



Ankara

# *Yalın Altı Sigma*

*Metot ve araçları*

Nisan 2020

*Nex*

eğitim &  
danışmanlık

Kalite Yönetim **Stratejisi**

Süreç iyileştirme **girişimleri** (kuşak programları)

Kalite **seviyesi** - 1 milyonda 4 hata

## Yöneticiler

- ✓ Üst
- ✓ Orta
- ✓ Saha

## Uzmanlar

- ✓ Kalite
- ✓ Planlama
- ✓ İK
- ✓ Mühendislik
- ✓ İmalat
- ✓ ...

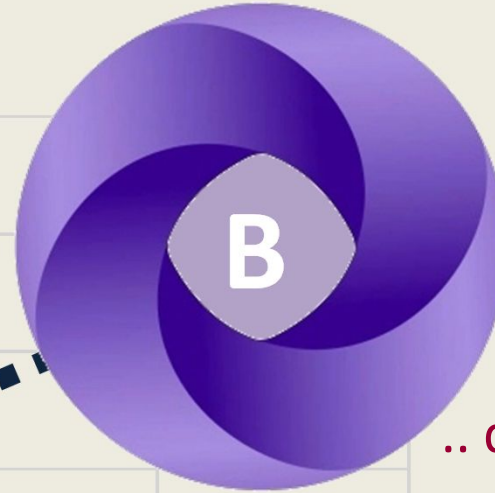
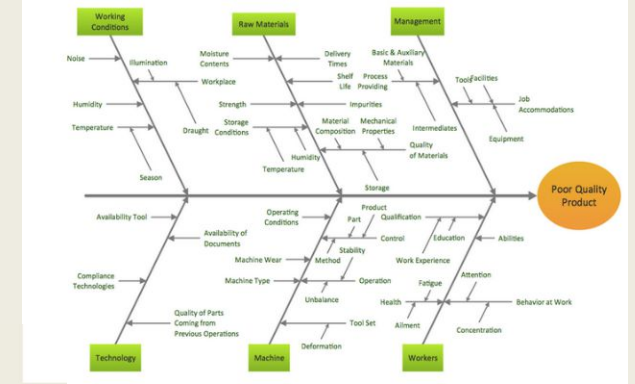


*Üst Yönetim*

*Altı Sigma metot ve araçları*

*Bilgi, sağduyu, deneyim*

## SOMUT, ÖLÇÜLEBİLİR İYİLEŞME



Daha iyi .. ?

.. daha kısa zamanda

.. daha kaliteli

.. daha düşük maliyetle



$$Y = f(x)$$



## TÖÇİK

Gerçek, basit, önemli, verisi bol bir süreç bul

Mevcut sürecin performansını ve potansiyelini ölç

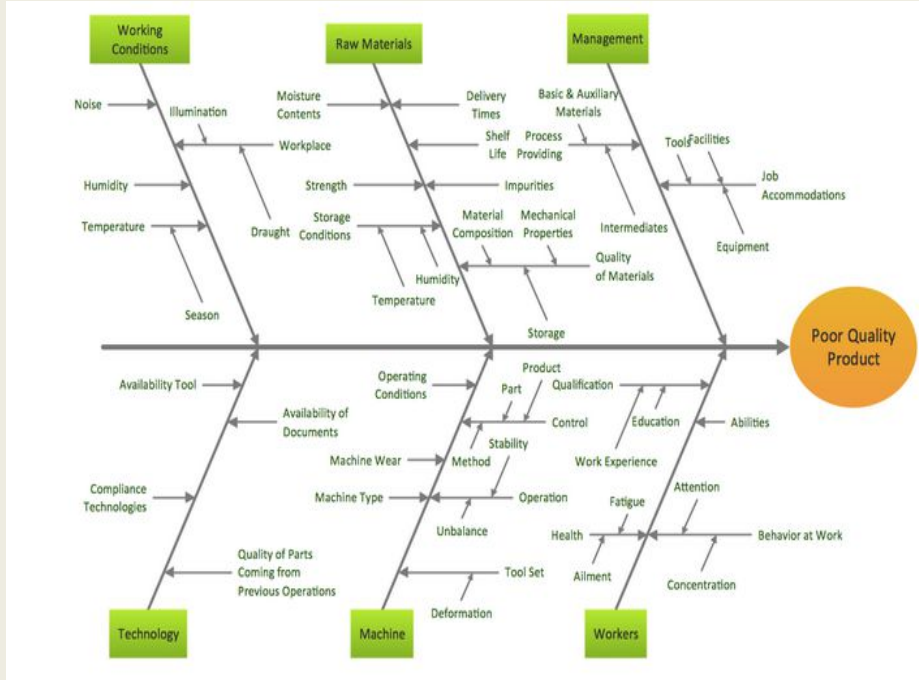
Sonuca etki edebilecek ana ve kritik faktörleri belirle

Değişkenliği azalt, min-max-opt

İyileşmenin kalıcı olmasını sağla



## Balık kılıçığı / Sebep - Sonuç



## Kalite Fonksiyonu Yayılımı (QFD)

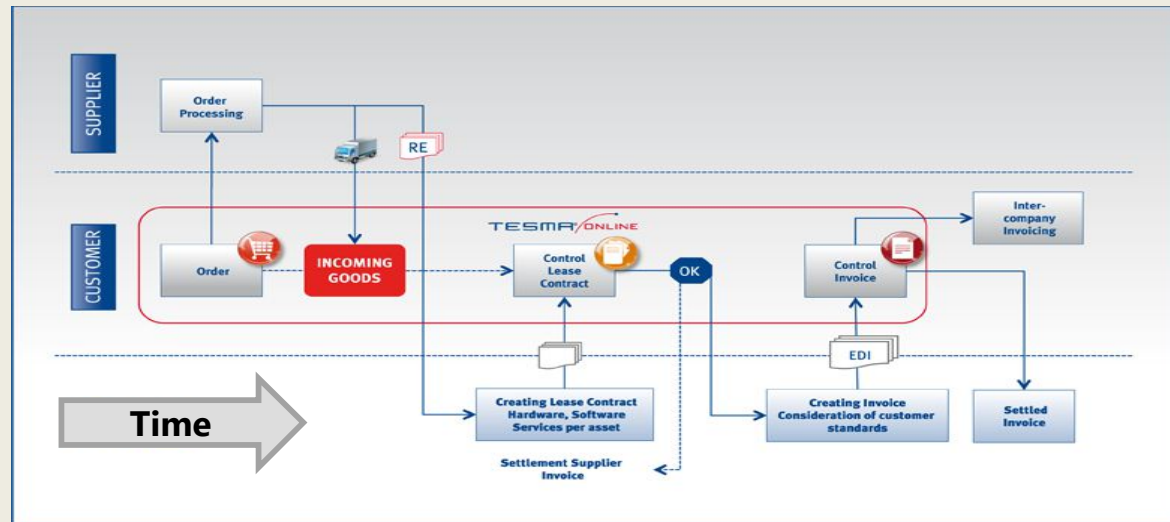
**INTERACTIONS:**  
 xx Strong negative relationship  
 x Mid negative relationship  
 ⊕ Mid positive relationship  
 ○ Strong positive relationship

**RELATIONSHIPS:**  
 ● Strong relationship  
 ○ Moderate relationship  
 ▲ Weak relationship

Customer Reqs.	Product Design Reqs.	1	5
Cust. envelope/interface	3		○
Max. Weight 160 lbs.	4	○	x
Bleed air 75 lbs/min	4		○
Turbine containment	5		ox
Elect pwr. 40 KYA	3		x
Reliable	5		ox
Support oil-cooled gen.	5		x
Technical Evaluation	5	x	x
Target Value	169 Lbs	158lb	<6 lb
Technical Difficulty	1	4	3
Importance Rating	39	35	42

**EVALUATIONS:**  
 x We  
 ○ XYZ Co.

## İş-Akış Şeması (Process Flow)



## Hata Modu Eftk Analizi

### FMEA

## Değer Akış Haritalama

### VSM

Altı hafta, 12 oturum, toplam 24 saat – On line senkron (20:00 – 22:00)

- Altı Sigma tanıtım
  - DMAIC
- Müşterinin sesi

Ça

Temel istatistik  
Grafikler

Cu

TANIMLAMA

Trend – Tahmin Modelleri

Ça

Dağılımlar

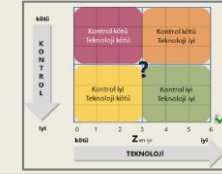
Cu

ÖLÇME

Proses Yeterlilik

Kontrol – Teknoloji Matrisi

Ça



Cu

Hipotez testleri  
Regresyon

Ça

Çoklu modeller

Cu

ANALİZ

YALIN ARAÇLARI

Ça

Deney tasarımları

Cu

İYİLEŞTİRME

Proses Kontrol Şemaları

Ça



Cu

KONTROL

$$f(x) \Rightarrow Y$$

**Sebepler**

**Sonu**

Yediklerimiz

Genetik

Uyku

Spor

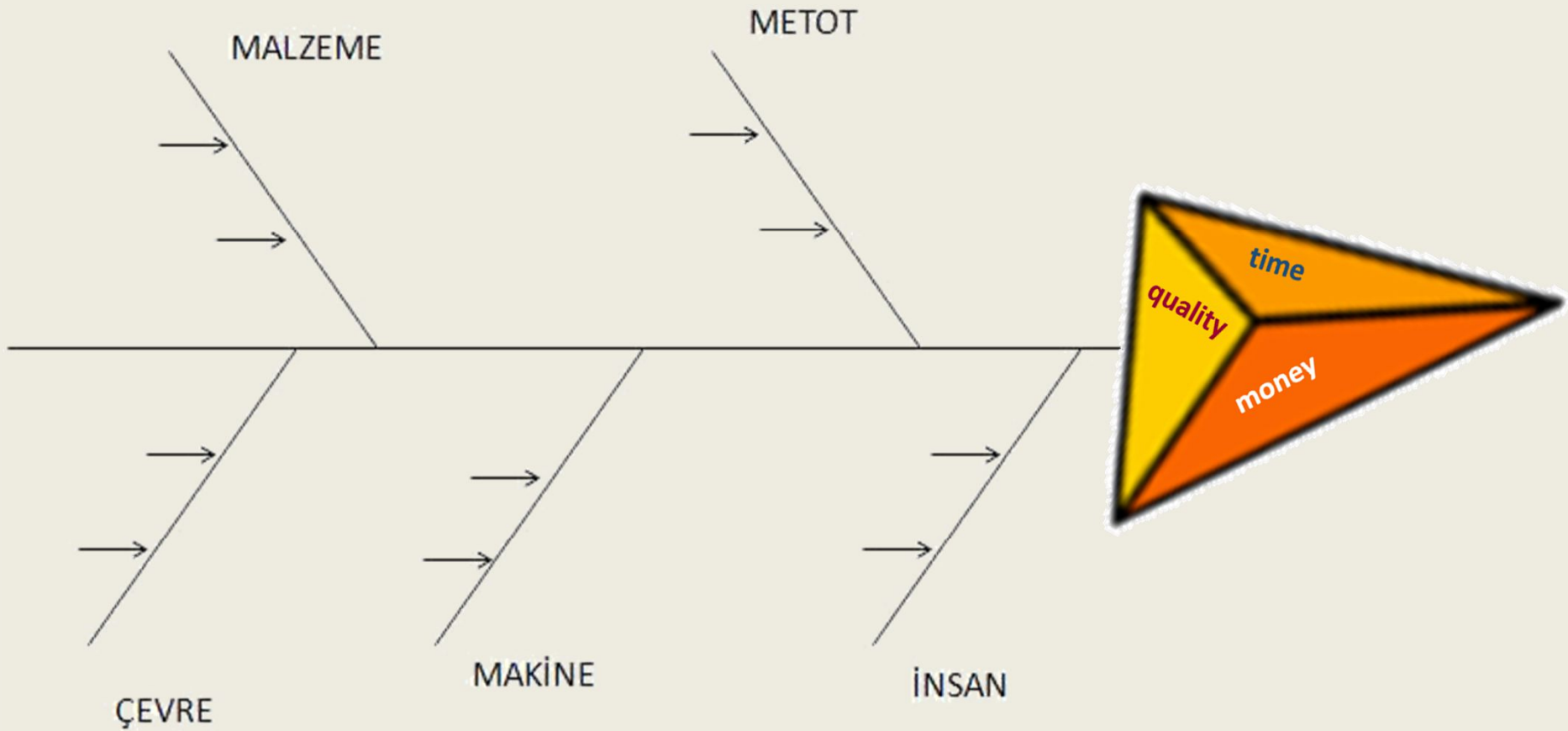
Stress

....



**Saėlık**





$$f(x) = y$$

## PARA

Kar / Zarar  
Satışlar  
Pazar Payı  
Maliyetler  
Ödemeler

.....

.....

....



## ZAMAN

Terminler  
Çevrim  
Bakım süresi

.....

.....

.....

## KALİTE

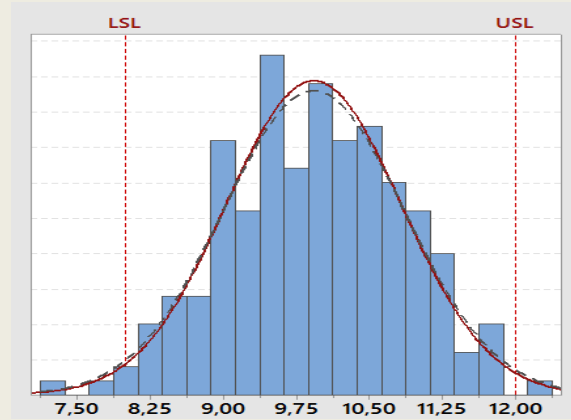
İmaj  
Ürün desteği  
Müşteri/çalışan memnuniyeti

.....

