

DST 20 September 2004.



A “Natural Rule-of-Thumb”

Some work has been done on the idea that a “Natural Rule-of-Thumb” exists which can be expressed as:-

$$\frac{\text{Effectivity (EY)} \times \text{Flexibility (FY)}}{\text{Complexity (CY)}} = \text{Constant}$$

Where:-

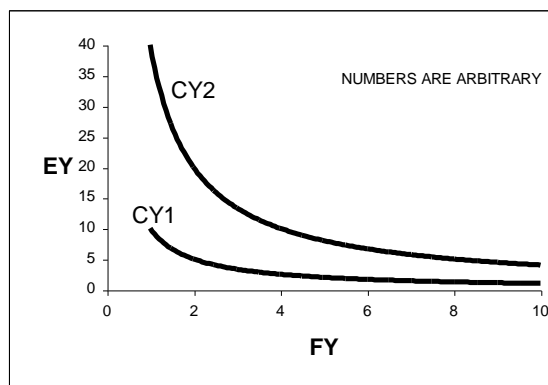
Effectivity = Getting the most out of a *particular* situation
(note – this word has been invented for the purpose);

Flexibility = Ability to operate over *a range of situations*
without unacceptable losses at the extreme;

Complexity = Number of elements involved.

CY is, of course a powerful driver of lifetime costs and its level may be either a choice restricted by such costs (say, CY1) or limited only by the current state of the art (say, CY2).

The idea can be illustrated by a diagram:-



It is not possible to give the proposed expression any *real* numbers in the general case but a way to make the point is to give examples. Some tables are attached for this purpose. It will be seen that they are drawn from 3 areas:-

- A. Products;**
- B. Production;**
- C. Operations.**

Conclusion

The “Natural Rule-of-Thumb” can provide a qualitative (and in some cases , it is believed, a quantitative) guide to understanding many situations.

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<u>EXAMPLE</u>	<u>EFFECTIVITY (EY)</u>	<u>FLEXIBILITY (FY)</u>	<u>COMPLEXITY (+ACY)</u>	<u>Remarks</u>
<u>A. PRODUCTS</u>				
1. Internal Combustion Piston Engines	Peak Power Swept Volume	Peak Power RPM Peak Torque RPM	2 Stroke <ul style="list-style-type: none"> Variable Exhaust Capacity Variable Exhaust Port Height 4 Stroke <ul style="list-style-type: none"> Variable Camshaft Timing Variable Inlet Pipe Length Variable Exhaust Pipe Length 	Also:- <ul style="list-style-type: none"> Variable Ignition Timing Variable Carburetter Choke Area Variable Air/Fuel ratio Also <ul style="list-style-type: none"> Clutch & Gearbox cf. External Combustion Engine <ul style="list-style-type: none"> Condenser Superheater
2. Gas Deflection Devices:- <ul style="list-style-type: none"> Wings Propellers Axial Compressors 	Subsonic <ul style="list-style-type: none"> Wings & Propellers:- Lift Drag Axial Compressors:- Pressure Ratio Supersonic <ul style="list-style-type: none"> Wings:- Maximum Speed 	Stalling Incidence Peak Lift Coefficient Incidence Acceleration Rate <ul style="list-style-type: none"> Inflow Distortion Tolerance 	Wings Slots; Flaps; Vortex Generators; Blowing Propellers Variable Pitch Variable Stagger Blading <ul style="list-style-type: none"> Bleed Valves Variable Sweep <ul style="list-style-type: none"> Fuel Transfer on Ogee Planform 	
3. Jointed Assemblies	Performance/Weight	Maintainability	Planned Cutting & Rejoining	<ul style="list-style-type: none"> Lightweight Aero Engine with GRP Compressor Casing (RB162-86) Nuclear Submarine Core replacement
4. Carbon Steel	Hardness (Ultimate Tensile Strength)	Ductility (% Elongation)	Case-Hardening	
5. Surface Vehicle Movement	Load/Power	Range of Surface Hardness	<ul style="list-style-type: none"> Christie Car/Tank Duplex-Drive Tank DUKW Amphib. Lorry Roebling Landing Vehicle (Tracked) 	Range of Vehicles from Rail - Road - Off-Road - Hovering to Floating

