Modeling the Demand of Oil Emerging from Petrochemical Feedstocks Worldwide

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Outline

1. INTRODUCTION
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INTRODUCTION

Motivation:

- Construction of a long-term oil demand model to enable policymakers to understand the potential opportunities related to the demand for various oil products from different regions.

- There are challenges in forecasting oil demand from different sectors. This challenge arises from each sector's unique characteristics.

- These unique characteristics require some insights into each sector to accurately forecast their respective oil demand.

INTRODUCTION

Motivation:

• Therefore the Long-Term KOMO Projects were initiated.

• The aim is to forecast the global demand of oil measured in mb/d through the demand of its products that is emerging from the following sectors:

i. Aviation sector.
ii. Maritime sector.
iii. Land transport sector.
iv. Power sector.
v. Residential/commercial & Agriculture sector.
vi. Petrochemical sector.

INTRODUCTION

Motivation:

•Petrochemicals are rapidly becoming the **largest driver** of global **oil** consumption.

• **Fast expansion of the petrochemicals sector** in the recent years. (ethane, in North America, the Middle East and Europe, naphtha demand in the Asian region, Russia and Europe).

•The chemical/**petrochemicals** sector is **a large source of oil demand**, **accounting for 14%** of primary demand of oil.

•The demand for oil in the industrial sector as feedstock for **petrochemicals is** gaining **more importance** as more **alternative technology** penetrates the combustion engine sector. **Faster penetration of electric vehicles** (less demand for road related products).

•The analysis of feedstock for petrochemicals is crucial for oil-based economies.

• **Oil-based economies** need to have a tool that enables them **to foresee changes in oil demand** by different **petrochemical feedstocks** to realize any **opportunities** and mitigate against potential **challenges**.

DATA AND METHODOLOGY

Model of demand functions for 8 regions and 4 feedstocks as function of prices and GDP and other exogenous variables, with annual data in the period 1970-2020.

AR model with lag = 1:

$$ln(X_{ij}) = a_0 + a_{ij}\, ln\,(p_{ij}) + b_i\, Y_i + \Sigma_k\, c_{i,k}\, Z_{i,k} + d\, ln(X_{ij,t-1}) + e_{ij} \qquad (1)$$

where:

j = Naphta, Ethane, Lpg, Other oil products

i = World, OECD Americas, OECD Asia Oceania, OECD Europe, Africa and Middle East, Non-OECD Americas, Eurasia, Non-OECD Asia (excluding China), China (P.R. of China and Hong Kong, China)

X = quantity demand

p = the price of a petrochemical feedstock, however if i=World, then price here is the price of brent

Y= GDP

Z = other exogenous variables: population, gdp per capita, percentage of urban population

The main drivers for each sector's demand for oil are representing changes and developments in economic growth, economic structure, population, price of oil.

DATA AND METHODOLOGY

Data sources:

GDP, population, GDP per capita, percentage of urban population

From World Bank Databank of World Development Indicators

Naphta, Ethane, Lpg, Other oil products, price of oil

From IEA world data bank

DATA AND METHODOLOGY

Descriptive statistics

Variable	Mean	Std Dev	Minimum	Maximum
NAPHTA	2.88988	1.19052	1.34168	4.85749
ETHANE	0.61773	0.5378	0.003718	1.77349
LPG	0.95101	0.32713	0.48079	1.55962
OTHOIL	4.82007	2.10365	1.94843	8.5772
GDPREAL	44724.93	19274.93	18683.9	84404.66
POPUL	5.69194	1.17581	3.76046	7.67328
URBANSHARE	58.34914	6.55066	46.98846	69.02583
BRENT	38.14662	29.377	12.71566	111.6697

DATA AND METHODOLOGY

Descriptive statistics

The units of the variables are:

Naphtha, Ethane, LPG, Other oil – million bbl/d

Gdpre1 – World GDP in real terms, 2015 base, billion of USD
Popul1 - World population, total billion
Urban1 – Share of urban population, percente
Brent – price of Brent USD/bbl

EMPIRICAL RESULTS

- We report **results for the WORLD** estimation.
- We obtain **good** and **robust econometric** results.
- We **run in sample forecast checking** whether our dynamic simulation is consistent with historical data.
- We **use the root mean squared error** or as check.
- We report **the summary diagnostic** of the estimation results **in Table 2**.
- We report the preliminary **estimated coefficients in Table 3**.
- **The in sample dynamic simulations** from the period 1980-2020 are shown **in Figure 5**.

DATA AND METHODOLOGY

- Preliminary set of the summary diagnostic of the estimation results in Table 2.
- The **coefficients** are **significant** and the estimation results are satisfactory.
- **R-squares** are **good** and the **F-tes**t of the regression are **all significant**.
- There is:
  - no sign of autocorrelation (**DW** test is close to 2),
  - no sign of heteroskedasticity (**LM** Het test is not significant),
  - no sign of misspecification (**RESET** test is not significant),
  - normality is accepted (**Jarque-Bera test** not significant, except Ethane),
  - the Root mean square percentage error is small.

- The in **sample dynamic simulations** from the period 1980-2020 are shown in **Figure 5**.

EMPIRICAL RESULTS

Table 2 Estimation diagnostics WORLD

Products	R sq	F test	DW	Reset2	LM Het	Jarque bera	RMSPE
NAPTHA	0.98	543**	1.9	0.03	2.6	0.14	0.05
ETHANE	0.98	514**	1.4	0.03	0.14	101*	0.05
LPG	0.95	117**	1.9	0.02	0.06	0.27	0.09
OTHER OIL PROD.	0.99	666**	2.2	0.01	0.16	0.21	0.01

EMPIRICAL RESULTS

Preliminary estimated coefficients in Table 3.

