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Factors affecting Economic Production Quantity (EPQ) at traditional red brick kilns of Sindh, Pakistan

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Abstract

Objective of the research article is to find optimum brick lot size that is to be manufactured at kiln in a cycle (*chakar*) i.e. EPQ (Economic Production Quantity) , to find *bhelli (*inferior*)* brick production quantity (how to get quality of production), to find best way to produce (by either rule of the thumb production or EPQ production), to find reasons of unwanted stoppage of kiln production, to find ways manage seasonal production and to find ways to cut cost per brick at a kiln.

EPQ is followed to avoid unnecessary blockage of funds and excess storage costs. It is to find sweet spot where setup cost (ordering cost) is balanced against holding costs. There are two costs associated with inventory at kiln. Ordering cost is cost of putting an order. Average order size is

5000 bricks per trolley. Holding cost tells about carrying costs to hold brick inventory for some time at kiln.

Sample includes random 90 kilns. Research is applied, with questionnaire form and survey technique used. There are many districts of the North Sindh. But for this research only three districts are chosen i.e. *Khairpur, Sukkur,* and *Larkana*. North Sindh traditional kilns are divided into three categories by scholar based on production level, infrastructure, land area and annual operating time i.e. small, medium and large kilns.

Average cycle/*chakar* production is 68952, 461726 and 488767 bricks for small, medium and large kilns. EPQ is 169286, 756556 and 630234 bricks per batch /cycle for small, medium and large kiln. It is suggested that 1.5, 0.7 and 0.31 times production per cycle should be increased to meet potential production level at small, medium and large kilns.

Kilns can be economically efficient and productive when they match their input with output via a system of check and balance. This improves economic production quantity.

Key words: Economic Production Quantity, EPQ, Holding cost, Ordering cost, brick, kiln production

1. Introduction

Kilns are factories that operate in cycles (*Chakar*) of production. Bricks are made in batches. Labour and raw materials are procured. Total output by the kiln fluctuates with change of the seasons. Usually construction activity takes pace during long days of the summer. Brick Production requires clay, water, capital, labour, etc. Bricks are available in many types depending on size and quality.

Brick production is hazardous job. There are many stakeholders in this process. *Munshi* (manager) operates a kiln. He interacts with owner, government officials, *Jamadars*, land rent seekers, sales agents, and procures all inputs for the brick production. He takes orders and keeps tab on the inventory. He utilizes current assets i.e. diesel generator, tractor trolley, motorcycle, etc to maximize the returns for the owner. *Munshis* work with *Mistrsi* and labour. They are all locally peer trained. Labour learns during work. Management becomes skilful in due time. Kilns operate better in summer. Sometimes rain, theft and over burning cause loss. Overall production rate is affected. Kilns operate near towns / villages. This causes easy access of local labour, water and fuel, etc. There are local laws which control kilns. Kilns can't burn rubber and plastic as fuel. Crops in the vicinity are also affected due to ash/ soot falling from kiln chimneys and higher heat radiation. Kilns utilize animals too. There are trees inside kilns depending on their area. Kilns are labour intensive in nature. Labour is required in greater proportion as compared to capital. Kilns require funds for smooth operation. Financing a kiln is tricky. There is a tax on specific amount of brick production. Taxes are usually not paid. Most kilns operate on debt. This increases cost of production.

EPQ is optimum brick lot size that is to be manufactured in a production unit (*chakar*) to avoid unnecessary blockage of funds and excess storage costs. Further EPQ and its constituents are explained as,

- EPQ (Economic production quantity): It is optimum brick lot size that is to be manufactured in a production unit (*chakar*) to avoid unnecessary blockage of funds and excess storage costs.
- Ordering cost: It is logistical cost. These are costs for purchasing a clay/fuel order. It may include, One Phone cost , Unloading of clay (labour), Clay Transport cost, etc.
- Holding cost: This is carrying cost. It includes cost of storage, rent, electricity, depreciation, spoilage, theft, interest, insurance, and taxes in a year. There is no spoilage cost for fuel.
- Annual Total Production: Traditional kilns are divided into three categories by scholar based on production level , infrastructure, land area and annual operating time i.e. small, medium and large kilns. Production of average bricks is 230429, 2465477 and 7147059 bricks for small, medium and large kilns respectively. Large kilns can produce 15 Million bricks in a year. Average acreage is 1, 3.5 and 5.5 acres for small, medium and large kilns. On the average there are 21, 49 and 108 labourers at small, medium and large kilns respectively. 35 kilns don't produce bricks in winter season as it is difficult to dry and demand is also low. Net profit is 281808, 3647403 and 14908971 Rs for small , medium and large kilns calculated in income statement.
- Potential Production: How much kiln can produce based on full usage capacity of labour , input etc. is called potential production.

