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Analyzing Inflationary Effects of Price Adjustments in Energy Markets Using Input-Output Model: The Case of Turkey

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1 Introduction

- This paper is about measuring the inflationary effects on domestic IO sectors of external price adjustments of imported energy items.
- In 2014 of total energy consumption in Turkey 90.5% is supplied from primary energy sources. The remaining 9.5% comes from renewable energy sources, mainly hydroelectric power plants.
- Primary energy sources are (in %):
  - natural gas 35.0
  - coal 28.5
  - oil 27.0
- On the other hand, 99% of natural gas, 89% of oil, and 60.4% of coal are met by imports.
- Natural gas comes mainly from Russia, Iran, Azerbaijan, Algeria, and Nigeria.
- Petrol is imported mainly from Iraq, Iran, and Russia.

- The prices of these two imported energy items are determined in oligopoly or cartel markets by suppliers.
- Thus, Turkey has limited bargaining power in determining prices of these energy items.
- Using a standard IO price model, this paper analysis the inflationary effects of price increases in imported energy items on domestic production sectors.
- Two main sources of data are: (i) 56-sector 2014 IO table compiled by WIOD; and (ii) 64-sector 2012 IO table compiled by the TurkStat.
- With both data framework two scenarios are designed.
- In each scenario import data are classified into three categories: natural gas and crude petroleum imports, refined petroleum imports, other imports.
- First scenario is named high inflation scenario in which original price increases in these three import items are assumed to vary between 15% and 25%. Additionally, the prices in the domestic transportation sector is allowed to increase by 25% automatically.

- Second scenario is named low inflation scenario in which the prices of the three import item are assumed to increase between 15% and 25%, but there will be no initial price changes in any domestic production sector.
- Results: the first scenario produced a GDP deflator of 1.074, meaning a 7.4% inflation rate.
- The second scenario produced a GDP deflator of 1.043, meaning a 4.3% overall inflation rate.
- The abovementioned scenarios are tried using the first data framework (WIOD 2014 table).
- The results with the second data source (TurkStat 2012 IO Table) is still under development.
- However, it is expected that the 2012 table would to produce similar numerical results.

2 Data Sources

- WIOD data come in two matrices: (i) Domestic input matrix, and (ii) Imported input matrix.
- For the purpose of this research import data are aggregated into three lines:
  - i. Imports of crude petroleum and natural gas
  - ii. Imports of refined petroleum products
  - iii. All other imports
- These three lines are appended into value added block of the domestic IO table.
- All values are expressed in Us dollars.
- A truncated version of the resulting IO table is shown in Table 1 below.

Table 1. IO Table of Turkey (2014, Millions of USD)

		1	5	6	10	1	2	3	q
		Agricul	Food-beve-tob	Textile	Coke-ref petr	Hh&Go consum	Gross investm	Export	Total output
1	Agricul	9,674	28,497	2,294	33	27,481	548	14,660	87,422
5	Food-bev-to	2,263	12,978	1,177	13	47,589	1,385	25,383	99,319
6	Textile	146	561	45,182	33	22,691	2,986	51,646	129,977
10	Coke-ref petr	675	200	609	949	2,792	-467	7,095	20,068
31	Land transpo	1,503	5,460	4,850	1,684	47,886	6,928	11,981	129,815
44	Real estate	2	151	360	15	74,093	18	1	93,378
51	Public serv	10	13	20	1	56,545	2	295	57,402
52	Education	0	28	24	3	35,700	71	65	37,480
53	Health serv	111	25	49	6	22,229	52	29	24,040
56	Extra terr act	0	0	0	0	0	0	0	0
	Dom inp tot	22,139	64,333	76,208	11,923	504,723	116,523	287,880	1,494,428
1	Cru p NG im	21	44	52	1,471	61	43	0	4,119
2	Ref pet imp	1,363	419	1,485	1,871	4,982	47	0	25,446
3	Other imp	6,022	11,433	16,743	1,024	33,258	43,198	0	222,612
4	Ind taxes	3,468	710	1,313	1,261	70,476	1,575	0	99,670
5	Value added	54,409	22,379	34,176	2,518	0	0	0	710,919
	Payments sector	65,283	34,985	53,769	8,145	108,777	44,863	0	1,062,765
q	Total Production, q	87,422	99,319	129,977	20,068	613,500	161,386	287,880	

3 IO Production model

- Standard IO production model is given by

$$q = Aq + f \qquad (1)$$

where

q = Output column vector

A = Matrix of input coefficients

f = Final demand column vector

- Solution to Equation 1 is

$$q = (I - A)^{-1}\mathrm{f} = \mathrm{Lf} \qquad (2)$$

$\mathrm{L} = (I - A)^{-1}$ is called the Leontief inverse.