•In detail **we have estimated** the equations **in log-log** form for **NAPTHA LPG** and **OTHEROIL** products

•We have estimated the **ETHANE equation** in **natural levels**, including a **time dummy** for the break in the series in 1989, in order **to obtain the best results.**

•Notice that almost all the coefficients are significant, and the lagged dependent variable coefficient is around 0.6 – 0.8, showing that there is some autoregression in the equation.

•Notice also that the **real GDP** as **a positive driving coefficient**, while the **oil** price has **a negative** driving coefficient.

•The significance of the coefficients is: *** = 1%; ** = 5%

EMPIRICAL RESULTS

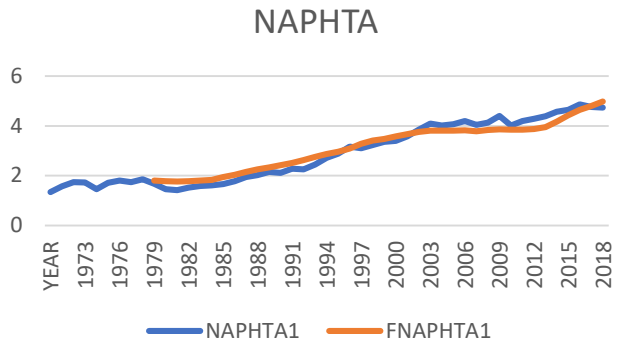
Table 3 Estimation results of the equation WORLD

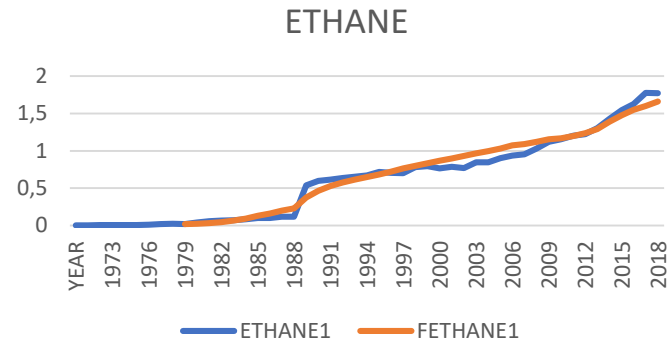
log(NAPHTA)	**Coefficient**	**t-statistic**	**P-value**
C	-1.75**	-2.41	[.020]
log(NAPHTA1t-1)	0.851***	11.15	[.000]
log(GDPRE1)	0.197**	2.46	[.018]
log(BRENT)	-0.0517**	-2.59	[.013]
ETHANE	**Coefficient**	**t-statistic**	**P-value**
C	-0.124**	-0.056	[.029]
ETHANE1t-1	0.584**	8.59	[.000]
GDPRE1	0.0000108***	2.13	[.039]
DUMETHANE1	-0.0117***	-3.66	[.001]
BRENT	-0.00088**	2.86	[.009]
log(LPG)	**Coefficient**	**t-statistic**	**P-value**
C	-3.11***	-2.75	[.009]
log(LPGNE1t-1)	0.654***	5.67	[.000]
log(GDPRE1)	0.302***	2.74	[.009]
log(BRENTt-1)	-0.0349*	-2.11	[.004]
log(OTHOIL)	**Coefficient**	**t-statistic**	**P-value**
C	-2.37***	-2.9	[.006]
log(LOTHOI1t-1)	0.787***	9.77	[.000]
log(GDPRE1)	0.270***	2.94	[.005]
log(BRENT)	-0.048***	-2.82	[.007]

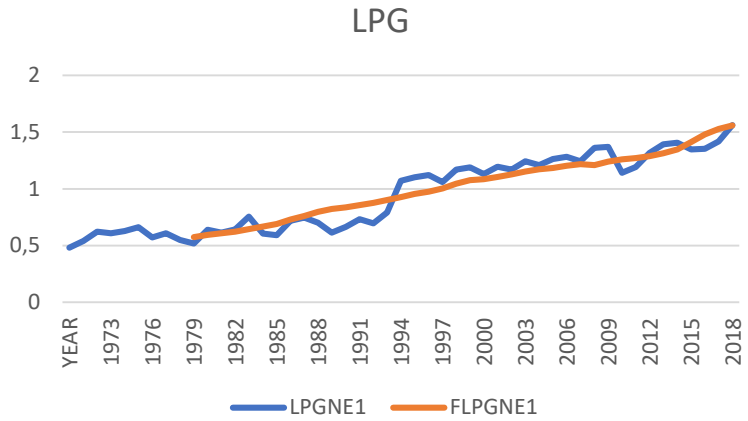
EMPIRICAL RESULTS

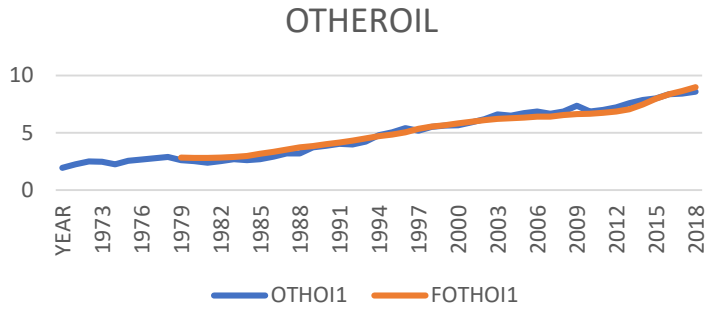
The in sample dynamic simulations from the period 1980-2020 are shown in Figure 5.

Figure 5 NAPTHA, ETHANE, LPG, Other petrochemical feedstocks Models simulation in sample 1980-2020 = World total (blue= history ; orange= simulated)









FURTHER EXAMINATION BY REGIONS

•This is the first econometric attempt of KAPSRC to model the petrochemical feedstock demand in a long term perspective for a detailed number of regions of the world separately for the main feedstocks.