- Potential Production Factor: It means how many times more production can be completed based on available resources. (PPF= 365/total working days)

Objective of the research article is to find optimum brick lot size that is to be manufactured at kiln in a cycle (*chakar*) , to find *bhelli (*inferior*)* brick production level, to find best way to produce (by either rule of the thumb production or EPQ production), to find reasons of unwanted stoppage of kiln production, how to manage seasonal production, how to cut cost per brick, how to get quality of production, to find optimal product mix, and how to get economies of scale at kilns.

2. Literature Review

India is the second largest producer of bricks in world after China. (Palash Patra et al., 2015). (Mayuree Das et al, 2018) (Siriman Naveen et al, 2016)Brick kiln industry is unorganized and traditional in nature. India is, after China, second largest producer of bricks with estimated annual production of 140 billion from 10000 kilns. 1.2 crore people are employed by this industry. Industry is comprised of people, market, water, and raw material. (Rizwan Khan et al., 2007)

Indian Brick sector constitutes 0.7% of GDP, and growing at the rate of 9%. 10% of GDP of India belongs to construction sector. Kilns are small scale, unorganized and family financed. Kilns use exploitive methods. Production capacity of kilns increased from 140 billion (2009) to 200 billion (2015) amounting 13% of world brick production (Siriman Naveen et al, 2016)

Term brick originated from period of Middle English. In the Dutch it was called *bricke* , in the old French *brique* , in new French *briquette*. Briquette means compressed coal dust or peat. In Sanskirit it is called *Aishtakam*. According to their research, brick industry is the oldest one in the human history. Bricks have survived 5000 years period. Bricks usage goes back to Neolithic period 10000B.C. Bricks have been used in the forms of, Green bricks, Sun dried bricks, and Dried bricks (Siriman Naveen et al, 2016)

Brick making is technical process involving many step i.e. procurement, tempering, moulding, drying/loading, firing and sorting. Kilns function at full capacity during December to March. (Palash Patra et al., 2015) Brick is ceramic in nature formed inside fire temperature range of 900-

1200^{o}C. Bricks are not burnt properly. Some are highly burnt while some are burnt at low temperature. Thus bricks are categorized on the basis of their burning in kiln. Bricks may differ because of the clay/soil used inside it. They conducted test to check quality of bricks made in Punjab on the basis of absorption of water and strength of brick. Water absorption quality of a brick was performed by dipping a brick in water for 24 hours at 27^{o}Cand re-measuring it weight. The brick is said to be durable if it does not absorb lot of water. More it is durable less it absorbs water. Including Boron rich materials cause bricks to be more durable with this respect. (Attiqur Rehman Tariq et al., 2014)

- Process of brick making has many steps(Mayuree Das et al, Assam, India, 2018)
- Raw bricks making: Patheras are involved I making raw bricks by mixing water and clay in right proportions. They work as family unit. Kiln owner fetch clay from nearby places at the cost of 400-500Rs per trolley. This cost depends on the distance and location of kiln. Sun dries bricks for 2-3 days. Green Bricks, which are dried in sun light without use of fire. It is natural way.
- Carriers of dried bricks to storage: *Kessarejas* are involved in taking bricks to storage place.
- Arrangers of bricks in line: Load *Mistrys* arrange bricks in a position that is best for burning.
- Covering arranged bricks with sand etc.: *Rabbishmen* cover bricks with sand dust.
- Burning/firing bricks: Firemen are the most important labourers at kilns who fire the bricks in the chimney.
- Carrying fried bricks to storage: *Nikashi* or *Pakkareja* take fried bricks out of kiln for final storage.
- Completing the first three steps do not require skill. Women duties were limited to first three steps only. It was discrimination. (Dr. Inam Rubab et al, 2020)

Rural kilns are usually clamp kilns with energy usage of 1.5-3.0 MJ/kg usually in form of coal) (Rizwan Khan et al., 2007). Kilns don't work during monsoon time i.e. June to September. (Sushmita Dey et al., 2015)

Siriman Naveen et al, 2016 have used Michael Porter model of Comparative Analysis at Hyderabad, is. They have analysed how a value chain is created and sustained in brick industry from producer to consumer, and how value is added to product. Value chain includes bringing product from conception and this includes Production phases, Delivery and Disposal after usage.