## Max

Kârlılık, Üretim, Verimlilik, Kalite,  
Pazar payı, Müşteri memnuniyeti, Yetkinlik, Süreklilik .....

## Optimize



Maliyet, Değişkenlik, Çevrim süreleri, Hatalar, Kayıplar,  
Şikayetler, Devamsızlık, İş kazaları...

## Min

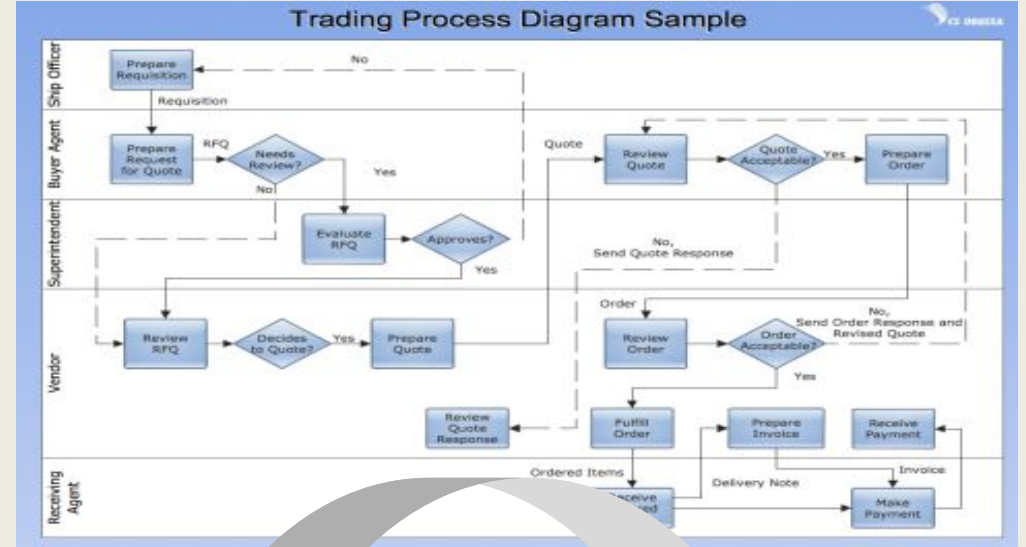
Hedefi ve sonucu olan ...

Kaynak kullanan

İnsan  
Mekan  
Makine  
Malzeme  
Enerji

...

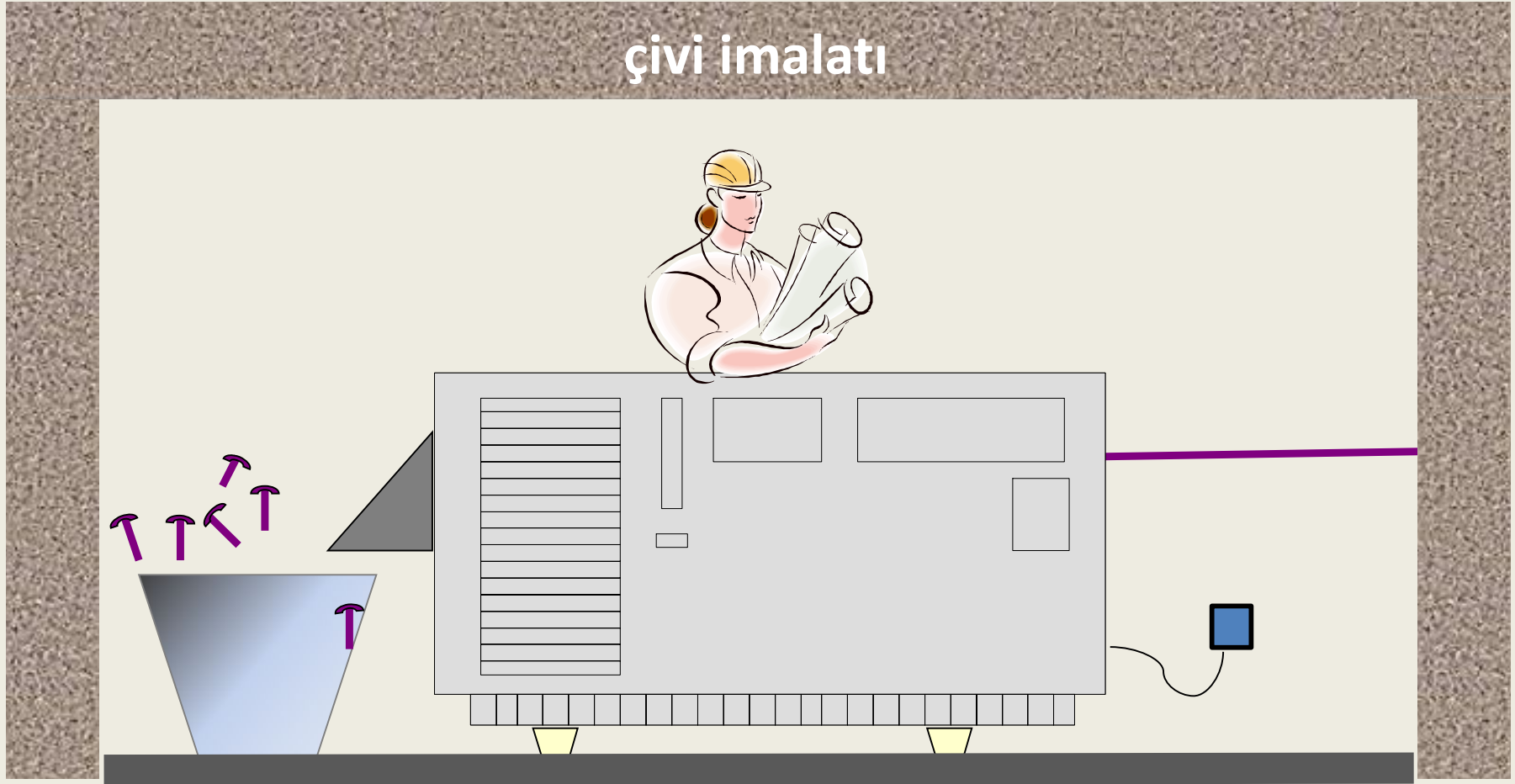
Zamana yayılmış, ilgili faaliyetler



proje

Fark ... tekrar

proses



Çiviler = f ( İnsan, Makine , Tesis, Malzeme, Metot, Enerji ...)

Y

x1

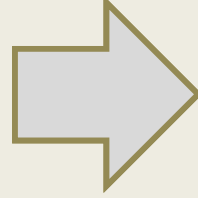
x2

x3

x4

x5

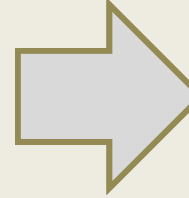
x6



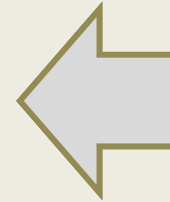
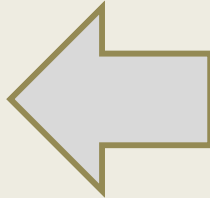
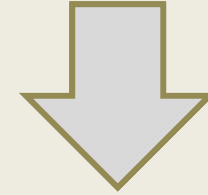
Maliyet

Süre

Test sonuçları



Motor Çevrim





# Y



# X

- ✓ İNSAN
- ✓ MAKİNE
- ✓ MALZEME
- ✓ METOT
- ✓ .....

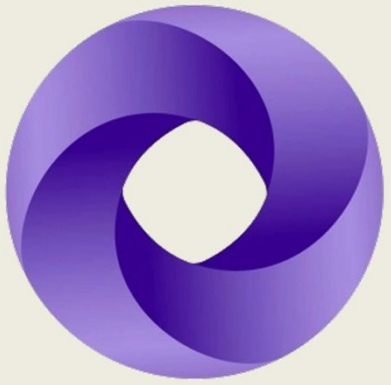
## PARA

Ciro  
Oda başı kar ?



## TIME

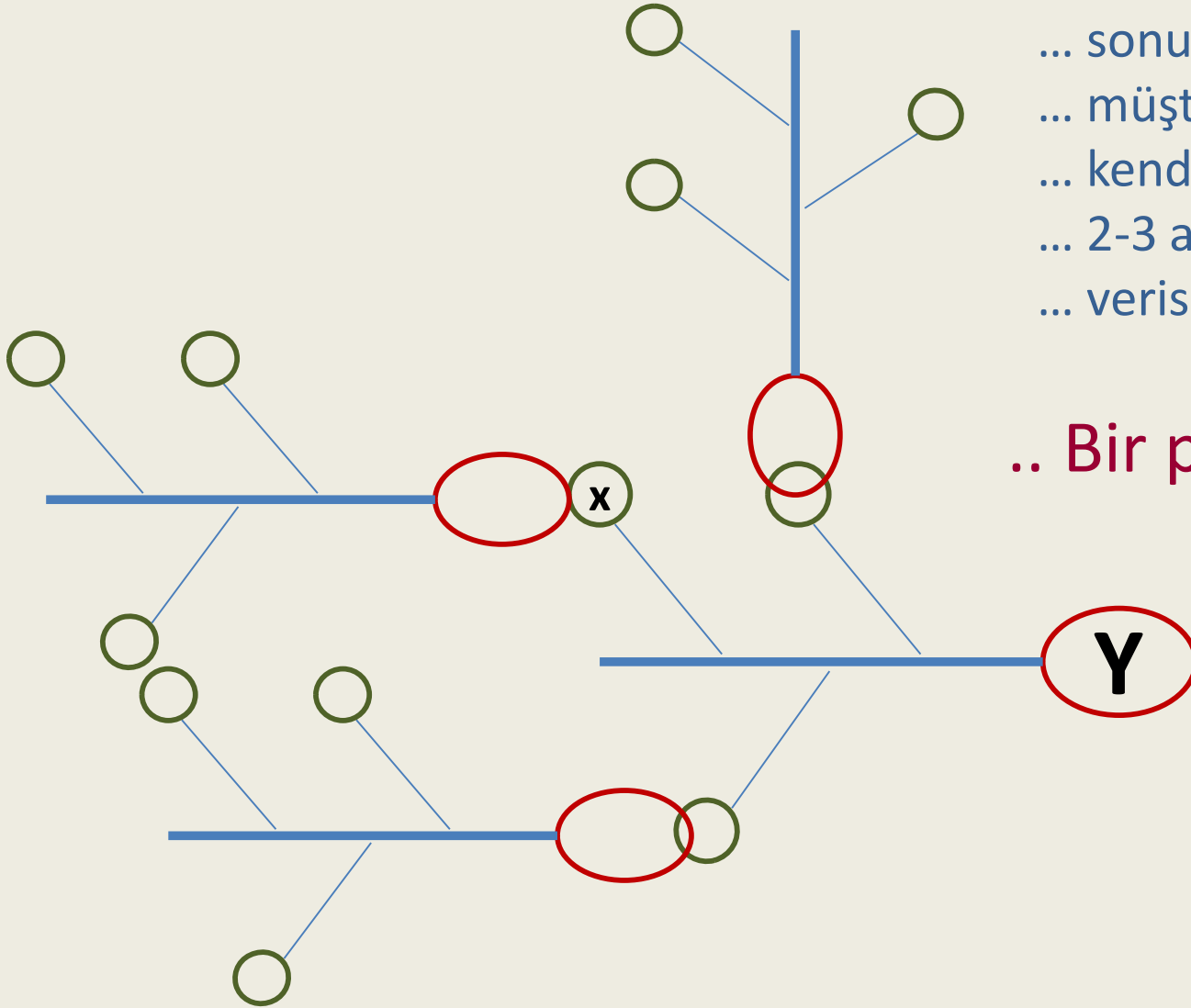
Kalma süresi  
Temizlik / bakım döngüleri