•Our model is a useful tool to help policymakers to assess the trajectory and the trends of the long term industrial and technological developments in the field of Petrochemicals

•We will expand the model to the regions

- OECD America
- OECD Asia Oceania
- OECD Europe
- Middle East & Africa
- Latin America
- Eurasia
- Non-OECD Asia (excluding China)
- China

FURTHER EXAMINATION BY REGIONS

Table 1 ETHANE estimation

Estimation of the demand for Ethane							
Region	**OECD America**	**OECD Asia Oceania**	**OECD Europe**	**Middle East & Africa**	**Latin America**	**Eurasia**	**Asia**
Dep var.	$\ln(ET_1)$	$\ln(ET_2)$	$\ln(ET_3)$	$\ln(ET_4)$	$\ln(ET_5)$	$\ln(ET_6)$	$\ln(ET_7)$
Regressors							
C	-26.78**	-13.95**	-11.41**	-8.25**	-25.5**	8.12**	-12.1**
$\ln(ET_j)_{t-1}$	0.57**	0.77**	0.66**	0.89**	0.30**		0.41**
$\ln(P_j)$	-0.16**	-0.29**	-0.11**	-0.09**	-0.15**	-0.32**	
$\ln(GDPRE_j)$	0.90**	0.50**	0.35**		0.82**	0.46**	
$\ln(GDPPC_j)$				1.09**			
$\ln(pop_j)$							
$\ln(Urban_j)$							2.84*
$Dln(pop_j)$			62.55**				
$\ln(pop)_{t-1}$							
$\ln(p_j/p_w)$							-.52*
R-square	.84	.90	.85	.99	.85	.54	.92
S.E.	.21	.10	.07	.10	.23	.19	.27
F-test	49.9**	52.4**	22.0**	2132.2**	38.6**	12.8**	69.5**
Breusch-G.	.55	.06	.22	0.08	0.05	2.88	3.1
Jarque-Bera	14.7	.60	1.13	.143	0.11	1.43	2.47
LM-het.	1.4	.02	3.1	0.42	0.59	2.88	5.69
RESET	2.43	2.8	.001	7.1	4.5	1.19	.020114

Legend:
** significant at 1%; * significant at 5%

Dependent variable: ET_j is the demand of ethane for region j=(1,2, ..8)

$\ln(ET_j)_{t-1}$ is the log of the lagged dependent variable for region j=(1,2, ..8)

P_j is the price for region j

$GDPRE_j$ is the GDP real for region j

$GDPPC_j$ is the GDP real per capita for region j

$Urban_j$ is the percentage of population living in urban areas for region j

Pop_j is the population for region j

$\ln(pop_j)$ is the log of population for region j

$Dln(pop_j)$ is the growth rate of population for region j

FURTHER EXAMINATION BY REGIONS

Table 2 NAPHTA estimation

Estimation of the demand for Naphtha								
Region	**OECD America**	**OECD Asia Oceania**	**OECD Europe**	**Middle East & Africa**	**Latin America**	**Eurasia**	**Asia**	**China**
Dep var.	$\ln(NT_1)$	$\ln(NT_2)$	$\ln(NT_3)$	$\ln(NT_4)$	$\ln(NT_5)$	$\ln(NT_6)$	$\ln(NT_7)$	$\ln(NT_8)$
Regressors								
C	-3.41*	-11.77**	0.31**	-11.98*	-13.88**	-92.1**	3.15**	-8.82**
$Ln(NT_j)_{t-1}$	0.82**	0.80**	0.68**	0.83**	0.68**	0.50**	.96**	0.49**
$Ln(P_j)$	-0.09**	-0.09**	-0.04*	-0.18**	-0.11**	-0.18**	-.063**	-0.10*
$Ln(GDPRE_j)$	0.12*	0.42**	0.57**	0.69**	0.72**	4.70**	00.106**	0.31**
$Ln(GDPPC_j)$				-0.90**	-0.79**	-4.73**		
$Dln(GDPPC_j)$	-1.90*	-.159*	0.67					
$Urban_j$								
$Ln(Urban_j)$			-4.08**					
$Ln(pop)_{t-1}$								
R-square	.61	.98	.88	.95	.98	.89	.996486	.994
S.E.	0.09	.07	.06	.20	.09	.18	.071979	.08
F-test	13.3**	676.7**	49.2**	147.4**	447.6**	48.1**	1937.63**	1202.9**
Breusch-G.	3.33	1.17	.09	.52	.67	2.30	1.88	0.44
Jarque-Bera	0.13	3.03	3.60	3.47	1.63	1.91	0.52	0.66
LM-het.	0.12	5.6*	0.02	1.26	4.49*	0.77	0.12	0.91
RESET	0.09	0.17	0.10	3.01	0.79	0.75	0.50	3.0

Legend:
** significant at 1%; * significant at 5%

Dependent variable: NT_j is the demand of ethane for region j=(1,2, ..8)

$\ln(NT_j)_{t-1}$ is the log of the lagged dependent variable for region j=(1,2, ..8)