Palash Patra et al, 2015, researched production, labour and environmental aspects of kilns on banks of Damodar river, India, West Bengal. They identified problems associated with kilns, labour and kiln villagers/ neighbors. (Palash Patra et al., 2015). Rizwan Khan et al, 2007, conducted environmental impact study of brick kilns in Ujjain city on the bank of river Kshipra (Rizwan Khan et al., 2007) Kaleemullah sheikh et al., Sindh 2020, conducted Research study on brick kilns in Tando Hyder to assess their environmental impact. Tando Hyder is part of North Sindh. (Kaleemullah sheikh et al., Sindh 2020)

Abdalla et al, Sudan, 2012, have given geographic details of target population area lying on the bank of river Nile. There are three climate seasons having average monthly temperature ranging between 22.1 to 33.7 °C, i.e., hot dry summer (April to June), autumn (July to September), and cool dry winter (October to March) (Elagib& Mansell, 2000). Average rainfall ranges between 100 and 300 mm which usually is concentrated in the months from July to August. And in these months river Nile causes floods as its width increases from 400m to 1000m. (Barakat, 1995; Hamad & El-Battahani, 2005).

Main reasons of Brick kiln industry bloom are cheap raw materials, low land rate, availability of labour, low cost of carrying raw material, and proximity of area to brick market. Big towns are connected by highway (Palash Patra et al., 2015).

Kiln industry belongs to informal economic sector of Pakistan. (Muhammad Sohail et al., 2020). ILO has defined informal economy as economic activity that is not covered or not sufficiently covered by formality in agreements either in practice or law. It is also called as unregulated, non-standard, flexible, grey, unobserved, undocumented, unorganized or dark economy which falls not in the realm of sate enacted observation, taxation and regulations. Kilns are not registered to authorities so as to save taxes. Labourers receive income below minimum wage, live sub standard life and have no right to make union. (Muhammad Sohail et al., 2020)

The Main clay for brick making is 75 % surface soil and 25% fly – ash. (Palash Patra et al., 2015) Ash-Clay bricks having 10%more ash are more durable. Brick made from Non calcareous clay /soil is of the best quality. Also bricks formed at heating temperature of 1000°C are more durable because volume of brick decreased, density increased, water absorption rate decreased. (Attiqur Rehman Tariq et al., 2014) Additives used in brick making are wood fuel, husk of soybean, fly- ash and some farm waste products. Bricks are added with additives for increasing strength. (Rizwan Khan et al., 2007).

Additives are added to lower down melting temperature and to reduce fuel usage. High temperature helps in forming bonds between clay particles while bricks are burnt / baked inside kiln. So additives are important to control durability, shape, weight and texture of the burnt clay bricks. (Kazmi et al., 2017).Additives decrease porosity of bricks (Chidiac and Federeco, 2007) Fly ash is waste material which is economical to increase brick strength. It is friendly to environment too.(Christy and Tensing, 2011) . Waste materials, as additives, that can be used in bricks are

- Fly ash (Kazmi et all, 2016a)
- Marble powder (Eliche – Quesada et al., 2012) (20% replacement)
- Rice husk ash (Kazmi et all, 2016a))(5 % replacement)
- Sugar Bagasse Ash (SBA) (Kazmi et al., 2017) (5% replacement)

They made such bricks with SBA by mixing both clay and SBA in determined proportions, and further performed tests on such manufactured bricks. They suggest 5 % addition of SBA to burnt bricks to decrease their weight retaining sufficient strength without decrease in efflorescence. (Kazmi et al., 2017)

FCBTK is dominant kiln technology with 57% usage in Nepal. MCBTK is banned in 2011 in Nepal and replaced by FCBTK. After vehicle emissions Brick kilns are second largest pollution producers in Nepal. (Seshananda Sanjel et al, 2016)

