 hold off;
140 xlabel('Time');
141 ylabel('x ');
142 title('Comparison of x');
143
144 % Plot X_s_norm
145 subplot(4, 5, 12);
146 plot(time, X_s_norm1, 'LineWidth', 1, 'Color', 'b');
147 hold on;
148 plot(time, X_s_norm2, 'LineWidth', 1, 'Color', 'r');
149 hold off;
150 xlabel('Time');
151 ylabel('X_s ');
152 title('Comparison of X_s');
153
154 % Plot X_h_norm
155 subplot(4, 5, 13);
156 plot(time, X_h_norm1, 'LineWidth', 1, 'Color', 'b');
157 hold on;
158 plot(time, X_h_norm2, 'LineWidth', 1, 'Color', 'r');
159 hold off;
160 xlabel('Time');
161 ylabel('X_h ');
162 title('Comparison of X_h');

```

```

163
164 % Plot w_norm
165 subplot(4, 5, 14);
166 plot(time, w_norm1, 'LineWidth', 1, 'Color', 'b');
167 hold on;
168 plot(time, w_norm2, 'LineWidth', 1, 'Color', 'r');
169 hold off;
170 xlabel('Time');
171 ylabel('w ');
172 title('Comparison of w');
173
174 % Plot e_y_norm
175 subplot(4, 5, 15);
176 plot(time, e_y_norm1, 'LineWidth', 1, 'Color', 'b');
177 hold on;
178 plot(time, e_y_norm2, 'LineWidth', 1, 'Color', 'r');
179 hold off;
180 xlabel('Time');
181 ylabel('e_y ');
182 title('Comparison of e_y');
183
184 % Plot e_x_norm
185 subplot(4, 5, 16);
186 plot(time, e_x_norm1, 'LineWidth', 1, 'Color', 'b');
187 hold on;
188 plot(time, e_x_norm2, 'LineWidth', 1, 'Color', 'r');
189 hold off;
190 xlabel('Time');
191 ylabel('e_x ');
192 title('Comparison of e_x');
193
194 % Plot e_h_norm
195 subplot(4, 5, 17);
196 plot(time, e_h_norm1, 'LineWidth', 1, 'Color', 'b');
197 hold on;
198 plot(time, e_h_norm2, 'LineWidth', 1, 'Color', 'r');
199 hold off;
200 xlabel('Time');
201 ylabel('e_h ');
202 title('Comparison of e_h');
203
204 % Plot e_s_norm
205 subplot(4, 5, 18);
206 plot(time, e_s_norm1, 'LineWidth', 1, 'Color', 'b');
207 hold on;
208 plot(time, e_s_norm2, 'LineWidth', 1, 'Color', 'r');

```

```

209 hold off;
210 xlabel('Time');
211 ylabel('e_s ');
212 title('Comparison of e_s');
213
214 % Plot p_h_norm
215 subplot(4, 5, 19);
216 plot(time, p_h_norm1, 'LineWidth', 1, 'Color', 'b');
217 hold on;
218 plot(time, p_h_norm2, 'LineWidth', 1, 'Color', 'r');
219 hold off;
220 xlabel('Time');
221 ylabel('p_h ');
222 title('Comparison of p_h');
223
224 % Plot p_s_norm
225 subplot(4, 5, 20);
226 plot(time, p_s_norm1, 'LineWidth', 1, 'Color', 'b');
227 hold on;
228 plot(time, p_s_norm2, 'LineWidth', 1, 'Color', 'r');
229 hold off;
230 xlabel('Time');
231 ylabel('p_s ');
232 title('Comparison of p_s');
233
234
235 %zoom on what relevant in comparison
236 time = 1:numel(c_h_norm1); % Time axis
237
238 plot(time, X_h_norm1, 'LineWidth', 1, 'Color', 'b');
239 hold on;
240 plot(time, X_h_norm2, 'LineWidth', 1, 'Color', 'r');
241 hold off;
242 xlabel('Time');
243 ylabel('X_h ');
244 title('Comparison of X_h');
245
246
247 plot(time, c_h_norm1, 'LineWidth', 1, 'Color', 'b');
248 hold on;
249 plot(time, c_h_norm2, 'LineWidth', 1, 'Color', 'r');
250 hold off;
251 xlabel('Time');
252 ylabel('c_h');
253 title('Comparison of c_h');
254 legend('no intervention', 'VAT cut');

```

```
255
256
257 % Plot c_s_norm
258 plot(time, c_s_norm1, 'LineWidth', 1, 'Color', 'b');
259 hold on;
260 plot(time, c_s_norm2, 'LineWidth', 1, 'Color', 'r');
261 hold off;
262 xlabel('Time');
263 ylabel('c_s ');
264 title('Comparison of c_s');
```

G R codes