## QUALITY

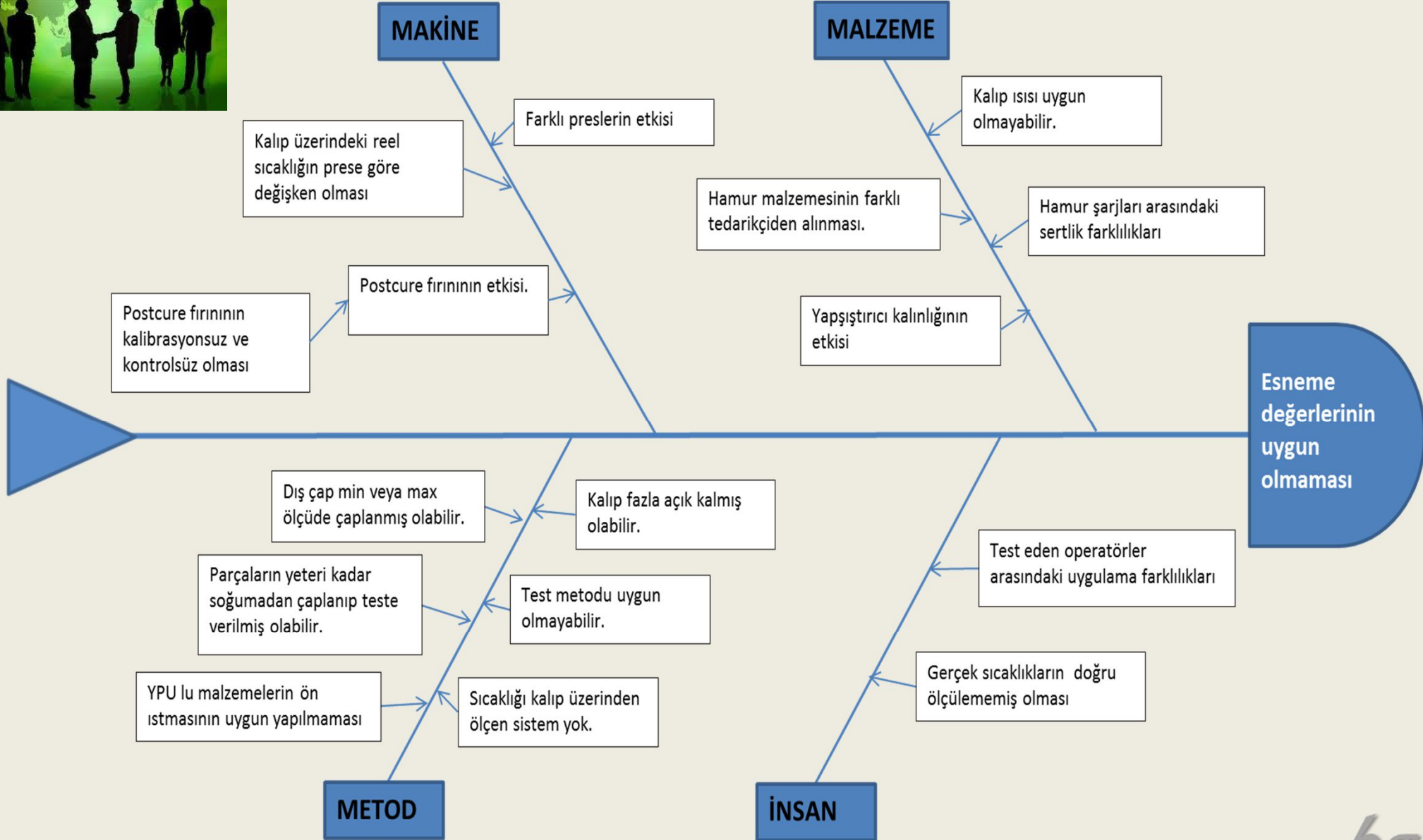
Memnuniyet





- ... başlayan, biten
- ... ritmi yüksek
- ... sonucu ölçülebilen
- ... müşteri ve üst yönetim için önemli
- ... kendi yetki ve ilgi alanımda
- ... 2-3 ayda iyileştirilebilecek
- ... verisi bol, güvenilir

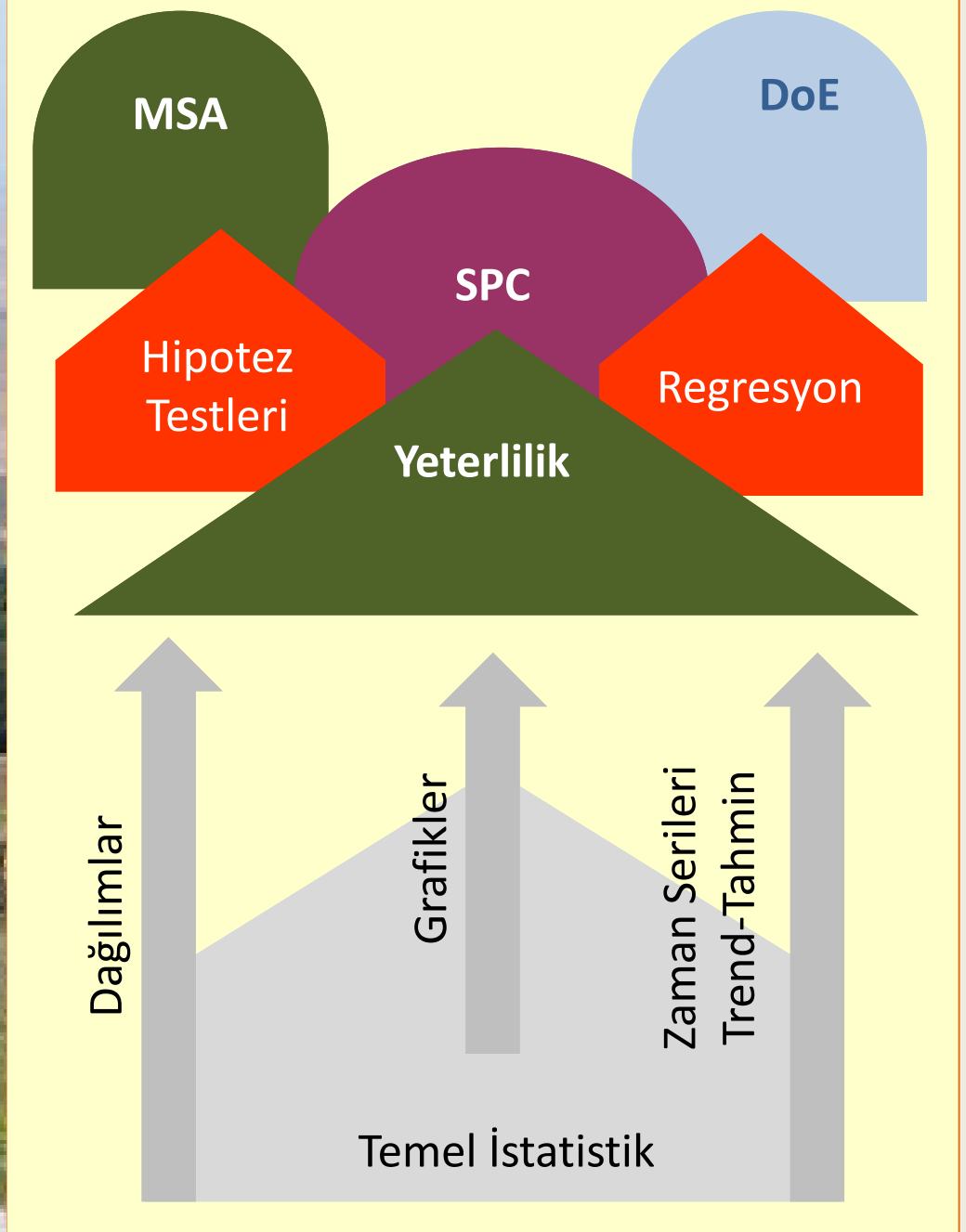
.. Bir proses ile ilgili olmalı !



↓	C1	C2	C3-T	C4-T	C5	C6-T	C7	C8	C9	C10-T	C11	C12	C13	C14	C15	C16
	esneme %	toplam üretim	vardiya	usta	hamur	tedarikçi	kalıp sıcaklığı C	postcure	fırın süresi	pres	yapıştırıcı mm	bakiye	bakiye ph	TPHR	TTHV	propanol %
1	0,039	13175	akşam	nuri	280	plastiksan	42,57	0,35	53,00	A100 cx	3,73	0,76	10,27	96,5	7,48	0,055
2	0,039												10,40	96,4	7,76	0,073
3	0,040												10,70	96,4	7,62	0,054
4	0,038												10,77	96,4	7,70	0,047
5	0,040			veysel	207	plastiksan	43,07	0,35	50,85	A78	3,70	0,60	10,83	96,4	7,88	0,077
6	0,038			veysel	310	unixa	45,60	0,34	59,25	A100	3,71	0,72	10,40	96,3	8,14	0,073
7	0,038		düz	aysel	365	plastiksan	46,15	0,35	60,75	A78	3,72	0,60	10,25	96,2	7,92	0,064
8	0,039		düz	aysel	485	unixa	48,80	0,35	61,50	A100 cx	3,75	0,70	10,35	96,2	8,16	0,065
9	0,037			veysel	620	unixa	45,05	0,35	60,50	A100 cx	3,67	0,64	10,30	96,2	7,98	0,103
10	0,039		m	nuri	620	unixa	43,35	0,35	60,75	A100	3,66	0,70	10,45	96,2	7,80	0,106
11	0,039			veysel	310	plastiksan	44,30	0,35	56,50	A100 cx	3,78	0,66	10,30	96,2	8,08	0,079
12	0,039		m	nuri	210	plastiksan	42,45	0,35	53,50	A100 cx	3,70	0,64	10,35	96,2	8,26	0,081
13	0,040		m	nuri	400	plastiksan	42,45	0,34	58,00	A100 cx	3,70	0,58	10,60	96,2	8,14	0,084
14	0,039			veysel	387	plastiksan	42,75	0,35	53,00	A100 cdx	3,70	0,63	10,50	96,2	7,65	0,054
15	0,039			veysel	400	plastiksan	42,75	0,35	53,00	A100 cdx	3,66	0,73	10,15	96,2	7,86	0,035
16	0,040			veysel	400	plastiksan	42,20	0,35	54,50	A100	3,71	0,74	10,20	96,3	8,26	0,032
17	0,039		düz	aysel	400	plastiksan	42,27	0,35	55,50	A78	3,69	0,78	10,23	96,3	8,09	0,032
18	0,037		düz	aysel	267	plastiksan	41,67	0,35	53,67	A100 cx	3,61	0,76	10,30	96,3	8,36	0,044
19	0,038			veysel	127	plastiksan	42,33	0,34	51,67	A100	3,67	0,73	10,53	96,3	8,45	0,045
20	0,040			veysel	370	unixa	42,30	0,35	53,33	A100 cdx	3,66	0,71	10,30	96,3	8,09	0,025
21	0,040			veysel	350	plastiksan	42,67	0,35	55,33	A100 cdx	3,70	0,74	10,33	96,3	8,45	0,028
22	0,039		m	nuri	350	unixa	41,80	0,35	56,00	A100 cdx	3,68	0,75	10,40	96,2	8,17	0,047
23	0,038		düz	aysel	350	unixa	44,00	0,35	62,50	A100	3,63	0,61	10,50	96,3	8,03	0,035

... en az 30 sütun

... en az 100 satır

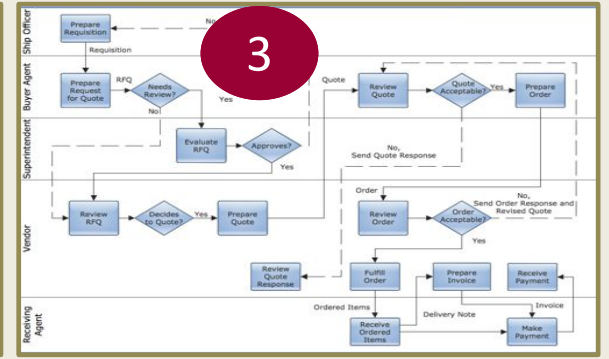
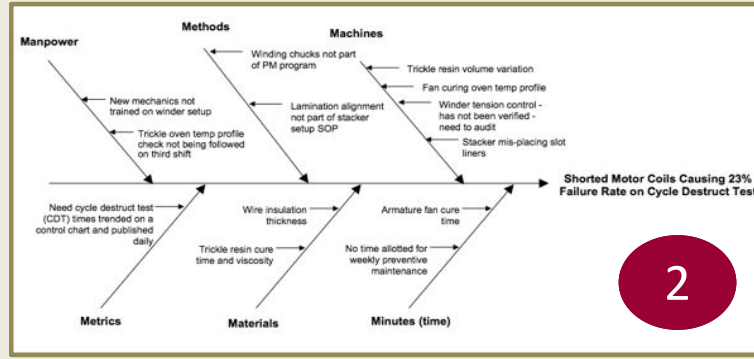




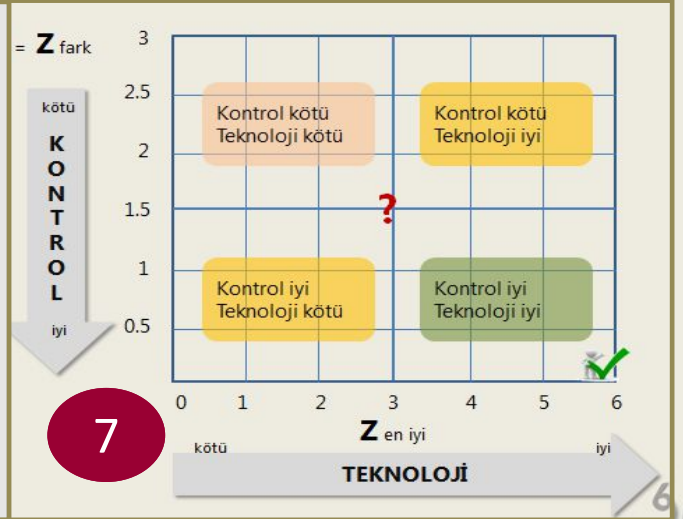
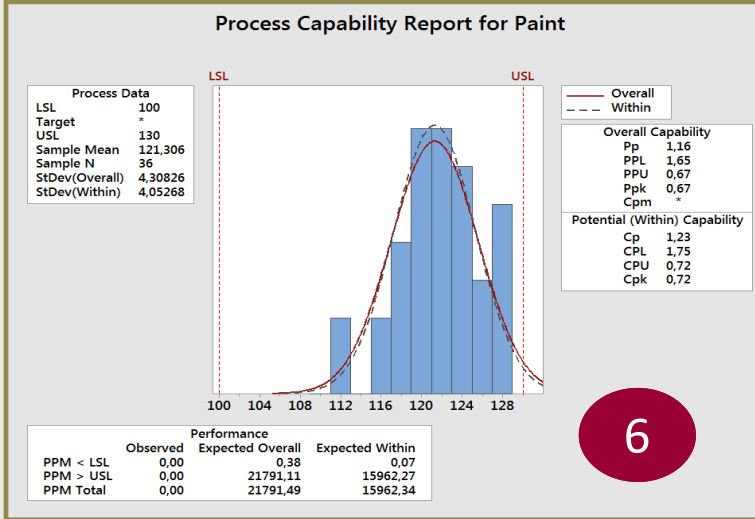
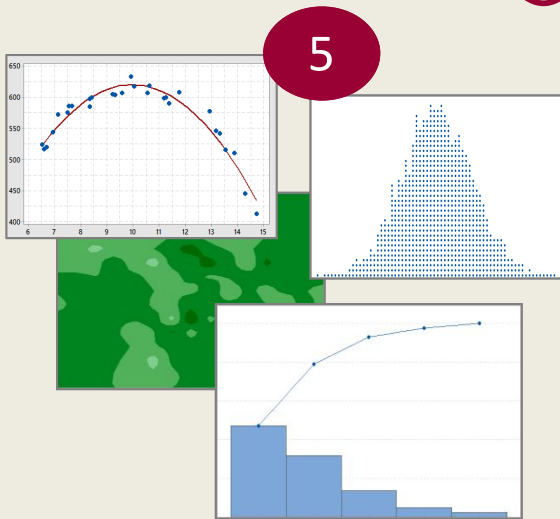
Proje ismi .....