Cheap fuels used at kilns include used motor oil, old tires, garbage and plastics. Kilns use energy inefficiently because heat distributed inside kilns is not even and walls are not properly insulated, so more fuel is consumed. (Seshananda Sanjel et al, 2016)

3. Research Methodology

3.1. Economic production Quantity (EPQ):

It is optimum lot size that is to be manufactured in a production unit to avoid unnecessary blockage of funds and excess storage costs. Formula for EPQ is

- $\sqrt{(2DS)/(H-(1-D/p))}$

D is annual production, p is potential annual production

Formula for ordering cost is

- O.C. = (D/Q)*S

D is annual clay/fuel demand

S is cost of placing an order. It is usually transport cost of a clay/fuel order.

Average S: It is average of costs of placing orders for both clay and fuel.
Formula for holding cost is

- H.C= (Q/2)*H

Q is quantity in an order

H = Sum of All holding Costs /Total production

Average H: It is average of H rate for both clay and fuel.

- Production Rate = Annual production/ Potential production
- Potential Production = Potential production factor * Annual production
- Potential production factor = 365/total working days

4. Results

It is for the convenience that demographic distribution of North Sindh is used here in this research. There are many districts of the North Sindh. But for this research only three districts are chosen i.e. *Khairpur, Sukkur,* and *Larkana*. North Sindh traditional kilns are divided into three categories by scholar based on production level, infrastructure, land area and annual operating time i.e. small, medium and large kilns.

4.1.Finding best way to produce (by either rule of the thumb production or EPQ production)

Production of average bricks is 230429, 2465477 and 7147059 bricks for small, medium and large kilns respectively. Large kilns can produce 15 Million bricks in a year. Average acreage is 1, 3.5 and 5.5 acres for small, medium and large kilns. On the average there are 21, 49 and 108 labourers at small, medium and large kilns respectively. 35 kilns don't produce bricks in winter season as it is difficult to dry and demand is also low. Net profit is 281808, 3647403 and 14908971 Rs for small, medium and large kilns calculated in income statement.

Table 1: Production at kilns

Size	Large	medium	Small
Production	7147059	2465476.19	230428.6
Labour relevant	82.58824	33.85714286	13.5
Ideal/standard hours	116028.1	44637.27482	9611.63
Per day	8.852941	8.666666667	8.142857
Actual hours	128657.6	48164.74285	9771.024
More %	0.083193	0.066288738	0.014286
Productivity per employee (Bricks)	89817.25	76759.34508	17588.64
Productivity per hour (Bricks)	56.12718	51.16197422	22.94333
Efficiency (work hours)	91.68067	93.37112623	98.57143

Annual Total Production: It is the indicator of the operational health of a kiln. Large kilns operate 24 hours of a day. Large kilns have Chimneys and produce 30000 to 50000 bricks on daily basis depending on the demand / consumption. It is range. Total stacking capacity of the kiln is 4 to 5 lakh bricks. Bricks can be stacked in series or parallel but usually done in sequence/series. During research it was not observed that any kiln has two chimneys or that any kiln operates in two or more shifts. *Mistri* puts fires on bricks usually work for 24 hours along with *Jalaiwala* labourers. New bricks (30k-50k) are continually stacked inside chimney while prepared /burnt/completed bricks (30k-50k)are rolled /pulled/carried out at large kilns. Small kilns remain active for specific duration. Theirs is no any big stacking capacity. They prepare, dry, sprinkle sand, and burn bricks in open. Production capacity per *chakar* ranges from 1 lakh to 20 lakh bricks. Also small kilns use different fuel. Fuel affects the quality of the bricks manufactured. For large kiln average production is 7147058 bricks, for medium 2476829 bricks and for small 238461 bricks per annum. Following is the district kiln profile for production level.