```
1 #replication of Hindriks and Serse on VAT cut 2014
2
3
4 library(readxl)
5 library(dplyr)
6 Price_data_sorted <- read_excel("~/Desktop/Price_data_sorted.xlsx",
7                                 sheet = "REPLICATION",
8                                 col_types = c("text",
9                                               "text", "text", "numeric", "date",
10                                              "text", "text", "text", "numeric",
11                                              "numeric", "text", "date", "numeric",
12                                              "numeric", "text", "text", "numeric",
13                                              "numeric", "text", "numeric", "numeric",
14                                              "numeric", "numeric", "numeric",
15                                              "numeric", "numeric", "numeric",
16                                              "numeric", "numeric", "numeric",
17                                              "numeric", "numeric", "numeric",
18                                              "text", "text", "text", "numeric",
19                                              "numeric", "numeric", "numeric",
20                                              "numeric", "numeric", "numeric",
21                                              "numeric", "numeric", "numeric",
22                                              "numeric", "numeric", "numeric",
23                                              "numeric", "numeric", "numeric",
24                                              "numeric", "numeric", "numeric",
25                                              "numeric", "numeric", "numeric",
26                                              "numeric", "numeric", "numeric",
27                                              "numeric", "numeric", "numeric",
28                                              "numeric"))
29
30
31
32 df_1 <- data.frame(Price_data_sorted)
33
34
35 #SELECT DATA
36 #consider only consumption of energy contract data
37 df_1 <- subset(df_1, type_contract == "Afname")
38
39 #take only contract price data in brussel
40 #(price per kWh does not change in other regions)
41 df_1 <- subset(df_1, region == "BXL")
42
43
```

```

44 #to use it when studying only variable contracts
45 #df_1 <- subset(df_1, type_product == "Variabel")
46
47
48 #TAKE ONLY HINDRIKS and SERSE SAMPLE (2014-2016)
49 df_1 <- subset(df_1, as.Date(Month)<= as.Date("2016-12-01"))
50
51
52 # create dataset for the regression
53 df_split <- split(df_1, f= df_1$Professioneel.Particulier)
54
55 # add 1 to vat rate column
56 df_split <- within(df_split, Particulier$vat_rate <- Particulier$vat_rate+1)
57 #compute vat inclusive prices for household only
58 df_split <- within(df_split, Particulier$price.kWh...21 <-
59     Particulier$price.kWh...21*Particulier$vat_rate)
60 #make vat rate for firm equal to 1
61 df_split <- within(df_split, Professioneel$vat_rate <- Professioneel$vat_rate/0.21)
62
63
64 df_adj <- rbind(df_split$Particulier, df_split$Professioneel)
65
66
67 #tao regressors
68 df_reg <- within(df_adj, vat_rate <- log(vat_rate)) #regressor ln(1+tao)
69
70 # price for dependent variable ln(price)
71
72 df_reg <- within(df_adj, price.kWh...21 <- log(price.kWh...21))
73
74 #Create dummy variables
75
76 # dummy for client type; household=1 and firm =0
77 df_reg <- within(df_reg, Professioneel.Particulier<-
78     ifelse(Professioneel.Particulier == "Particulier", 1, 0))
79
80
81
82 # Create dummy for the VAT cut equal to 1 during VAT cut period
83
84 df_reg <- within(df_reg, Month <- ifelse(as.Date(Month)>=as.Date("2014-03-01")
85     & as.Date(Month)>=as.Date("2015-08-01"), 1, 0))
86
87 #method 1 standard DiD
88 #multiply dummies to get coefficient
89 #df_reg <- within(df_reg, vat_rate <- Month*Professioneel.Particulier)

```

```

90
91 # method 2 modification of standard DiD implemented by HES: ln(1+tao)
92
93 # Regression Model
94
95 model <- lm(price.kWh...21~ Professioneel.Particulier + Month + vat_rate, df_reg)
96
97
98
99 #simple difference regression
100 modelsimple <- lm(price.kWh...21~ vat_rate, df_reg)
101
102
103
104 summary(model)
105 summary(modelsimple)
106
107
108 #avarages for plot fixed and variable trends
109 avg_t <- aggregate(df_split$Particulier$price.kWh...21,
110                   list(df_split$Particulier$Month), FUN = mean)
111 avg_c <- aggregate(df_split$Professioneel$price.kWh...21,
112                   list(df_split$Professioneel$Month), FUN = mean)
113
114
115 #plot prices to check parallel trend
116 library(lubridate)
117 library(ggplot2)
118 library(scales)
119
120 library(colorspace)
121 p1 <- ggplot() +
122   geom_line(data = avg_t, aes(x = Group.1, y = x , color = "household")) +
123   geom_line(data = avg_c, aes(x = Group.1, y = x, color = "firm")) +
124
125   scale_colour_manual(name="Line Color",
126                       values=c(household = "red", firm="blue", vatcut= "black"))+
127   xlab('Months') +
128   ylab('Avarage price per kWh')
129
130 p1
131
132 # create a plot the zoom on VAT cut
133
134 avg_t_z <- subset(avg_t, as.Date(Group.1)>= as.Date("2014-03-01")
135                 & as.Date(Group.1)<= as.Date("2015-08-01"))

```