<b>Problem / Fırsat</b> Rusiyi azeri primadentit indoversonoyeyskoye jazykoye slava. On voprosy k ego slavaoye gruppe, U nego mnogo rodstvennykh jazykov.	<b>Projeciler</b> <ul style="list-style-type: none"> <li>Sahip</li> <li>Sorumlu</li> <li>Takim</li> </ul>
<b>Proses</b> beloruskiy, bolgarskiy, polskiy, ▪ Birim ▪ Mevcut seviye Z veya p(d) ▪ Hedeflenen seviye	<b>Plan</b> <ul style="list-style-type: none"> <li>Tanımlama .../.../2016</li> <li>Ölçme .../.../2016</li> <li>Analiz .../.../2016</li> <li>İyileştirme .../.../2016</li> <li>Kontrol .../.../2016</li> </ul>

Hedef (TL, %, etc)



↓	C1-T	C2-T	C3	C4	C5	C6	C7	C8	C9	C10	C11-T	C12-T	C13	C14	C15	C16
	Damage	Defects	Counts	Faults	Shift	Weight	Rejects	Sampled	Blemish		Flaws	Period		Paint	Thicken	Sample
1	Scratch	Missing Screws	274	0,22435	1	905	20	98	2		Scratch	Day		120	124	51
2	Scratch	Missing Clips	59	0,29532		930	18	104	4		Scratch	Day		123	121	35
3	Bend	Defective Housi	19	0,35517		865	14	97	1		Peel	Day		121	121	21
4	Chip	Leaky Gasket	43	0,25060		895	16	99	1		Peel	Day		118	124	32
5	Dent	Scrap	4	0,04660	1	905	13	97	4		Smudge	Day		120	117	48
6	Scratch	Unconnected Wir	8	0,01963	2	885	29	102	5		Scratch	Day		111	117	19
7	Chip	Missing Studs	6	0,12111	2	890	21	104	2		Other	Day		127	103	12
8	Scratch	Incomplete Part	10	-0,72188	2	930	14	101	1		Other	Evening		122	135	31