Table 2: District Production level profile

Item	Khairpur	Larkana	Sukkur
Chakars	9.363636364	4.4	12.71428571
winter production Kilns	38	5	11
Average Q per chakar	441457.4807	441457.4807	344503.9683
Total working days	230.1509844	230.1509844	239.7805092
Average total production	4088272.727	4088272.727	4575000

Small kilns operate only few specific summer months of the year because of the unavailability of the labour and less demand in the winter. On average small kilns remain active 5.8 months, medium kilns for 8.3 months and large kilns for 9.8 months. Overall 8.5 months activity (average) for all 90 kilns

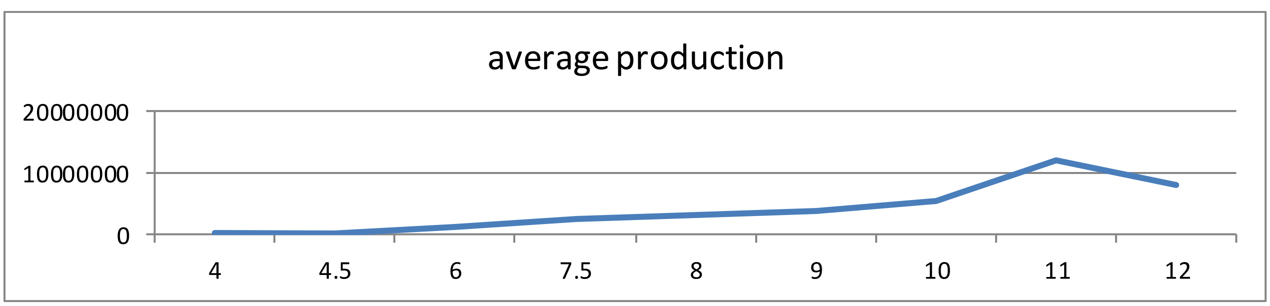

Figure 1: Relationship between active months and production level

Kilns are close for business on all Fridays. On other days kilns operate. Their working day starts very early in summer and late in winter. In winter it is difficult to dry bricks because days are short. Days in active month range from 24 to 26 in quantity.

4.2. Finding optimum brick lot size that is to be manufactured at kiln in a cycle (*chakar*) ,

Chakars or Cycles: Kilns operate in cycles / chakars of production. Dried bricks are stacked into chimneys (*Khuro*) or laid on land in open in case of small kilns. Some small kilns are called *Da'as* in local language. Bricks laid vary in quantity depending on chimney type or capacity, and labour or capital utilization. It usually takes one month to complete one production cycle. In winter relatively less bricks are made due to small day time and less availability of sunlight to dry bricks. This is why small kilns don't operate in winter.

Kiln operators / managers / *munshis* calculate profits on basis of number of successful completion of chakars. Each chakar produce superior as well as interior quality of bricks. Ratio changes for each kiln depending on the use of fuel type/quality, duration of fire, etc.

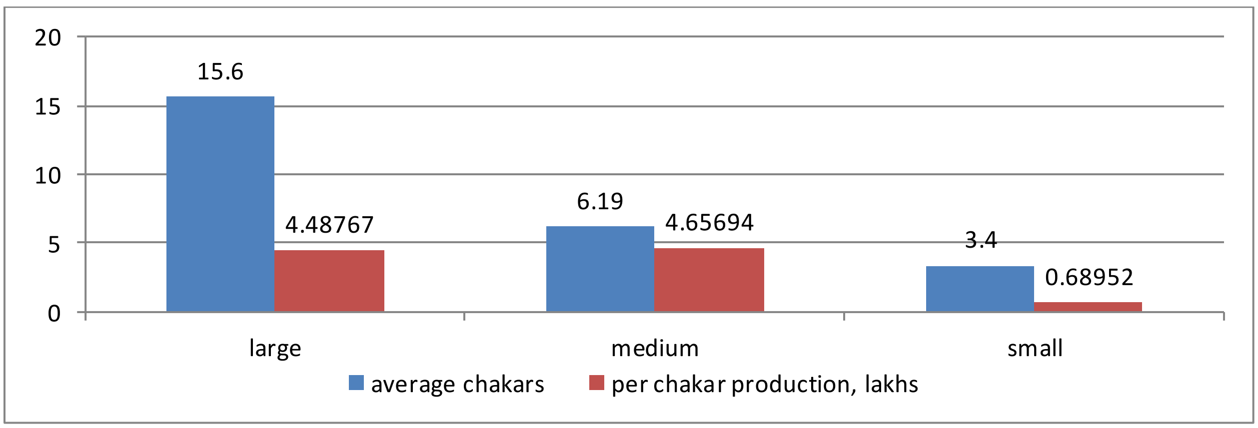

Figure 2: Chakar production relation with chakar quantity

Beginning inventory of Bricks (i.e. last year's unsold brick quantity): Following results were achieved when quantity of unsold bricks of last year was asked. BI for small kilns is 23571 bricks, for medium kilns is 167714 bricks and 196382 bricks. For district khairpur BI is 177121 bricks, for Larkana is 58200 bricks and for Sukkur 127071 bricks.