```

136 avgc_z <- subset(avg_c, as.Date(Group.1)>= as.Date("2014-03-01")
137           & as.Date(Group.1)<= as.Date("2015-08-01"))
138
139
140 zoom <- ggplot() +
141   geom_line(data = avgt_z, aes(x = Group.1, y = x), color = "red") +
142   geom_line(data = avgc_z, aes(x = Group.1, y = x), color = "blue") +
143   xlab('Months') +
144   ylab('price per kWh')
145
146 zoom

```

```

1 # only luminus contract; only brussel, 01/2017 - 07/2022
2 #fixed and variable contracts, first together and than separate
3
4
5 library(readxl)
6 library(dplyr)
7 Price_data_sorted <- read_excel("~/Desktop/Price_data_sorted.xlsx",
8                                sheet = "VATCUT2022",
9                                col_types = c("text",
10                                             "text", "text", "numeric", "date",
11                                             "text", "text", "text", "numeric",
12                                             "numeric", "text", "date", "numeric",
13                                             "numeric", "text", "text", "numeric",
14                                             "numeric", "text", "numeric", "numeric",
15                                             "numeric", "numeric", "numeric",
16                                             "numeric", "numeric", "numeric",
17                                             "numeric", "numeric", "numeric",
18                                             "numeric", "numeric", "numeric",
19                                             "text", "text", "text", "numeric",
20                                             "numeric", "numeric", "numeric",
21                                             "numeric", "numeric", "numeric",
22                                             "numeric", "numeric", "numeric",
23                                             "numeric", "numeric", "numeric",
24                                             "numeric", "numeric", "numeric",
25                                             "numeric", "numeric", "numeric",
26                                             "numeric", "numeric", "numeric",
27                                             "numeric", "numeric", "numeric",
28                                             "numeric", "numeric", "numeric",
29                                             "numeric"))
30
31

```

```

32
33
34 df <- data.frame(Price_data_sorted)
35
36 #selectt only period of interest for 2022 VATcut
37 df <- subset(df, as.Date(Month) > as.Date("2016-12-01") & as.Date(Month)
38             <= as.Date("2022-07-01"))
39
40 #take only consumption contracts
41 df_1 <- subset(df, type_contract == "Afname")
42
43
44 #try to check with only fixed/variable contracts
45 #df_1 <- subset(df_1, type_product == "Variabel")
46
47 #SELECT DATA
48 #take only variable contract for each month that was offered from 01-2013;
49 #otherwise is following different products
50 df_spl <- split(df_1, f = df_1$type_product)
51 df_s <- subset(df_spl$Variabel, as.Date(date_from) == as.Date("2013-01-01"))
52
53 df_1 <- rbind(df_s, df_spl$Vast)
54
55
56 # change dataset for the regression
57 df_split <- split(df_1, f= df_1$Professioneel.Particulier)
58
59 # add 1 to vat rate column
60 df_split <- within(df_split, Particulier$vat_rate <- Particulier$vat_rate+1)
61
62 #compute vat inclusive prices for household only
63 df_split <- within(df_split, Particulier$price.kWh...21 <-
64                   Particulier$price.kWh...21*Particulier$vat_rate)
65
66 #make vat rate for firm equal to 1
67 df_split <- within(df_split, Professioneel$vat_rate <- Professioneel$vat_rate/0.21)
68
69
70 #compute avarage price of firm and of household
71 avgt <- mean(df_split$Particulier$price.kWh...21)
72 avgc <- mean(df_split$Professioneel$price.kWh...21)
73 sde_t <- sd(df_split$Particulier$price.kWh...21)
74 sde_c <- sd(df_split$Professioneel$price.kWh...21)
75
76
77 df_adj <- rbind(df_split$Particulier, df_split$Professioneel)

```