P_j is the price for region j

$GDPRE_j$ is the GDP real for region j

$GDPPC_j$ is the GDP real per capita for region j

$Urban_j$ is the percentage of population living in urban areas for region j

Pop_j is the population for region j

$\ln(pop_j)$ is the log of population for region j

$Dln(pop_j)$ is the growth rate of population for region j

FURTHER EXAMINATION BY REGIONS

Table 3 LPG estimation

Estimation of the demand for LPG								
Region	**OECD America**	**OECD Asia Oceania**	**OECD Europe**	**Middle East & Africa**	**Latin America**	**Eurasia**	**Asia**	**China**
Dep var.	$\ln(LT_1)$	$\ln(LT_2)$	$\ln(LT_3)$	$\ln(LT_4)$	$\ln(LT_5)$	$\ln(LT_6)$	$\ln(LT_7)$	$\ln(LT_8)$
Regressors								
C	-10.77**	-5.54**	-15.74**	-32.33**	-23.7**	-21.37**	-11.4**	-26.8**
$\ln(LT_j)_{t-1}$	0.62**	0.82**	0.79**	0.21**	0.65**	0.59**	0.91**	0.54**
$\ln(P_j)$	-0.12**	-0.38**	-0.11*	-0.26**	-0.29**	-0.48**	-0.57**	-0.56**
$\ln(GDPRE_j)$	0.36**	0.18**	0.51**	1.05**	0.82*	0.74**	0.50**	0.98**
R-square	0.986	0.95	0.97	0.99	0.89	0.94	0.99	0.98
S.E.	0.10	.10	.11	.18	.20	0.22	.20	0.2
F-test	34.5**	189.2**	253.6**	1992.4**	55.2**	44.15**	811.0**	228.9**
Breusch-G.	0.76	0.03	2.07	.43	6.3*	0.81	1.45	0.09
Jarque-Bera	.67	.77	2.87	1.59	7.10*	3.11	1.42	0.26
LM-het.	1.38	1.48	2.84	1.24	6.9*	3.64	1.08	1.42
RESET	.28	0.01	0..01	2.04	.01	1.96	3.32	0.08

Legend:
** significant at 1%; * significant at 5%

Dependent variable: LT_j is the demand of ethane for region j=(1,2, ..8)

$\ln(LT_j)_{t-1}$ is the log of the lagged dependent variable for region j=(1,2, ..8)

P_j is the price for region j

$GDPRE_j$ is the GDP real for region j

Ln(time) is a log time trend

FURTHER EXAMINATION BY REGIONS

Table 4 OTHER OIL estimation

Estimation of the demand for OTHER OIL							
Region	**OECD America**	**OECD Asia Oceania**	**OECD Europe**	**Middle East & Africa**	**Latin America**	**Eurasia**	**Asia**
Dep var.	$\ln(OT_1)$	$\ln(OT_2)$	$\ln(OT_3)$	$\ln(OT_4)$	$\ln(OT_5)$	$\ln(OT_6)$	ln(OT7)
Regressors							
C	11.7**	-22.42	-27.19**	-15.99**	-9.50*	-25.37**	-1.57**
$Ln(OT_j)_{t-1}$	0.77**	0.75	0.21*	.66**	0.87**	0.46**	0.78**
$Ln(P_j)$	-0.20**	-0.09	-0.10*	-.12**	-0.10*	-0.67**	-0.11**
$Ln(GDPRE_j)$		0.75	0.85**	.52**	0.33*	0.94**	
$Ln(pop_j)$							
$Dln(GDPRE_j)$	-0.23**						
$urban_j$							.04**
R-square	.97	.97	.87	.96	.96	.83	.99
S.E.	0.20	.17	.13	.17	.122	.36	.12
F-test	146.1**	375.7**	55.5**	165.0**	222.5**	29.7**	588.2**
Breusch-G.	1.20	7.26*	1.88	.07	.39	.36	2.59
Jarque-Bera	.92	.44	1.55	.56	.49	3.2	1.71
LM-het.	.02	.67	1.26	2.13	2.67	1.76	4.2
RESET	2.26	1.35	2.29	0.02	.86	.26	.62

Legend:
** significant at 1%; * significant at 5%

Dependent variable: OT_j is the demand of ethane for region j=(1,2, ..8)

$\ln(OT_j)_{t-1}$ is the log of the lagged dependent variable for region j=(1,2, ..8)