A Matrix (Partial)

	Agricul	Food-beve-tob	Textile	Coke- ref petr
Agricul	0.111	0.287	0.018	0.002
Food-bev-to	0.026	0.131	0.009	0.001
Textile	0.002	0.006	0.348	0.002
Coke-ref petr	0.008	0.002	0.005	0.047
Land transpo	0.017	0.055	0.037	0.084
Real estate	0.000	0.002	0.003	0.001
Public serv	0.000	0.000	0.000	0.000
Education	0.000	0.000	0.000	0.000
Health serv	0.001	0.000	0.000	0.000
Extra terr act	0.000	0.000	0.000	0.000

- To understand IO production model further three new coefficient matrices should be defined.
- These are given in the following table

Table 2. Direct input coefficients

A	B
C	D

where

A = Input-output coefficient matrix (as in Eq 1).

B = Final demand coefficient matrix, obtained by dividing column elements into respective column totals.

C = Primary input coefficient matrix

D = Coefficient matrix defined for primary inputs into final demand categories.

- Table 2 shows a part of final demand coefficient matrix B.

Table 3. Final demand coefficient matrix B

		1	2	3	4	5
		Household consump	Govern consump	Gross fixed cap form	Changes in stocks	Export
1	Agriculture	0.055	0.003	0.000	0.878	0.051
2	Forestry	0.001	0.000	0.000	0.037	0.000
3	Fishery	0.001	0.000	0.000	0.006	0.002
4	Mining	0.002	0.001	0.000	0.307	0.016
5	Food bev. tobacco	0.092	0.015	0.001	2.210	0.088
6	Textile	0.043	0.013	0.010	2.436	0.179
7	Wood prod	0.001	0.000	0.000	0.140	0.006
8	Paper prod	0.003	0.000	0.000	-0.668	0.010
9	Pres - publication	0.004	0.000	0.001	-0.366	0.002
10	Coke-ref pet prod	0.005	0.001	0.002	-1.390	0.025
27	Construction	0.001	0.000	0.478	0.000	0.006

C Matrix (Partial)

		1	5	6	10
		Agricul	Food-beve-tob	Textile	Coke- ref petr
1	Crude pet NG imp	0.253	0.648	0.586	0.594
2	Ref pet imports	0.000	0.000	0.000	0.073
3	Other imports	0.016	0.004	0.011	0.093
4	Indirect taxes	0.069	0.115	0.129	0.051
5	Value added	0.040	0.007	0.010	0.063

D Matrix

		Final consumption expend by hholds	Final consumption expend by government	Gross fixed capital formation	Changes in inventories and valuables	Exports
		1	3	4	5	6
1	Crude Petroleum and Nat gas ımports	0.000	0.000	0.000	0.002	0.000
2	Refıned petroleum and other gas ımports	0.010	0.002	0.000	0.001	0.000
3	Other ımports	0.063	0.016	0.267	0.506	0.000
4	Net ındırect taxes	0.141	0.005	0.010	0.000	0.000
5	Value added	0.000	0.000	0.000	0.000	0.000

Cumulative input-output coefficients

- Let y denote the column vector of total incomes of primary inputs:

$$y = Cq + h \qquad (3)$$

h is a vector of direct final uses of production factors.

- Inserting q from Eq (2) into the first component of y in Eq. 3:

$$Cq = CLf \qquad (4)$$

- Let g denote the column sum of total expenditures of all final demand categories.
- The row sum of final demand block in IO table gives column vector f.

$$f = Bg \qquad (5)$$

- Then, the direct final use of primary inputs:

$$h = Dg \qquad (6)$$

- From the last three equations primary income total:

$$y = CLBg + Dg = (CLB + D)g \quad (7)$$

or

$$y = [C(I - A)^{-1}B + D]g \quad (8)$$

- Now a new matrix can be defined.

$(I - A)^{-1}$	$(I - A)^{-1}$B
$C(I - A)^{-1}$	C$(I - A)^{-1}B + D$

- This new matrix is known as a tableau of cumulative IO coefficients.