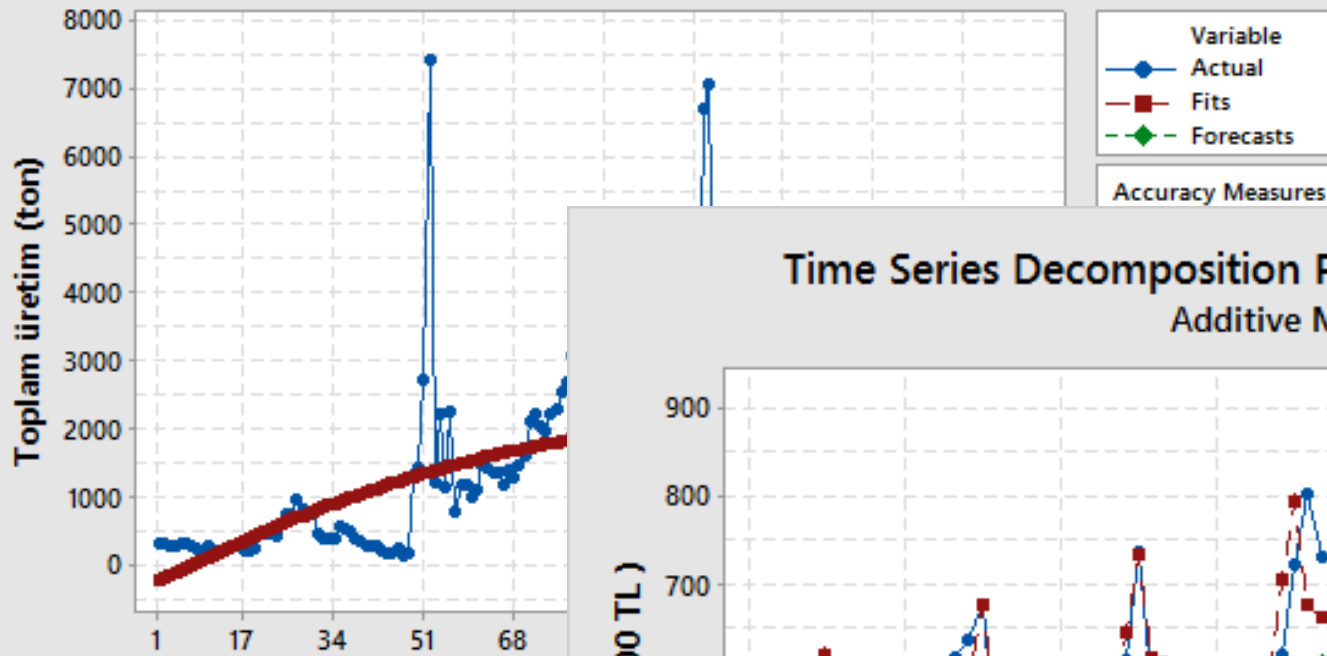




### Trend Analysis Plot for Toplam üretim (ton)

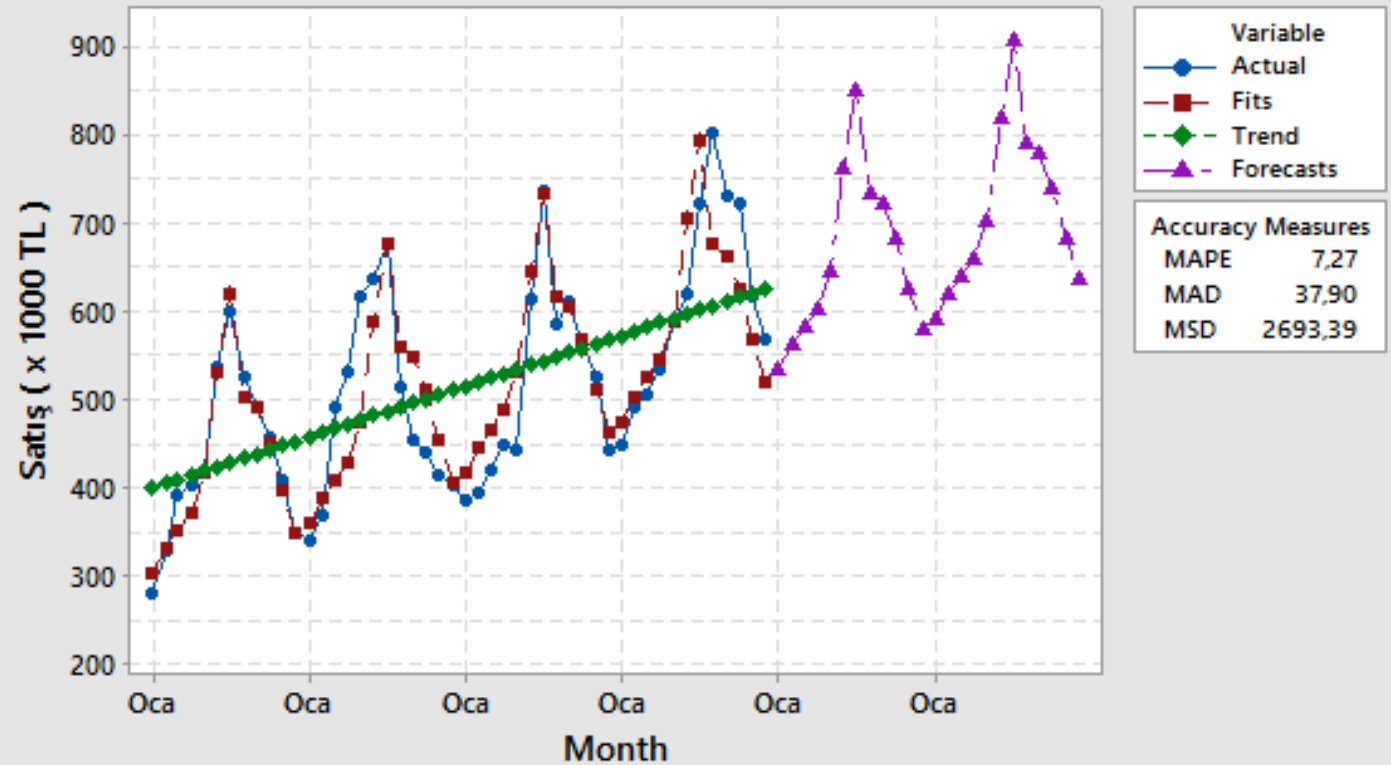
Quadratic Trend Model

$$Y_t = -286 + 40,47 \times t - 0,1719 \times t^2$$



### Time Series Decomposition Plot for Satış ( x 1000 TL )

Additive Model

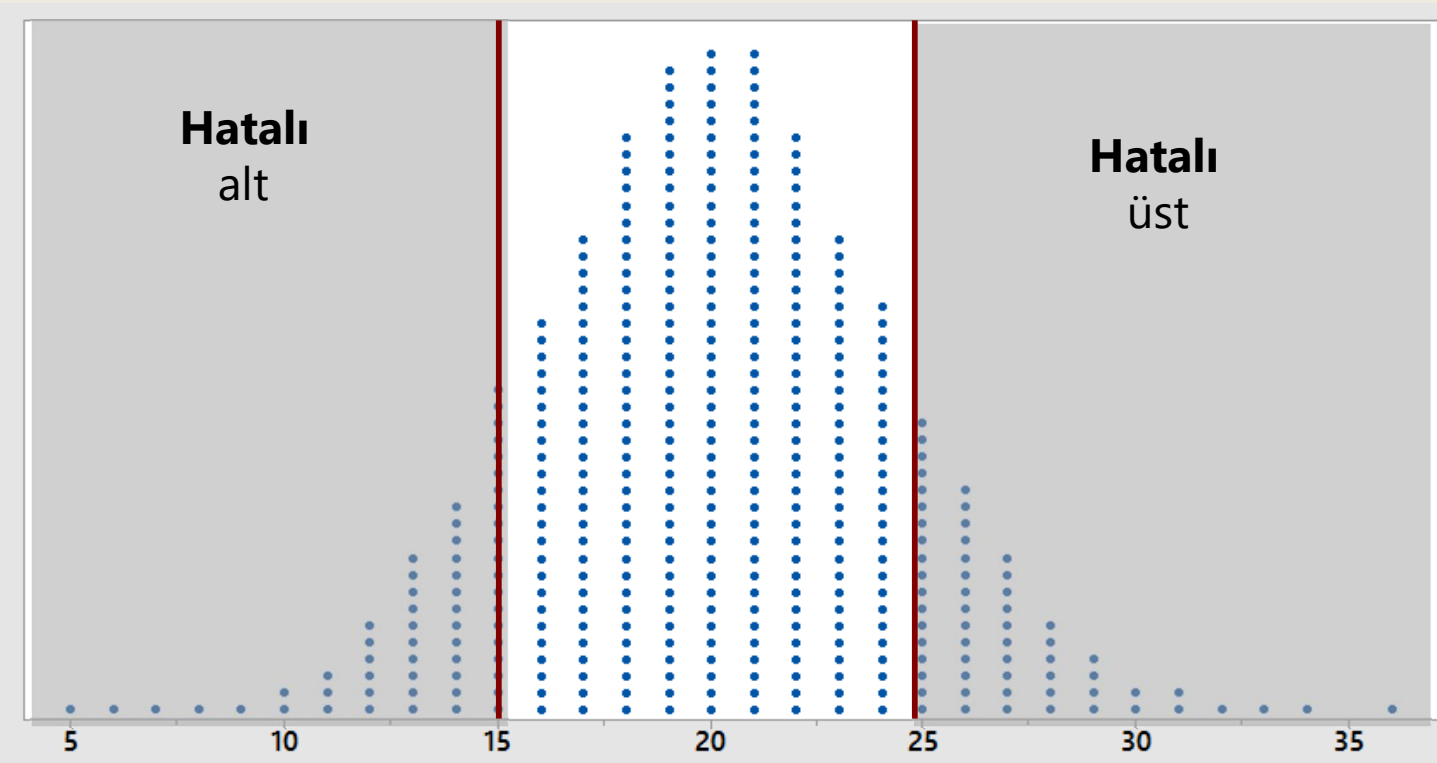


$$Z_{alt} = \frac{\bar{x} - \text{Alt Limit}}{s}$$

$$Z_{üst} = \frac{\text{Üst Limit} - \bar{x}}{s}$$

$$P(d)_{üst} + P(d)_{alt}$$

**P(d)toplam**

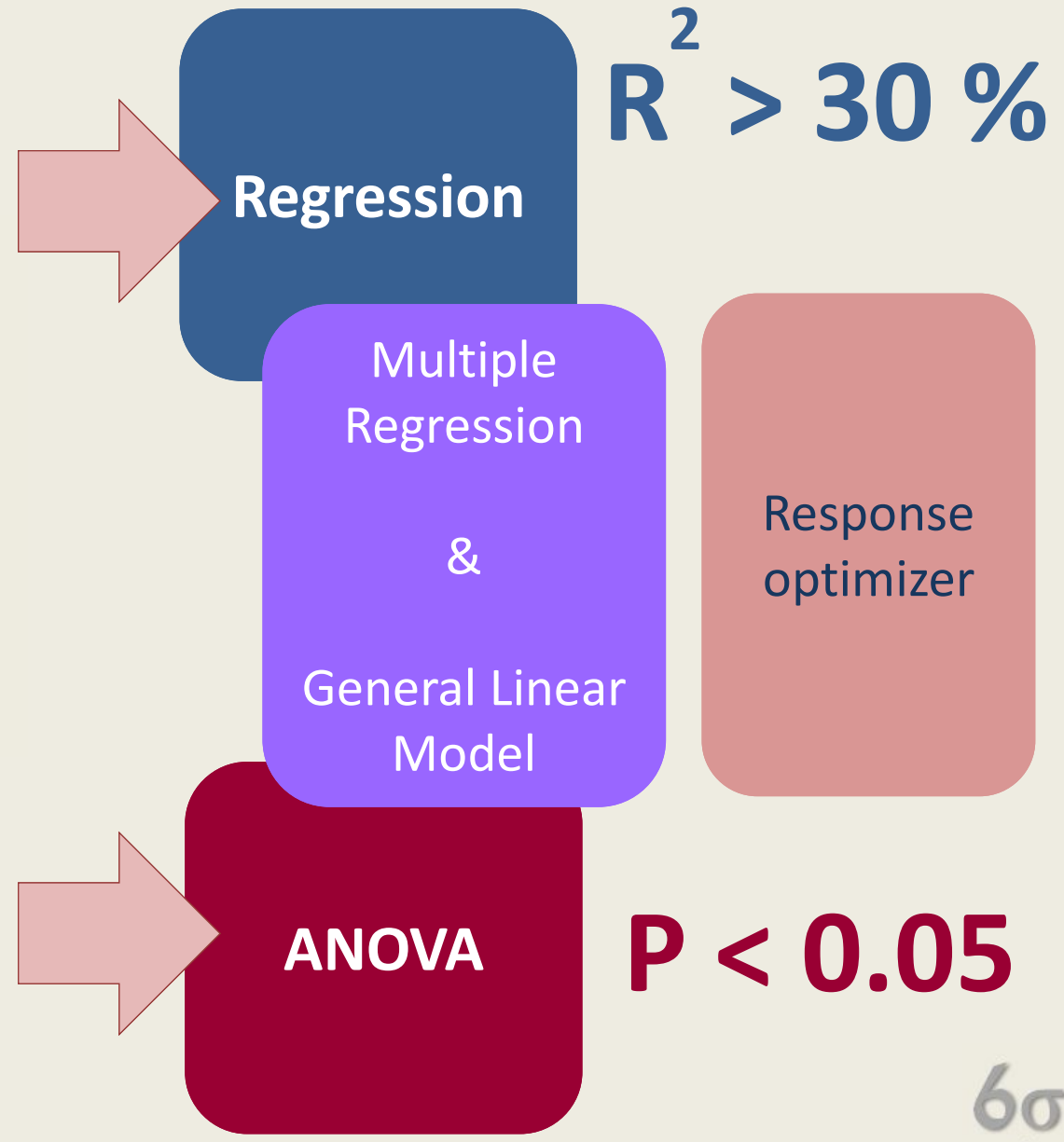
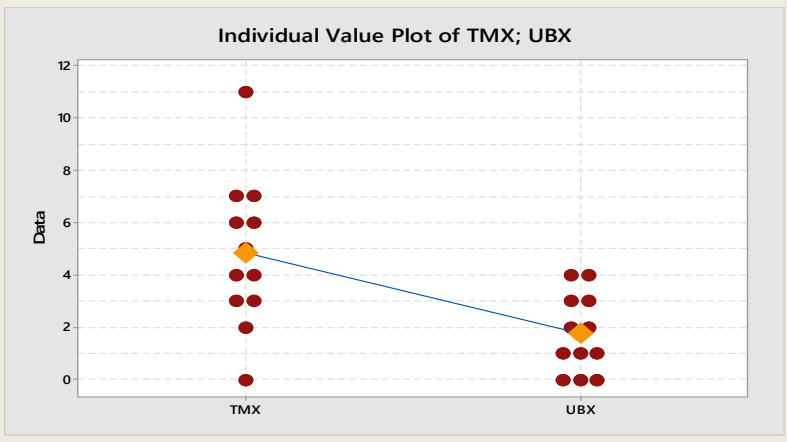
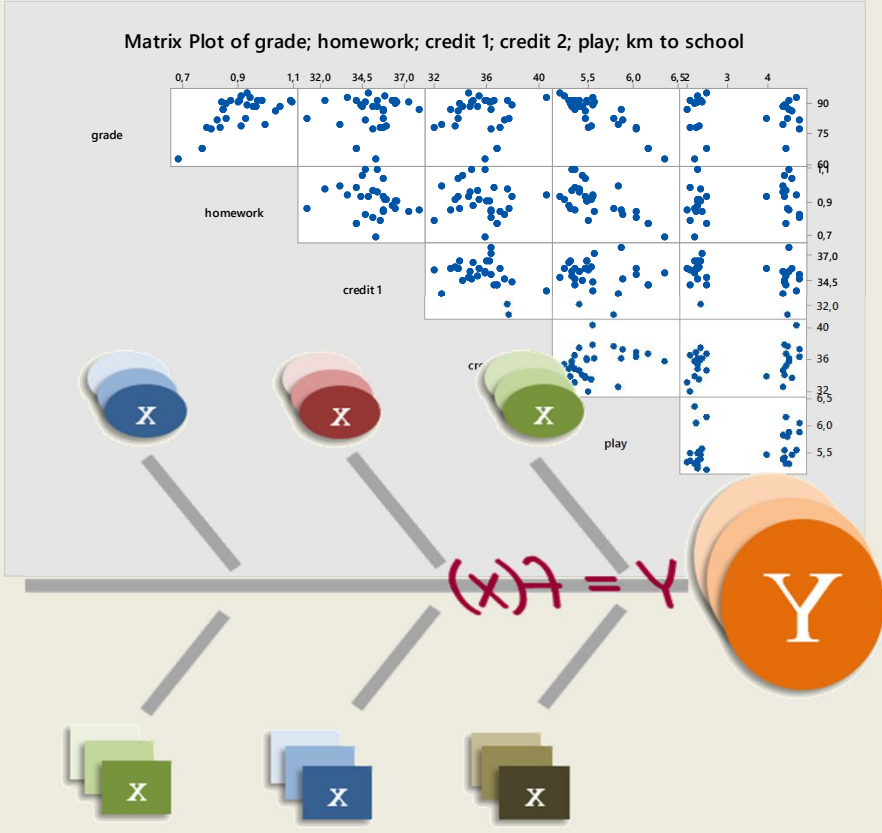


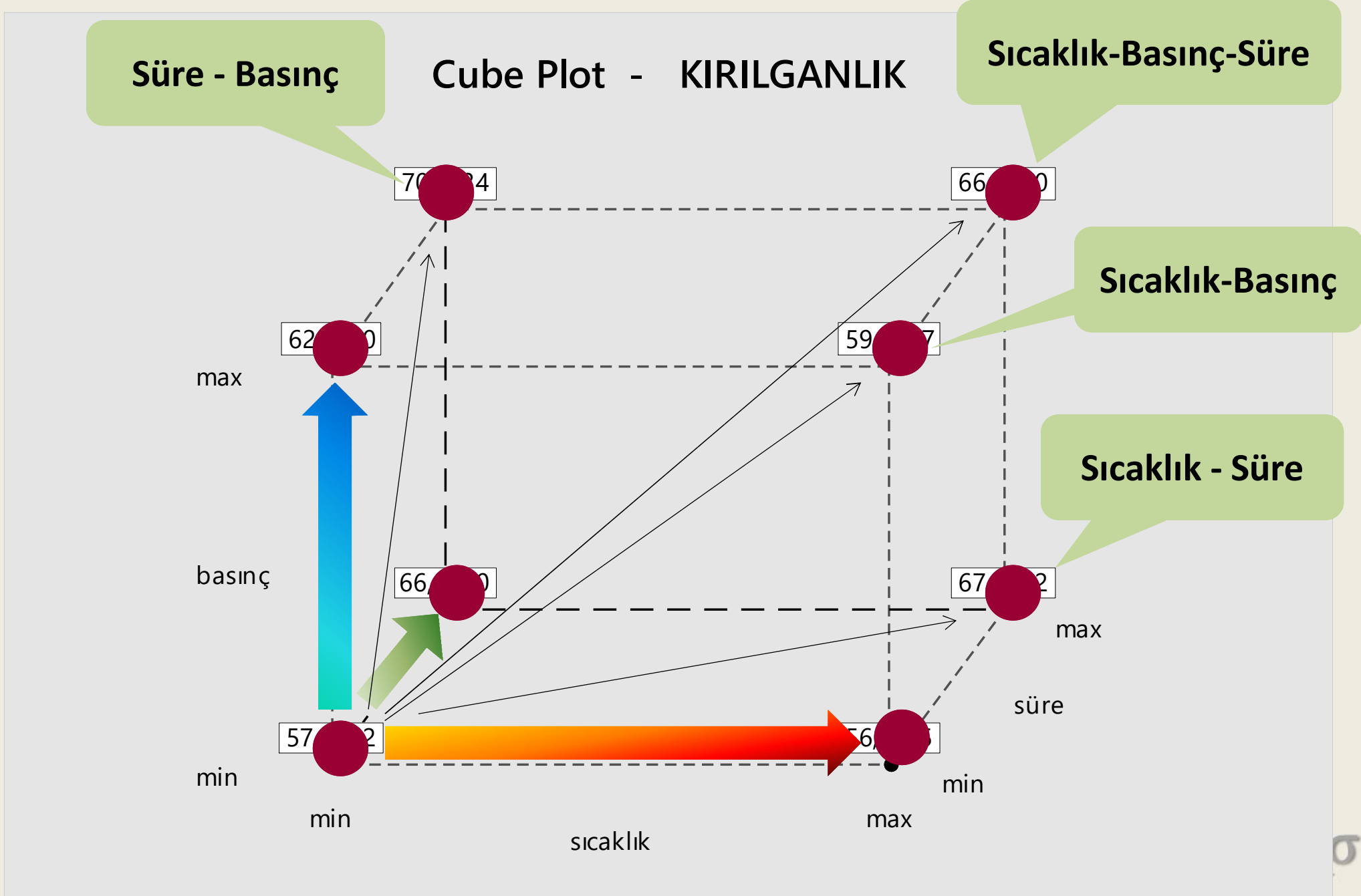
Normal Distribution (expressed in decimal form)

Z	Pisana	Z	Pisana	Z	Pisana	Z	Pisana	Z	Pisana
-4.25	1.00000	-3.75	0.999912	-1.25	0.094320	1.25	0.105680	3.75	0.000088
-4.20	1.00000	-3.70	0.999882	-1.20	0.084320	1.20	0.095680	3.80	0.000074
-4.15	1.00000	-3.65	0.999869	-1.15	0.074320	1.15	0.086320	3.85	0.000061
-4.10	1.00000	-3.60	0.999861	-1.10	0.064320	1.10	0.077320	3.90	0.000048
-4.05	1.00000	-3.55	0.999857	-1.05	0.054320	1.05	0.068320	3.95	0.000035
-4.00	1.00000	-3.50	0.999857	-1.00	0.044320	1.00	0.059320	4.00	0.000022
-3.95	1.00000	-3.45	0.999863	-0.95	0.034320	0.95	0.050320	4.05	0.000009
-3.90	1.00000	-3.40	0.999873	-0.90	0.024320	0.90	0.041320	4.10	0.000007
-3.85	1.00000	-3.35	0.999886	-0.85	0.014320	0.85	0.032320	4.15	0.000005
-3.80	1.00000	-3.30	0.999901	-0.80	0.004320	0.80	0.023320	4.20	0.000003
-3.75	1.00000	-3.25	0.999917	-0.75	0.000000	0.75	0.014320	4.25	0.000001
-3.70	1.00000	-3.20	0.999933	-0.70	0.000000	0.70	0.005320	4.30	0.000000
-3.65	1.00000	-3.15	0.999949	-0.65	0.000000	0.65	0.000000	4.35	0.000000