P_j is the price for region j

$GDPRE_j$ is the GDP real for region j

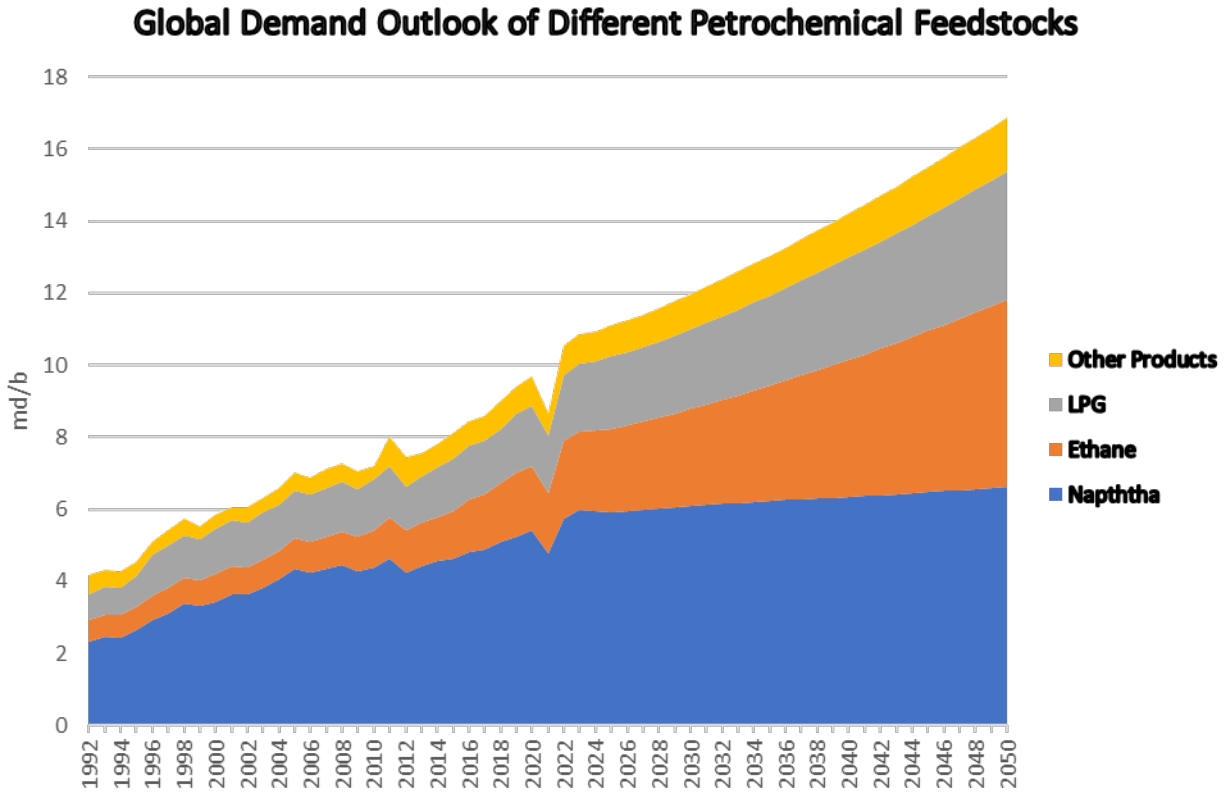
Ln(time) is a log time trend

FURTHER EXAMINATION BY REGIONS

- There is a projected **growth of 4.27** mb/d from 2021 to 2045, of which:**2.17 mb/d** of **Ethane**; **0.99 mb/d** of **LPG**; **0.54 mb/d** projected incline of **Naphtha**.

- In 2021 the **petrochemical feedstocks total demand** was estimated at **11.38 mb/d** and expected to reach **15.49 mb/d** by 2045.

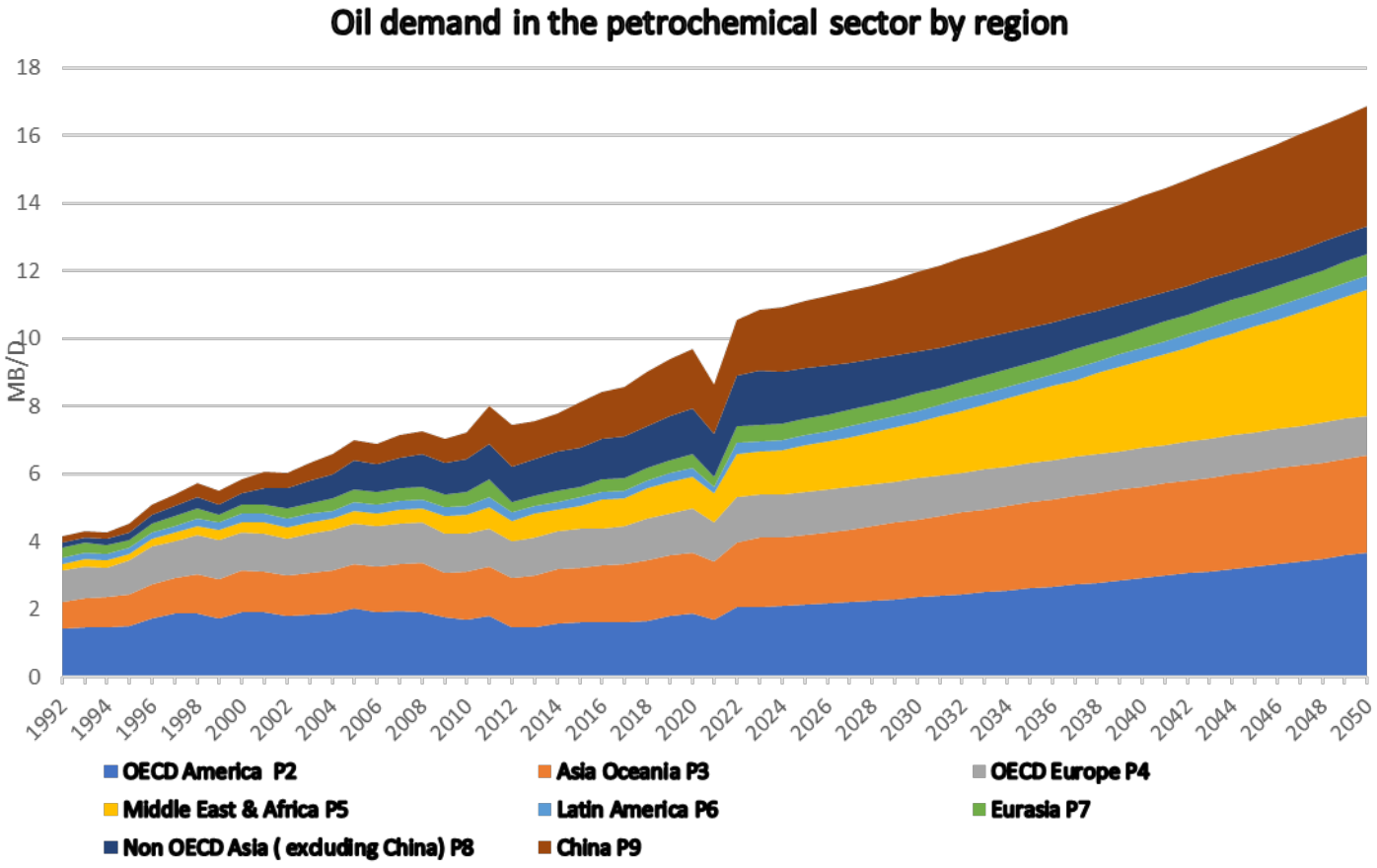
- In 2021 **Naphtha** represents only **52.12% of total demand** of petrochemical feedstocks and **Ethane is 20.34%**. **By 2045** they are **expected** to represent **41.77%** and **28.92 %** respectively.