Linv = $(I - A)^{-1}$

			Crop and animal prod	Forestry and logging	Fishing and aquaculture	Mining and quarrying	Manuf of food , bev and tobacco	Manuf of textiles, wearing apparel	Manuf of wood except furniture	Activities of extraterritorial org
			1	2	3	4	5	6	7	56
CCrop and animal prod		1	1.136	0.002	0.015	0.004	0.377	0.038	0.006	0.000
Forestry and logging		2	0.000	1.007	0.000	0.003	0.001	0.000	0.104	0.000
Fishing and aquaculture		3	0.000	0.000	1.011	0.000	0.001	0.000	0.000	0.000
Mining and quarrying		4	0.005	0.005	0.005	1.023	0.008	0.010	0.016	0.000
Manuf of food , bev and tobacco		5	0.035	0.002	0.035	0.007	1.164	0.019	0.006	0.000
Manuf of textiles, wearing apparel		6	0.005	0.003	0.007	0.013	0.014	1.537	0.025	0.000
Manufact of wood except furniture		7	0.001	0.000	0.000	0.001	0.001	0.001	1.110	0.000
Activities of extraterritorial org		56	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000

$(I - A)^{-1}\mathrm{B}$

		Final consump expend by households	Final consump expend by govern	Gross fixed capital formation	Changes in inventories	Exports
		1	3	4	5	6
Crop and animal prod	1	0.109	0.019	0.003	1.895	0.103
Forestry and logging	2	0.002	0.001	0.001	0.031	0.002
Fishing and aquaculture	3	0.002	0.000	0.000	0.009	0.002
Mining and quarrying	4	0.012	0.010	0.013	-0.191	0.038
Manuf of food beve tobacco	5	0.123	0.028	0.005	2.618	0.114
Manuf of textiles	6	0.073	0.033	0.024	3.659	0.293
Manuf of wood and wood prod	7	0.002	0.001	0.007	0.142	0.011
Manuf of paper paper products	8	0.008	0.008	0.005	-0.813	0.019

$$C(I-A)^{-1}$$

		Crop and animal prod	Forestry and logging	Fishing and aquaculture	Mining and quarrying	Manuf of food , bev and tobacco	Manuf of textiles, wearing apparel	Manuf of wood except furniture	Activities of extraterritorial org
		1	2	3	4	5	6	7	56
Crude Petrol and Nat gas imports	1	0.002	0.001	0.001	0.006	0.002	0.003	0.005	0.000
Refıned petroleum imports	2	0.022	0.015	0.026	0.038	0.019	0.027	0.022	0.000
Other ımports	3	0.096	0.018	0.053	0.092	0.191	0.235	0.277	0.000
Net indirect taxes	4	0.050	0.018	0.032	0.045	0.035	0.029	0.023	0.000
Value added	5	0.830	0.948	0.887	0.820	0.753	0.707	0.673	1.000
Total		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

$$\mathrm{C}(I - A)^{-1}B + D$$

		Final consump expend by households	Final consump expend by govern	Gross fixed capital formation	Changes in inventories	Exports
		1	3	4	5	6
Crude Petrol and Nat gas imports	1	0.003	0.002	0.004	-0.129	0.006
Refined petroleum imports	2	0.027	0.016	0.021	-0.101	0.025
Other imports	3	0.146	0.103	0.398	-0.236	0.258
Net indirect taxes	4	0.166	0.025	0.035	0.012	0.031
Value added	5	0.659	0.854	0.543	1.455	0.679
Total		1.000	1.000	1.000	1.000	1.000

4 IO Price Model

4.1 Basic IO price model

- Basic IO price model is given in Equation 9 below.

$$p = pA + rC + p^* \qquad (9)$$

where

p = Unit sectoral price index vector in row form (initial or new)

A = Domestic inputs coefficient matrix

C = Primary inputs (including imports) coefficient matrix

r = Price index row vector for primary inputs

p* = Excess (arbitrary) price increases in some sectors, if any, (in percentage)

- The solution to Equation 9 is given by

$$p = rC(I - A)^{-1} + p^*(I - A)^{-1} \qquad (10)$$

4.2 Calculation of Deflators

- Deflator, d, is defined as the price index numbers for all final demand categories.
- Assuming fixed coefficients for all elements of B and D, as for A and C, d is given by

$$d = pB + rD \qquad (12)$$

where
d = Deflator, a row vector
B and D are defined above
p will come form Eq. 11

- Putting p from Eq. 11 into Eq. 12:

$$d = r[C(I - A)^{-1}B + D] + p^{*}(I - A)^{-1}B \qquad (13)$$

5 Application

5.1 Price formation in energy markets

Table 4 shows price composition and changes in Fuel markets in Istanbul

Table 4. Unleaded fuel price formation in Istanbul (TL per liter)

	January 2016		November 2016		January 2017		Inc (y/y) (%)
Product price	0.94	22.1	1.18	24.4	1.60	30.1	70.2
Wholesale margin	0.05	1.2	0.06	1.2	0.06	1.1	20.0
Income contribute	0.00	0.1	0.00	0.1	0.00	0.1	4.1
Distributor margin	0.44	10.3	0.47	9.7	0.47	8.8	6.8
Total tax	2.83	66.4	3.12	64.6	3.19	59.9	12.7
Sale price	4.26	100.0	4.83	100.0	5.32	100.0	24.9
Price increase (%)	10-month: 13.4		2-month: 10.1		12-month: 24.9		