A. PRODUCTS Continued:

<u>EXAMPLE</u>	<u>EFFECTIVITY (EY)</u>	<u>FLEXIBILITY (FY)</u>	<u>COMPLEXITY (+ACY)</u>	<u>Remarks</u>
6. Vehicle Steering	Stability = Automatic Path -Keeping	Control = Ability to change path	Motion Sensors and Micro-Chip Computer linked to servo controls	
7. Surface Vehicle Suspension	Cornering Speed	Minimised Centre -of -Gravity- Displacement over Bumps	<ul style="list-style-type: none"> • Roll-Stiffening Bars • Active Suspension i.e. Motion Sensors and Micro-Chip Computer linked to servo suspension 	<u>Also</u> :- Ground-Effect control by Active Suspension
8. Weapon Systems:- <u>Mobile</u> <ul style="list-style-type: none"> • Warships • Fighters • Bombers • Tanks <u>Static</u> <ul style="list-style-type: none"> • Fortifications 	Offensive Power	Defensive Resistance	<u>Mobile</u> :- <ul style="list-style-type: none"> • Greater Power/Weight Propulsion Systems (e.g. for Warships:- Sail to Steam with Coal then Oil Fuel, then Gas Turbines) • Multiple Engines <u>Static</u> :- Turrets	Fossil Fuel required extra Complexity of shore systems for supply 15thC Bastioned trace 20thC Atlantic Wall
9. Structures & Mechanisms	Performance/Weight	Fail-Safe	<u>Passive</u> <ul style="list-style-type: none"> • Crack-Stoppers • Inspection Systems • Fatigue Gauges <u>Active</u> <ul style="list-style-type: none"> • Constant-Mesh Gearbox v. Sliding Mesh (e.g. M125) 	Especially Airframes
10. Machine Tools	Accuracy	Range of Operations	Active Control by Micro-Chip Computer	
11. Vertical Take-Off-and- Landing (VTOL) Flight	Wing-borne Flight	Land Anywhere	<ul style="list-style-type: none"> • Rotating Wings (Helicopters) • Swivelling Nozzles (Harrier) • Tilt-Wing 	

<u>EXAMPLE</u>	<u>EFFECTIVITY (EY)</u>	<u>FLEXIBILITY (FY)</u>	<u>COMPLEXITY (+ACY)</u>	<u>Remarks</u>
<u>B. PRODUCTION</u>				
1. Plant:-				
• Design & Equipment	Cheap Products	Range of Products	<ul style="list-style-type: none"> • Experimental Workshop upstream; • Modification Centre downstream; of the Main Production Plant 	
• Size	Cheap Products	Range of Output Rates	<ul style="list-style-type: none"> • Sub-Contract 	
2. Material Utilisation	(Output/Input) weight ratio	Design Changes	?	
3. Product Design	Cheap Product Manufacturing Specification	Chance of a successful Product	Multiple Design Teams	
4. Energy Generation	Cheap Power	Resistance to Fuel Supply Interruptions	Multiple Fuels & Conversion Processes	
5. Miscellaneous:-				
• Customer-Choice Catering	Cheap Meals on Demand	Wide Menu	Deep-Frozen Food + Freezer + Microwave Oven	
• Pedestrian Crossing	Free Traffic Flow	Pedestrians crossing on Demand	Active Control - People Sensors (Puffin Crossing)	
• Road Transport	Cheap Running Costs (Motor-Way)	Go-Anywhere (Byway)	?	

<u>EXAMPLE</u>	<u>EFFECTIVITY (EY)</u>	<u>FLEXIBILITY (FY)</u>	<u>COMPLEXITY (+ACY)</u>	<u>Remarks</u>
C. OPERATIONS				
1. Organisations	Cheap Operations	Chance of Successful Operations	<ul style="list-style-type: none"> • Project & Function Matrix • Reserves • Reconnaissance • Fortifications • Mobility Enhancement 	
2. Language:-	Rapid Communication	Resistance to:-	Redundancy	
<ul style="list-style-type: none"> • Open 		<ul style="list-style-type: none"> • Loss of Signal • Noise 		
<ul style="list-style-type: none"> • Secret 	Rapid Communication	Resistance to Eaves-Dropping	<ul style="list-style-type: none"> • Cypher Machines • Scramblers • UHF Transmissions (Line of Sight) 	
3. Record Preservation	Cheap Retrieval	Chance of Survival	<ul style="list-style-type: none"> • Microfiche • Computerisation 	
4. Government:-	Rapid Decision-Making	Chance of Correct Decisions	Cabinet based on Democracy + Civil Service	
<ul style="list-style-type: none"> • Peaceful 				
<ul style="list-style-type: none"> • Warlike 	Rapid Decision-Making	Chance of Correct Decisions	War Cabinet + Minister of Defence + Chiefs of Staff + Theatre Commanders	<u>Special Case:-</u> Allied Warfare
5. (Capital-Asset) Resource-Sharing	Cheap Operations	Resistance to Shocks	Common Back-Up	