FURTHER EXAMINATION BY REGIONS

- In the year 2045, **China**, **Asia Oceania**, **Non-OECD Asia** will count for **44.77%** of the total demand of petrochemical feedstocks.

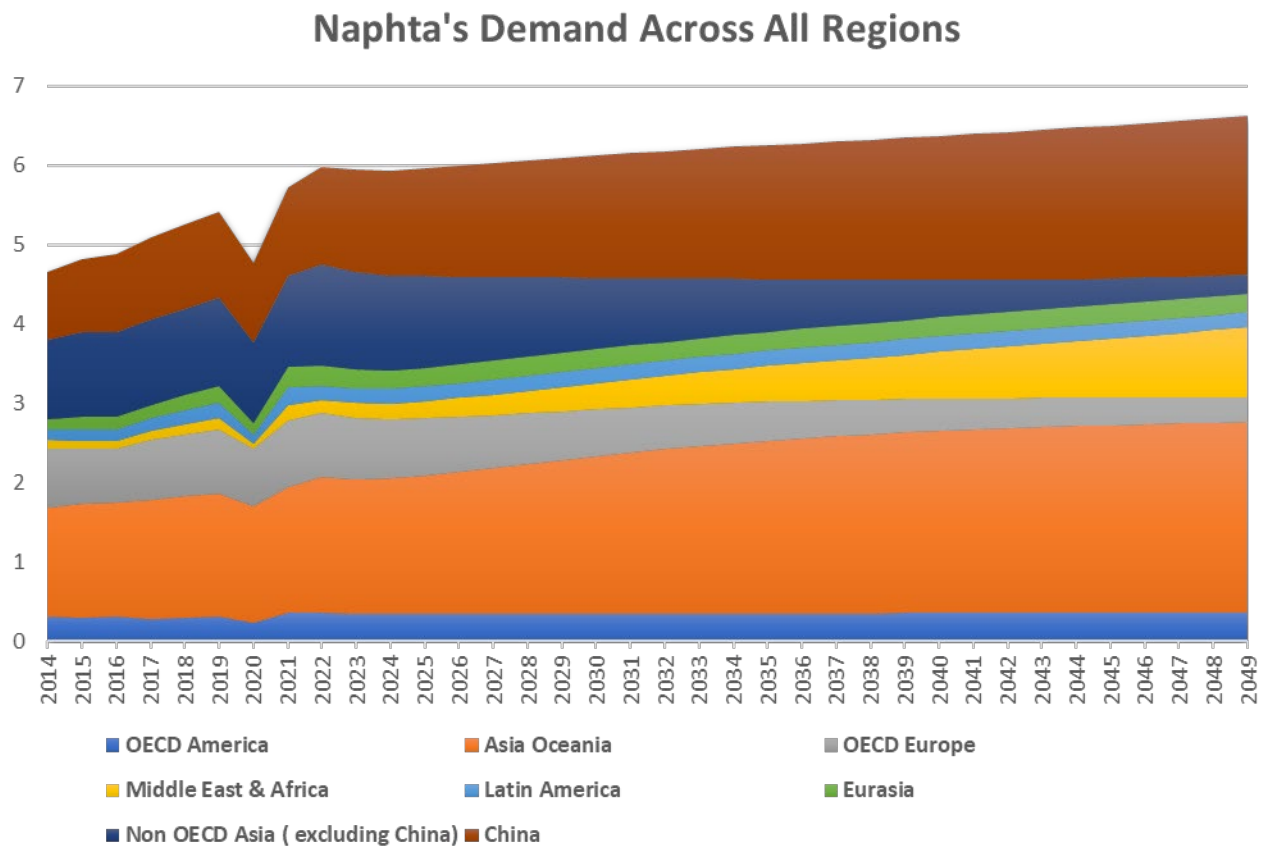
- Hence most of the demand is projected to come mostly from **Asia**.



FURTHER EXAMINATION BY REGIONS

- Most of the demand in the year 2045 is expected to emerge from Asia specifically from **China**, **Asia Oceania** (Japan, South Korea…etc.).

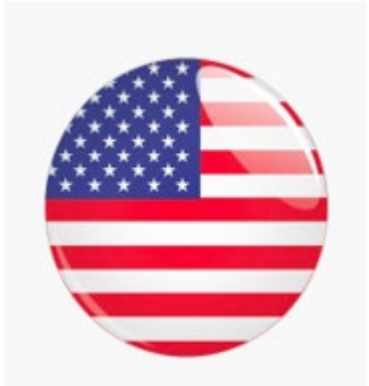
- In year 2021, **China** represent only **19.64%** of the total demand of Naphtha and **Asia Oceania** is **28.41%**. By 2045 the demand is expected to represent **29.66%** and **36.39%** respectively.