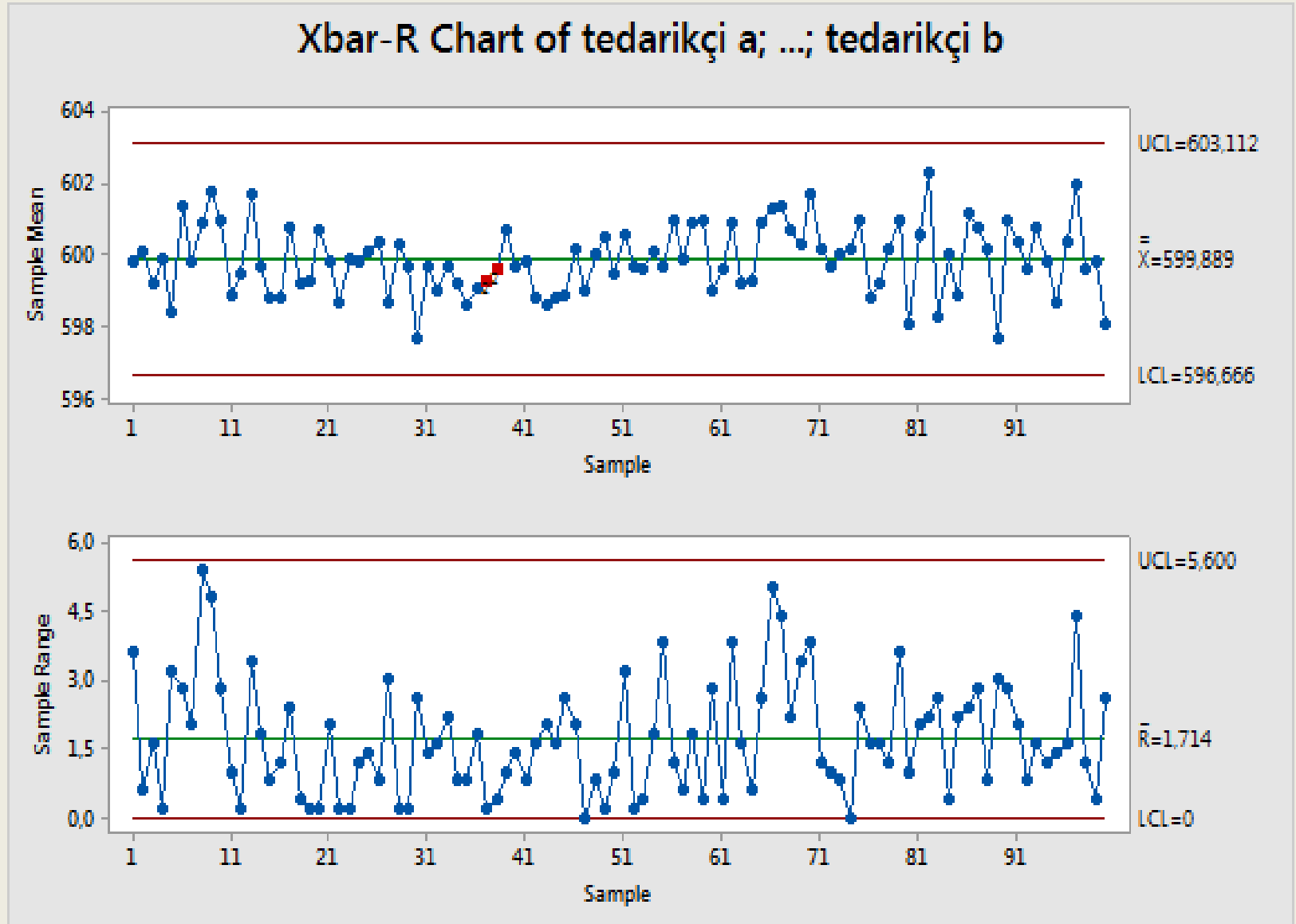
**Z toplam**

**Z bench**



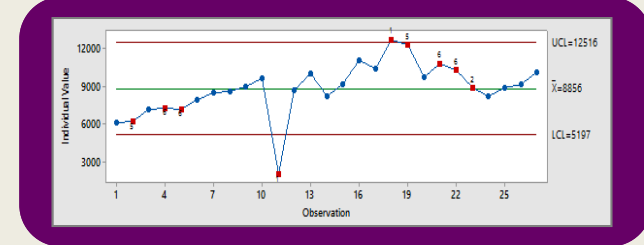


C2	C3
tedarikçi a	tedarikçi b
598,0	601,6
599,8	600,4
600,0	598,4
599,8	600,0
600,0	596,8
600,0	602,8
598,8	600,8
598,2	603,6
599,4	604,2
599,6	602,4
599,4	598,4
599,4	599,6
600,0	603,4
598,8	600,6
599,2	598,4
599,4	598,2
599,6	602,0
599,0	599,4
599,2	599,4
600,6	600,8
598,8	600,8
598,8	598,6

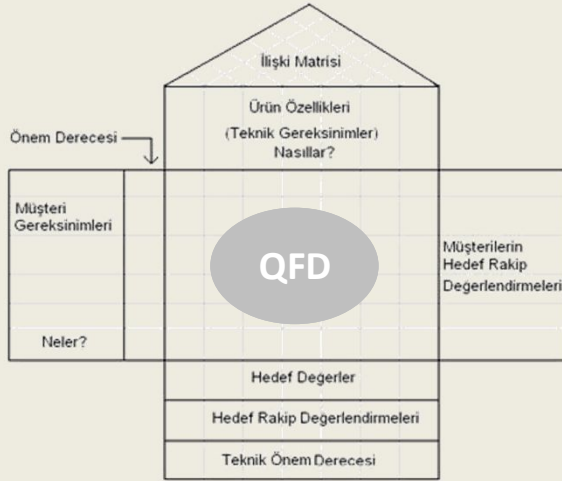
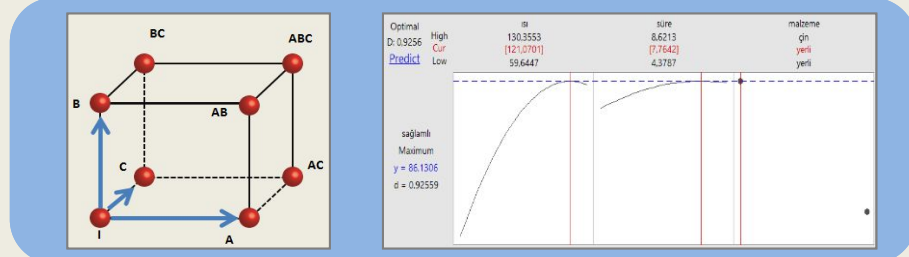


Her mavi nokta iki tedarikçinin **ortalaması ve aralığı**

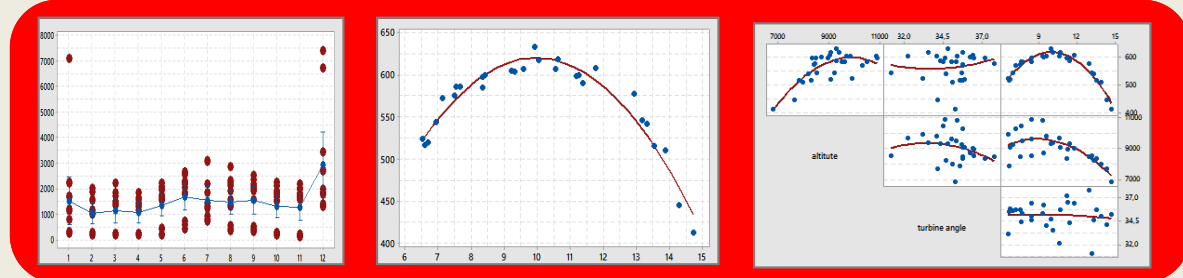
## Kontrol



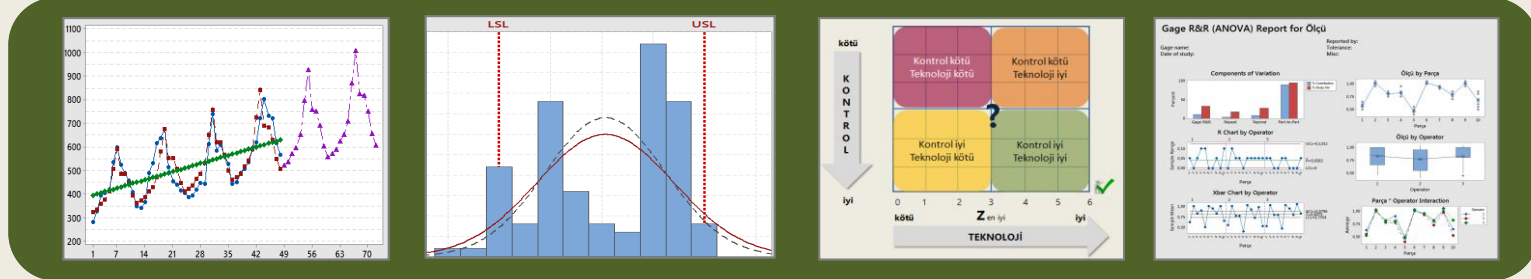
## İyileştirme



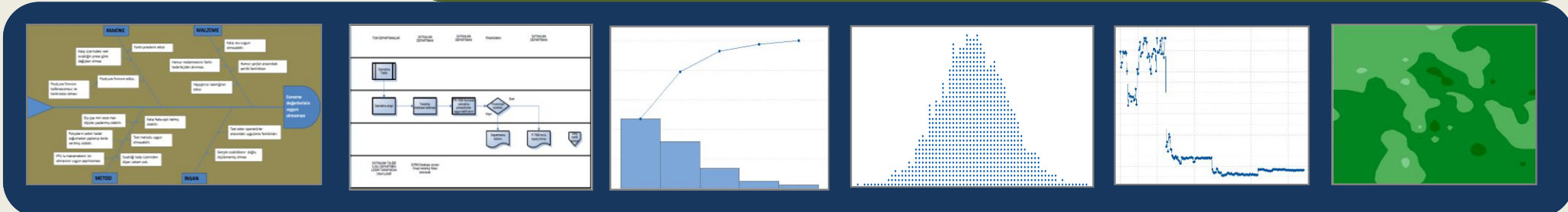
## Analiz



## Ölçme



## Tanımlama





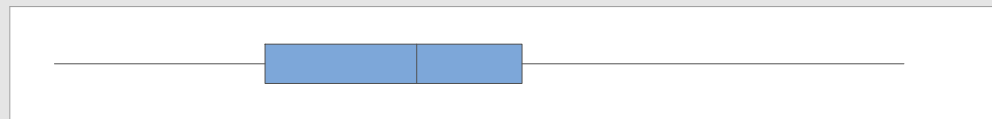
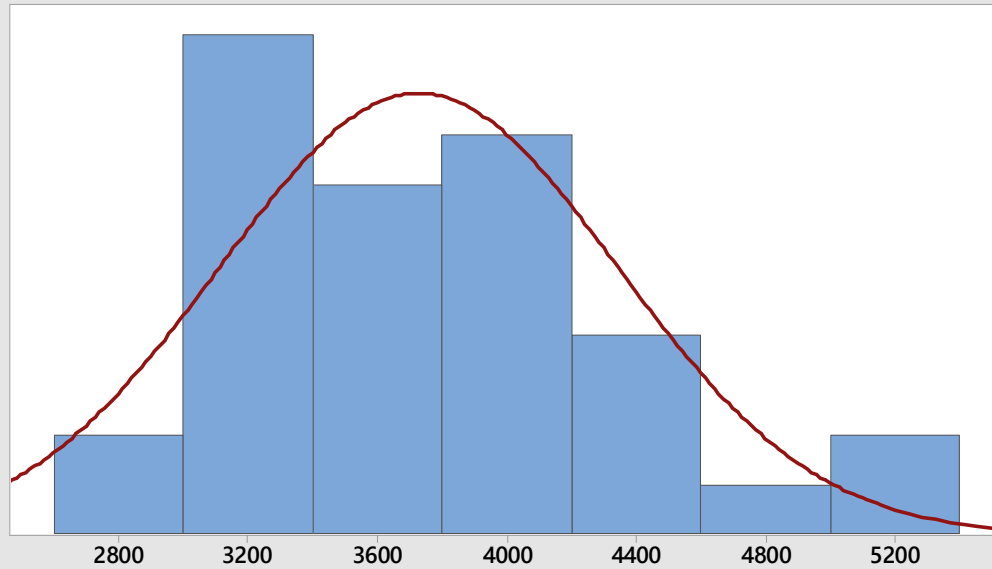
Y

X ler

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10-D
	MAX. KUVVET (N)	MAX. KUV. UZAMA (MM)	MAX. GERİLME (N/MM <sup>2</sup> )	KOPMA KUVVETİ (N)	KOPMADA UZAMA (MM)	KOPMADA UZAMA (%)	AKMA SINIRI (N/MM <sup>2</sup> )	TEST SÜRESİ	KESİT ALANI (MM <sup>2</sup> )	TEST TARİHİ
1	2603,0	10,010	67,765	2603,0	5,080	5,080	67,765	3,5	38,4120	24.10.2019
2	3027,0	6,650	78,804	3026,0	6,870	6,870	78,804	5,2	38,4120	24.10.2019
3	3420,0	6,610	89,035	3420,0	6,680	6,680	89,035	5,0	38,4120	24.10.2019
4	3969,0	5,975	103,327	3969,0	6,060	6,060	103,327	4,7	38,4120	24.10.2019
5	3149,3	6,557	116,928	3149,3	6,657	6,657	116,928	5,0	26,9340	23.08.2019
6	3686,4	5,992	94,538	3686,4	6,062	6,060	94,538	4,7	38,9940	23.08.2019
7	5180,0	19,610	107,692	5178,0	19,940	19,940	107,692	12,8	48,1000	5.08.2019
8	5227,3	6,753	133,998	5227,3	6,857	6,857	133,998	5,1	39,0104	5.08.2019
9	4670,7	6,853	119,729	4670,7	6,940	6,940	119,729	5,2	39,0104	5.08.2019
10	3834,0	5,465	98,282	3834,0	5,535	5,535	98,282	4,4	39,0104	5.08.2019
11	3147,3	8,037	80,679	3147,3	8,107	8,107	80,679	5,9	39,0104	5.08.2019
12	3295,3	6,350	84,473	3295,3	6,457	6,457	84,473	4,9	39,0104	5.08.2019
13	3136,7	4,187	79,729	3136,7	4,260	4,260	79,729	3,6	39,3414	5.08.2019
14	3396,7	6,873	87,148	3396,7	6,953	6,953	87,148	5,2	38,9760	5.08.2019
15	3864,7	8,787	103,889	3964,7	8,840	8,840	103,889	6,3	37,2000	20.07.2019
16	4388,0	9,143	117,957	4388,0	9,220	9,220	117,957	6,5	37,2000	20.07.2019
17	4020,0	9,150	108,064	4020,0	9,223	9,223	108,064	6,5	37,2000	20.07.2019
18	4128,7	9,510	110,986	4128,7	9,573	9,573	110,986	6,8	37,2000	20.07.2019
19	3945,5	8,075	102,303	3930,0	9,038	9,038	102,303	5,7	38,5671	17.07.2019
20	3757,0	13,865	77,067	3756,0	14,115	8,310	77,005	9,4	48,7500	17.06.2019
21	3829,3	12,377	78,550	3829,3	12,547	7,380	78,550	8,4	48,7500	17.06.2019
22	2959,3	14,873	60,704	2958,0	15,750	9,260	60,308	10,3	48,7500	17.06.2019
23	4486,0	13,320	92,020	4483,3	13,677	8,050	91,952	9,1	48,7500	17.06.2019
24	3700,0	7,005	77,000	3700,0	8,060	4,740	77,000	5,0	48,7500	17.06.2019