```

78
79 #descriptive statistics
80
81 df_s <- split(df_adj, f=df_adj$type_product)
82 avgvar <- mean(df_s$Variabel$price.kWh...21)
83 avgfix <- mean(df_s$Vast$price.kWh...21)
84 sdevar <- sd(df_s$Variabel$price.kWh...21)
85 sdefix <- sd(df_s$Vast$price.kWh...21)
86
87 #tao regressors
88 df_reg <- within(df_adj, vat_rate <- log(vat_rate)) #regressor ln(1+tao)
89
90 # price for dependent variable ln(price)
91
92 df_reg <- within(df_adj, price.kWh...21 <- log(price.kWh...21))e
93
94 #Create dummy variables
95
96 # dummy for client type; household=1 and firm =0
97
98 df_reg <- within(df_reg, Professioneel.Particulier<-
99     ifelse(Professioneel.Particulier == "Particulier", 1, 0))
100
101 # Create dummy for the VAT cut
102
103
104 df_reg <- within(df_reg, Month <-
105     ifelse(as.Date(Month)>=as.Date("2022-03-01"), 1, 0))
106
107 #method 1 standard DiD
108 #multiply dummies to get coefficient
109 #df_reg <- within(df_reg, vat_rate <- Month*Professioneel.Particulier)
110
111
112 #method 2 use the transformed regressor to measure directlt PT: ln(1+tao)
113
114 # Regression Model
115
116 model <- lm(price.kWh...21~ Professioneel.Particulier + Month + vat_rate, df_reg)
117
118
119
120 #simple difference regression
121 modelsimple <- lm(price.kWh...21~ vat_rate, df_reg)
122
123

```

```

124
125 summary(model)
126 summary(model$summary)
127
128 #robustness check - compute robust standard errors
129 library(sandwich)
130 robust_se <- vcovHC(model, type = "HC3")
131
132 coefficients <- coef(model)
133 se <- sqrt(diag(robust_se))
134
135 # Combine coefficients and standard errors into a data frame
136 results <- data.frame(coef = coefficients, se = se)
137
138 # Print the results
139 print(results)
140
141 #plot prices to check for parallel trend
142 library(lubridate)
143 library(ggplot2)
144 library(scales)
145
146 library(colorspace)
147
148
149 df_t <- data.frame(df_split$Particulier$price.kWh...21,
150                   df_split$Particulier$Month)
151 df_c <- data.frame(df_split$Professioneel$price.kWh...21,
152                   df_split$Professioneel$Month)
153
154 tc <- data.frame(df_c, df_t)
155
156 p <- ggplot() +
157   geom_line(data = df_t, aes(x = df_split.Particulier.Month,
158                             y = df_split.Particulier.price.kWh...21),
159            color = "red") +
160   geom_line(data = df_c, aes(x = df_split.Professioneel.Month,
161                             y = df_split.Professioneel.price.kWh...21),
162            color = "blue") +
163   xlab('Months') +
164   ylab('price per kWh')
165
166 p
167
168
169 # create a plot the zoom on VAT cut

```

```

170 t_z <- subset(df_t, as.Date(df_split$Particulier$Month)>= as.Date("2022-01-01"))
171 c_z <- subset(df_c, as.Date(df_split$Professioneel$Month)>= as.Date("2022-01-01"))
172
173
174 zoom <- ggplot() +
175   geom_line(data = t_z, aes(x = df_split.Particulier.Month,
176     y = df_split.Particulier.price.kWh...21),
177     color = "red") +
178   geom_line(data = c_z, aes(x = df_split.Professioneel.Month,
179     y = df_split.Professioneel.price.kWh...21),
180     color = "blue") +
181   xlab('Months') +
182   ylab('price per kWh')
183
184 zoom
185
186 #avarages for plot fixed and variable
187 avg_t <- aggregate(df_split$Particulier$price.kWh...21,
188   list(df_split$Particulier$Month), FUN = mean)
189 avg_c <- aggregate(df_split$Professioneel$price.kWh...21,
190   list(df_split$Professioneel$Month), FUN = mean)
191
192
193 p1 <- ggplot() +
194   geom_line(data = avg_t, aes(x = Group.1, y = x , color = "household")) +
195   geom_line(data = avg_c, aes(x = Group.1, y = x, color = "firm")) +
196
197   scale_colour_manual(name="Line Color",
198     values=c(household = "red", firm="blue", vatcut= "black"))+
199   xlab('Months') +
200   ylab('Avarage price per kWh')
201
202 p1
203
204 # create a plot the zoom on VAT cut
205
206 avgt_z <- subset(avg_t, as.Date(Group.1)>= as.Date("2022-01-01"))
207 avgc_z <- subset(avg_c, as.Date(Group.1)>= as.Date("2022-01-01"))
208
209
210 zoom <- ggplot() +
211   geom_line(data = avgt_z, aes(x = Group.1, y = x), color = "red") +
212   geom_line(data = avgc_z, aes(x = Group.1, y = x), color = "blue") +
213   xlab('Months') +
214   ylab('price per kWh')
215

```