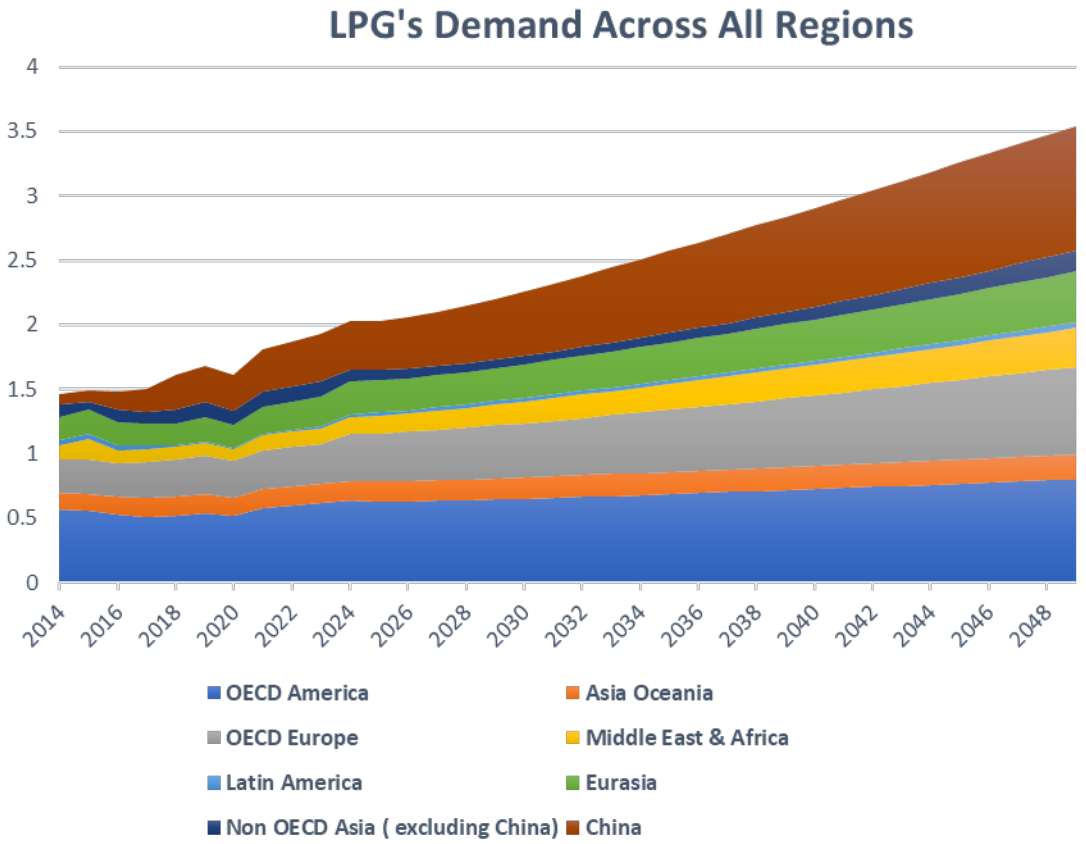


FURTHER EXAMINATION BY REGIONS

- Most of the demand in the year 2045 is expected to emerge from **China**, **OECD America**, and **OECD Europe**.

- In year 2021, **China** represented only **22.25%** of the total demand of LPG, **OECD America** is **31.47%**, and **OECD Europe** is **15.79%**. By 2045 the demand is expected to represent **27.22%**, **23.56%**, and **18.93%** respectively.