Örnek proje

## Summary Report for MAX. KUVVET (N)



### Anderson-Darling Normality Test

A-Squared	0,46
P-Value	0,251

Mean	3727,6
StDev	614,1
Variance	377134,8
Skewness	0,684049
Kurtosis	0,314281
N	34

Minimum	2603,0
1st Quartile	3254,3
Median	3721,7
3rd Quartile	4047,2
Maximum	5227,3

### 95% Confidence Interval for Mean

3513,3	3941,9
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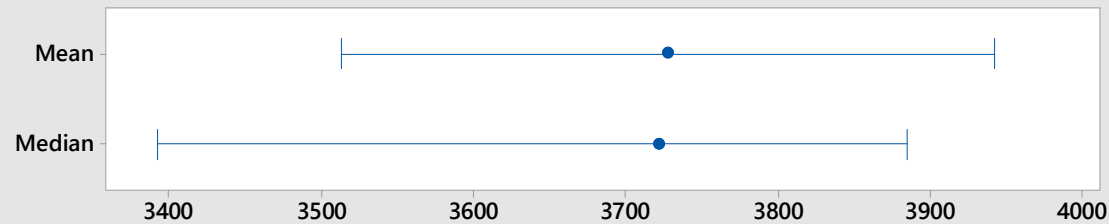
### 95% Confidence Interval for Median

3392,2	3885,2
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### 95% Confidence Interval for StDev

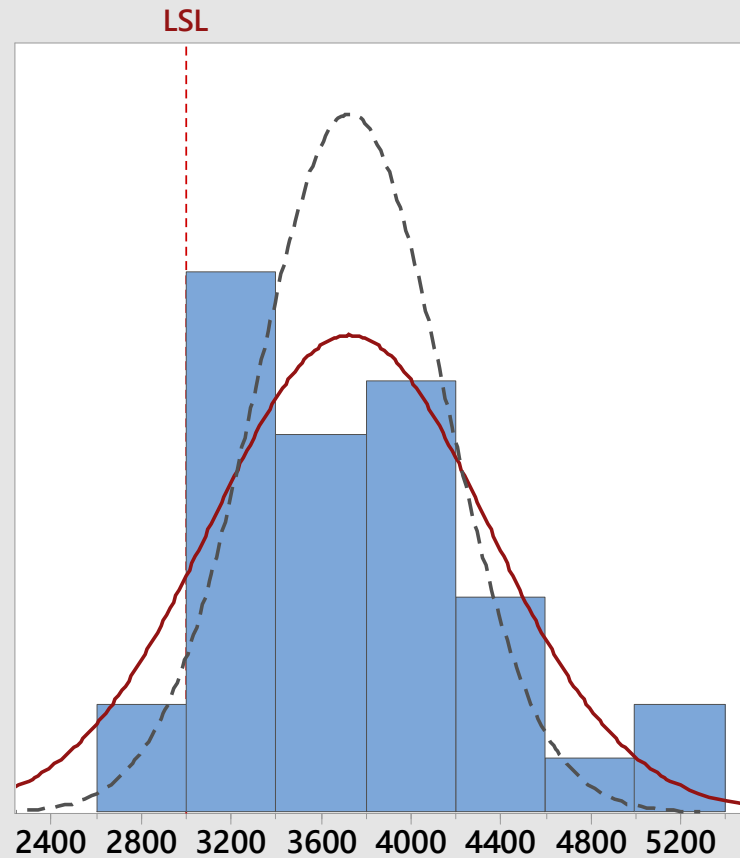
495,3	808,3
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### 95% Confidence Intervals



## Process Capability Report for MAX. KUVVET (N)

Process Data	
LSL	3000
Target	*
USL	*
Sample Mean	3727,59
Sample N	34
StDev(Overall)	614,113
StDev(Within)	419,504

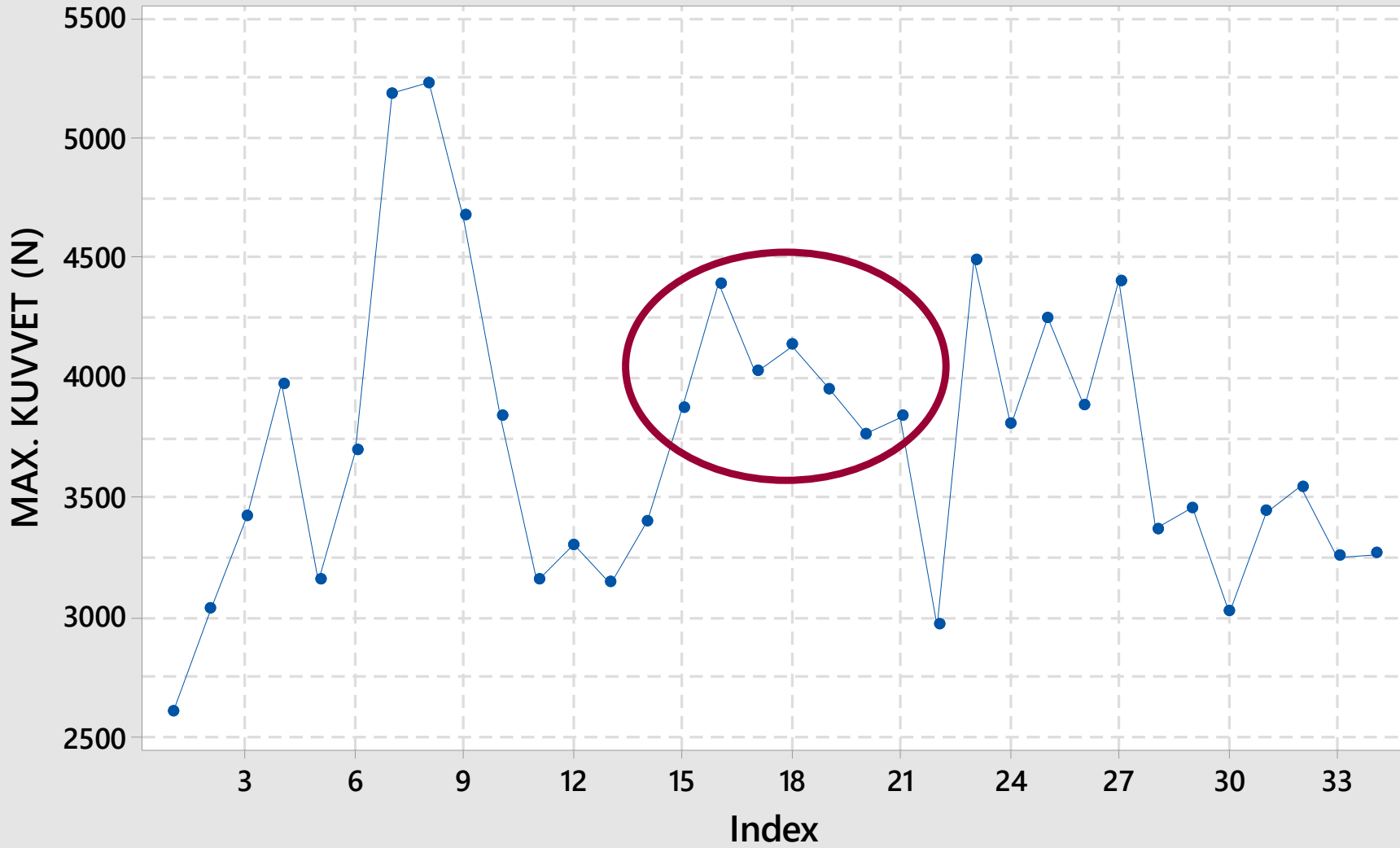


—	Overall
- - -	Within

Overall Capability	
Z.Bench	1,18
Z.LSL	1,18
Z.USL	*
Ppk	0,39
Cpm	*
Potential (Within) Capability	
Z.Bench	1,73
Z.LSL	1,73
Z.USL	*
Cpk	0,58

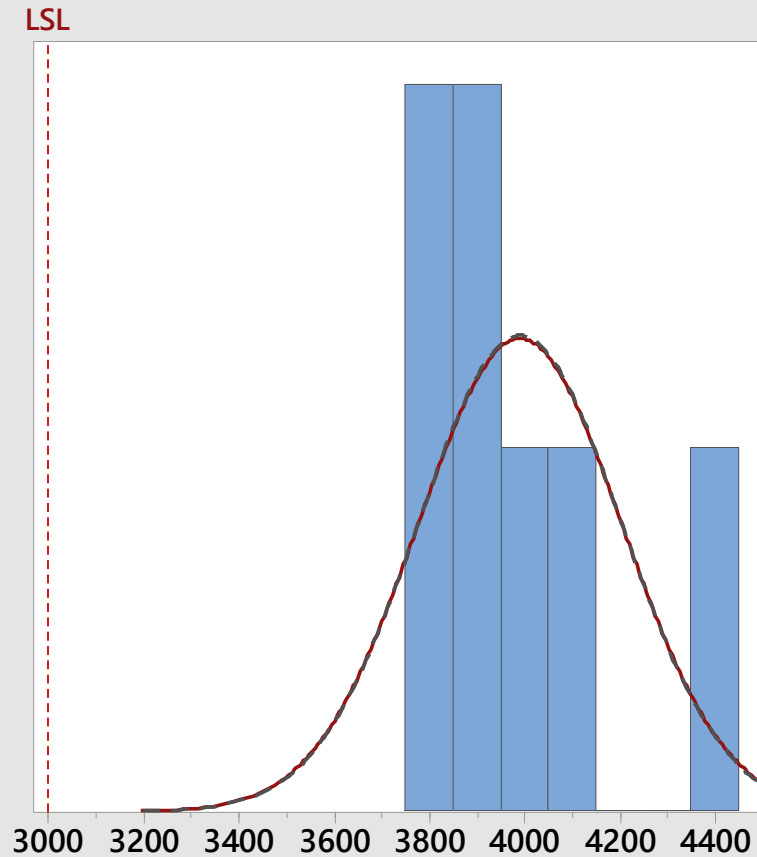
	Observed	Performance	
		Expected Overall	Expected Within
% < LSL	5,88	11,81	4,14
% > USL	*	*	*
% Total	5,88	11,81	4,14

Time Series Plot of MAX. KUVVET (N)



## Process Capability Report for en iyi

Process Data	
LSL	3000
Target	*
USL	*
Sample Mean	3990,46
Sample N	7
StDev(Overall)	214,606
StDev(Within)	213,357