- Turkish consumers pay relatively high energy price.
  Table 5 shows the least affordable 10 countries for oil consumption

Table 5. Least affordable 10 countries for oil consumption

		Price per gallon $	Average daily wage $	Wage paid for a gallon of petrol (%)
1	India	3.75	4.77	78.62
2	Pakistan	2.32	3.97	58.44
3	Philippines	3.17	8.14	38.94
4	Egypt	2.66	10.25	25.95
5	South Africa	3.19	13.03	24.48
6	Nigeria	1.94	8.00	24.25
7	Indonesia	2.23	9.89	22.55
8	Turkey	5.77	26.13	22.08
9	Bulgaria	4.05	18.93	21.39
10	Thailand	3.44	16.23	21.20

5.2 Inflationary Scenarios

- To measure the effects of supply side price increases in energy markets on domestic production sectors two scenarios are designed.
- Scenario A: High inflation scenario, and Scenario B: Low inflation scenario.

Scenario A: High Inflation

- Initial price increases in three import categories are given in Table 6.
- Table 5 also shows that there is an arbitrary price increase of 25% in the domestic land transportation sector.

Table 6. Initial price increases in three import items

	Primary inputs	Initial price increase %
1	Crude oil and natural gas	25.0
2	Refined petroleum products	15.0
3	Other imports	20.0
4	Indirect taxes	0.0
5	Value added	0.0
31	Land transport service	25.0

- Resulting top ten highest inflation rates in domestic sectors are shown in Table 7.

	Table 7. Top ten inflation rates in Scenario A , %		
1	31	Land transportation	30.5
2	17	Computer, electronics, optical instr	11.4
3	15	Basic metal production	11.2
4	20	Motor vehicles production	11.2
5	22	Furniture production	10.6
6	16	Fabricated metal products	10.3
7	13	Rubber and plastics	10.1
8	18	Electrical equipment	9.9
9	11	Chemical products	9.4
10	10	Coke and refined petroleum pro	9.0

Deflators in Scenario A

- Deflators resulting in Scenario A are given in Table 8.

Table 8. Deflators resulting in Scenario A		
Final demand items	Deflator	Inflation rate %
Private consumption: C	1.071	7.1
Government consumption: G	1.035	3.5
Gross fixed capital formation: I	1.107	10.7
Changes in stocks: S	1.004	0.4
Export products: X	1.088	8.8
GDP deflator: d	1.074	7.4

Scenario B: Low Inflation

- Scenario B is the same as high inflation scenario except there is no additional arbitrary price increase in any sector.
- Table 9 shows initial price increases in imported energy items

	Table 9. Initial price increase in imported energy items	
	Primary inputs	Initial price increase %
1	Crude oil and natural gas	25.0
2	Refined petroleum products	15.0
3	Other imports	20.0
4	Indirect taxes	0.0
5	Value added	0.0

- In Scenario B, top ten highest inflation rate sectors are shown in Table 10 .

Table 10. Top ten highest inflation rates in Scenario B, %

1	**17**	Computer, electronics, optical inst	**9.4**
2	15	Basic metal production	9.1
3	20	Motor vehicles production	9.0
4	16	Fabricated metal products	8.5
5	13	Rubber and plastics	8.3
6	22	Furniture production	8.2
7	18	Electrical equipment	7.7
8	11	Chemical products	7.3
9	19	Machinery and equipment (n.e.c.)	7.2
10	7	Wood products, excluding furniture	6.0

- Deflators resulting in Scenario B are given in Table 11.

Table 11. Deflators resulting in Scenario B

	Deflator	Inflation rate %
Private consumption: C	1.034	3.4
Government consumption: G	1.024	2.4
Gross fixed capital formation: I	1.084	8.4
Changes in stocks: S	0.905	-9.5
Export products: X	1.057	5.7
GDP deflator: d	1.043	4.3

6. Conclusions

- Traditional price index methods cannot answer the question: what happens to consumer price index if the price of imported oil increases by, say, 10%?
- In this regard, standard IO price model is a powerful tool with strong theoretical base.
- Decision makers in regulatory government agencies in energy markets should test the effects of their pricing policy using IO price model.
- The Turkish economy is heavily dependent on imports for all types of energy items – crude oil, refined oil, natural gas and its variants.
- Current form of international energy market structures makes Turkey a price taker. That is Turkey has a limited bargaining power in energy markets.
- Therefore, Turkey should increase investment in domestic renewable and clean energy sources.
- In the process of domestic price formation, after an increase in the price of imported energy items, additional arbitrary price increases in domestically produced goods and services should be avoided.

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Thank
You !