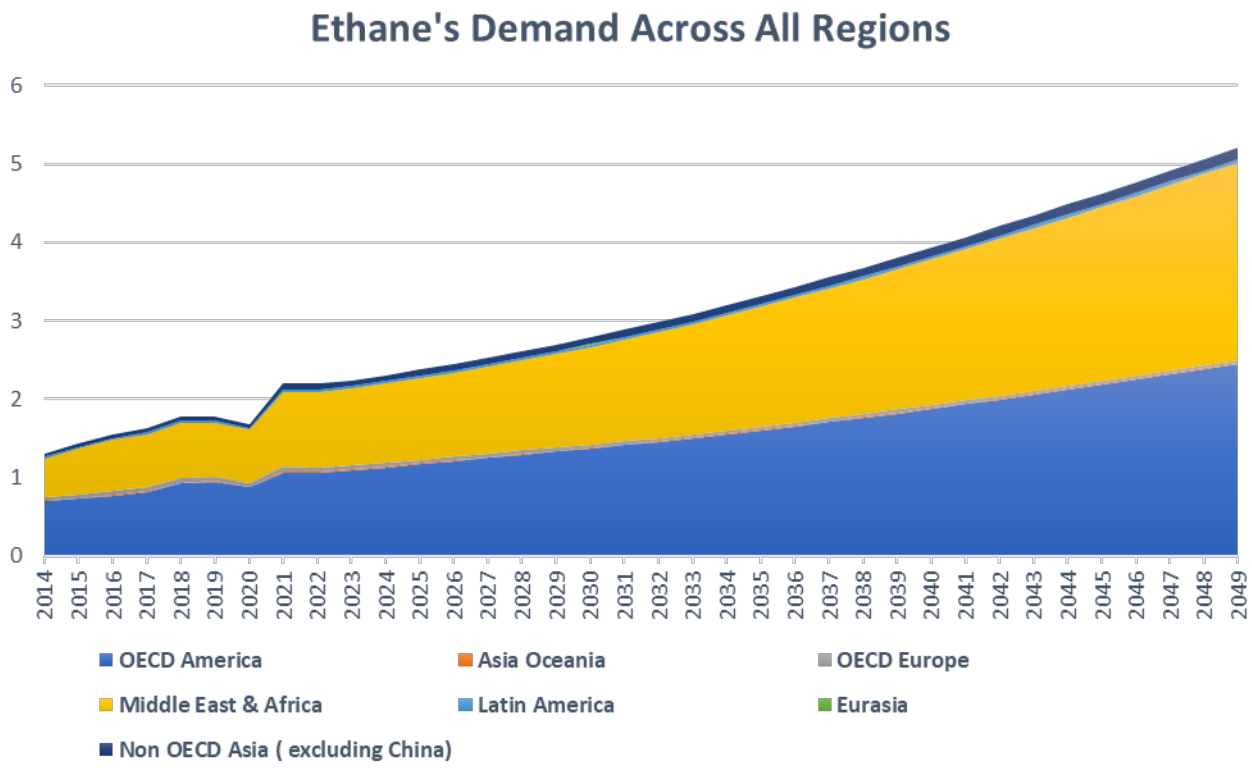




FURTHER EXAMINATION BY REGIONS

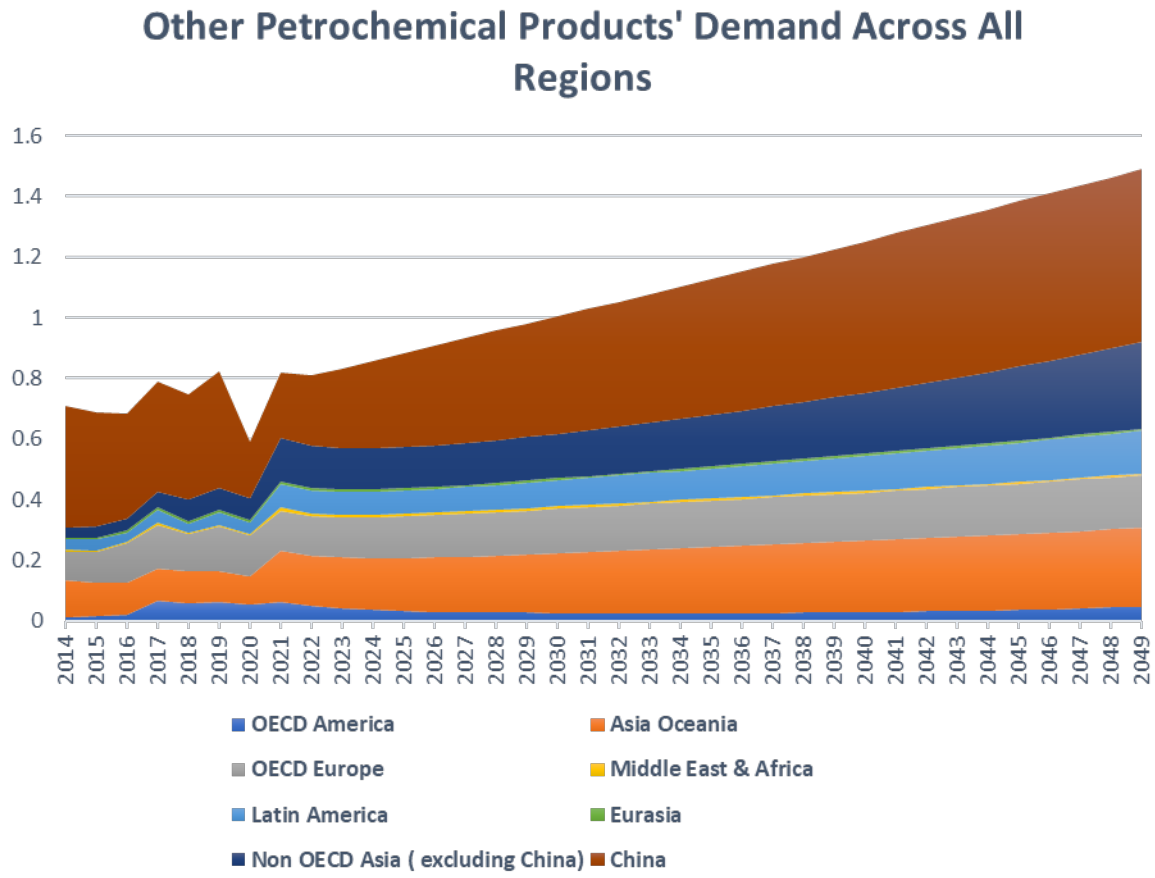
- **Most of the demand** in the year 2045 is expected to emerge from the **middle east & Africa** region, and **OECD America.**

- In year 2021, the **middle east & Africa** region represent only **43.49 %** of the total demand of Ethane, **OECD America** is **48.12%**. By 2045 the demand is expected to represent **48.04%**, and **47.25%**, respectively.

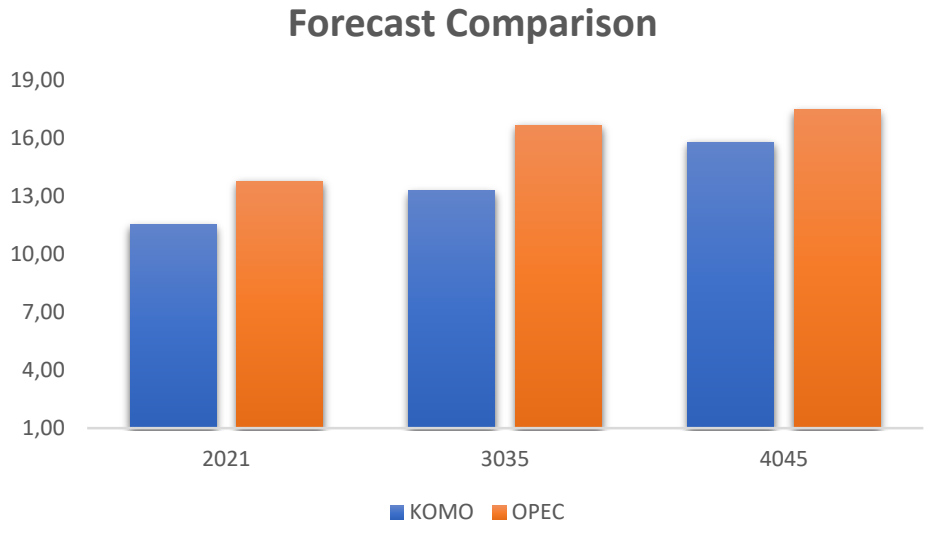


FURTHER EXAMINATION BY REGIONS

- Most of the demand in the year 2045 is expected to emerge from Asia.
- In year 2021, **China** represent only **26.18%** of the total demand of other petrochemical feedstocks, **Asia Oceania** is **20.90%**, and **Non-OECD Asia** is **17.54 %**. By 2045 the demand is expected to represent **39.35%**, **18.09%**, and **17.65%** respectively.



FORECAST COMPARISON



THANK YOU