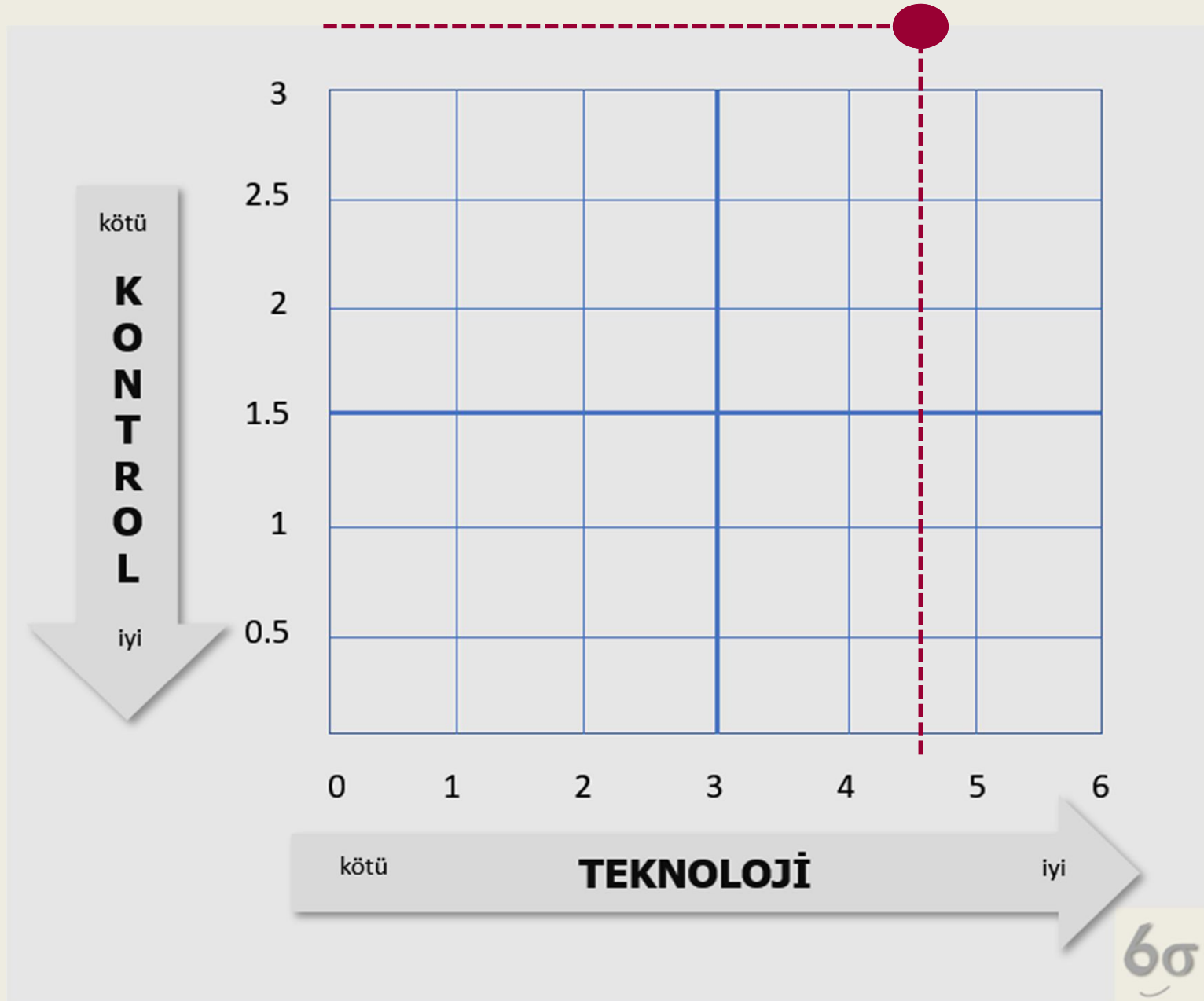


— Overall  
- - - Within

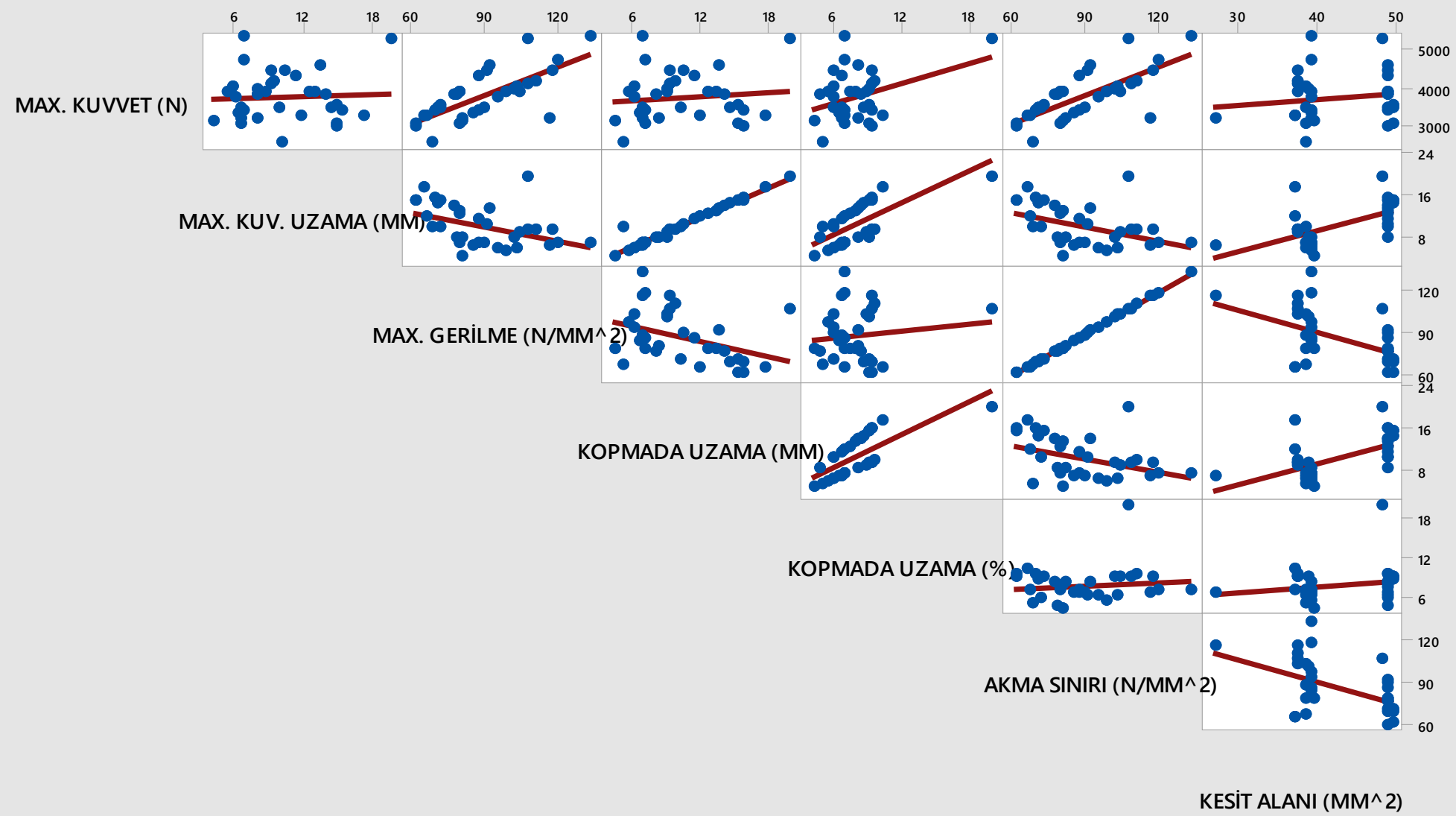
Overall Capability	
Z.Bench	4,62
Z.LSL	4,62
Z.USL	*
Ppk	1,54
Cpm	*

Potential (Within) Capability	
Z.Bench	4,64
Z.LSL	4,64
Z.USL	*
Cpk	1,55

	Observed	Performance	
		Expected Overall	Expected Within
% < LSL	0,00	0,00	0,00
% > USL	*	*	*
% Total	0,00	0,00	0,00



## Matrix Plot of MAX. KUVVET ; MAX. KUV. UZ; MAX. GERİLME; ...





Regression X

C1	MAX. KUVVET (N)
C2	en iyi
C3	MAX. KUV. UZAMA
C4	MAX. GERİLME (N)
C5	KOPMA KUVVETİ (
C6	KOPMADA UZAMA
C7	KOPMADA UZAMA
C8	AKMA SINIRI (N/MM
C9	TEST SÜRESİ
C10	KESİT ALANI (MM
C11	TEST TARİHİ

Responses:

'MAX. KUVVET (N)'

Continuous predictors:

'MAX. KUV. UZAMA (MM)' 'MAX. GERİLME (N/MM<sup>2</sup>)' 'KOPMADA UZAMA (MM)'  
'AKMA SINIRI (N/MM<sup>2</sup>)' 'KESİT ALANI (MM<sup>2</sup>)'

Categorical predictors:

Model... Options... Coding... Stepwise...

Select

Graphs... Results... Storage...

Help

OK Cancel

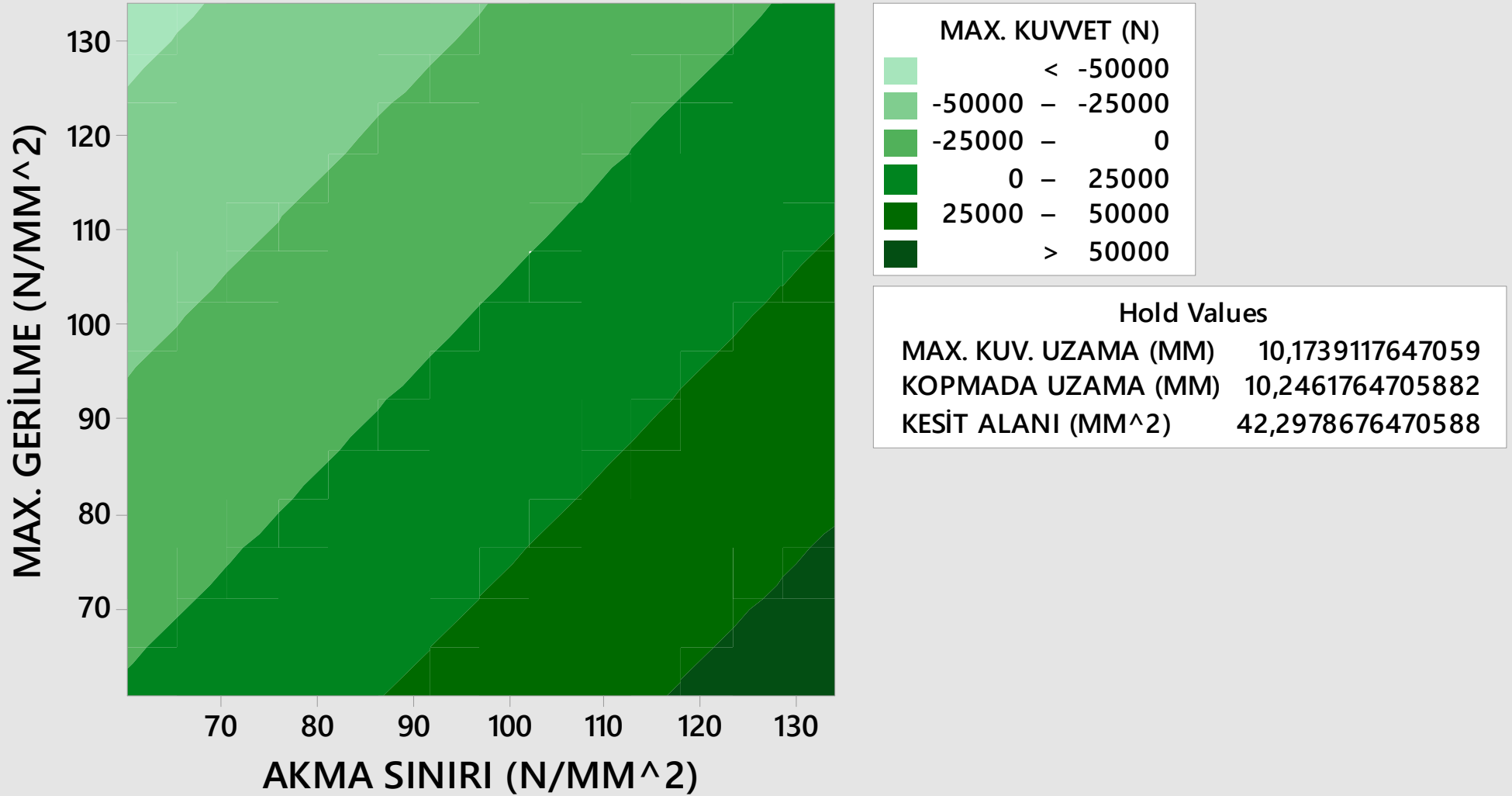
## Regression Analysis: MAX. KUVVET versus MAX. KUV. UZ; MAX. GERİLME; KOPMADA UZAM; ...

### Analysis of Variance

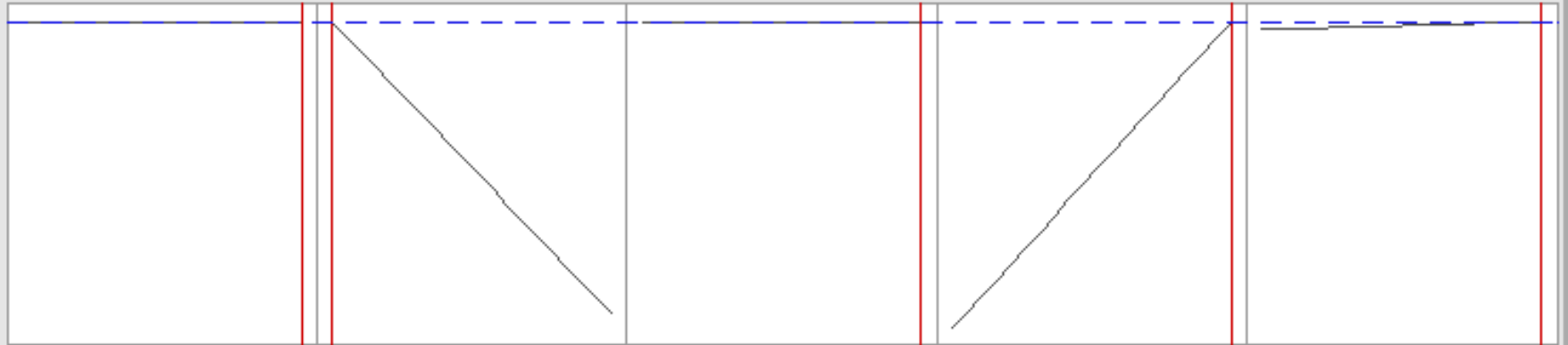
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	5	11486150	2297230	67,05	0,000
MAX. KUV. UZAMA (MM)	1	202	202	0,01	0,939
MAX. GERİLME (N/MM <sup>2</sup> )	1	423135	423135	12,35	0,002
KOPMADA UZAMA (MM)	1	3460	3460	0,10	0,753
AKMA SINIRI (N/MM <sup>2</sup> )	1	460940	460940	13,45	0,001
KESİT ALANI (MM <sup>2</sup> )	1	2504010	2504010	73,09	0,000
Error	28	959298	34261		
Total	33	12445448			

### Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
185,096	92,29%	90,92%	82,35%

Contour Plot of MAX. KUVVET vs MAX. GERİLME (N/MM<sup>2</sup>); AKMA SINIRI (N/

Optimal		MAX. KUV	MAX. GER	KOPMADA	AKMA SIN	KESİT AL
D: 1,000	High	19,610	133,9980	19,940	133,9980	49,4050
<u>Predict</u>	Cur	[19,610]	[60,7040]	[19,940]	[133,9980]	[49,4050]
	Low	4,1870	60,7040	4,2630	60,3080	26,9340



MAX. KUV  
Maximum  
 $y = 6,542E+04$   
 $d = 1,0000$

Deney geçerli (D= 1.000)  
Maximum Kuv. İçin  
Gerilim min  
Akma sınırı max olmalı