Ending Inventory of Bricks (i.e. unsold brick quantity in present year): Ending Inventory bricks are 76290, 32424 and 11250 bricks for large, medium and small kilns.. Ending Inventory bricks for large kilns are 42348, 26000 and 11250 bricks for Khairpur, Larkana and Sukkur respectively.

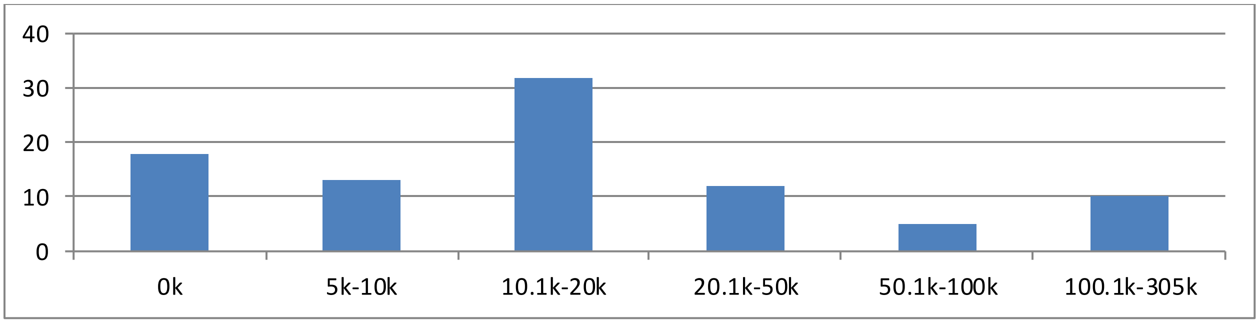

Figure 3: Kilns with levels of ending inventory

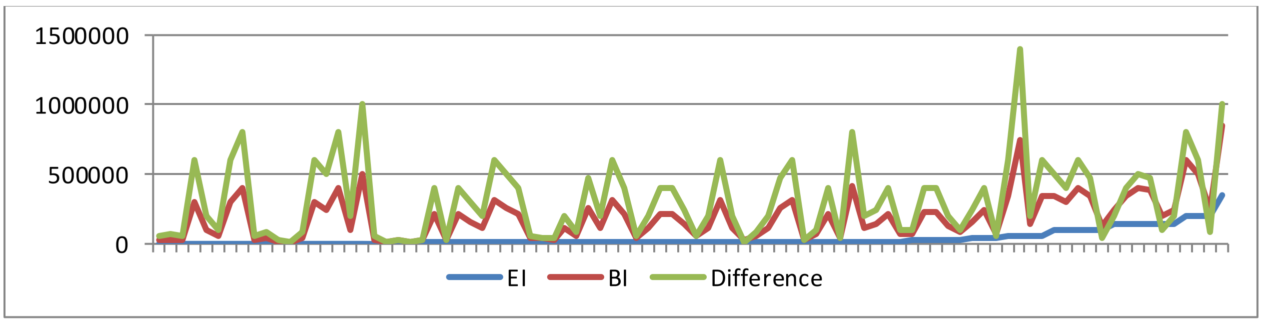

Figure 4: Difference between E.I. and B.I. of the kiln

4.3. Finding *bhelli (*inferior*)* brick production level

Normal/good bricks comparison with Bhelli (Inferior) bricks is as (percentage each)

Table 3: (bricks) normal/good vs *bhelli* percentage each

Kiln type	Bhelli % (not total wasted bricks)	normal bricks
Large	6.823529	93.17647
Medium	6.904762	93.09524
Small	7.357143	92.64286

As kiln size decreases Bhelli brick production, as % of total production, increases. Kiln size is inversely related to Bhelli production. It is easy to make *Qisti* brick as compared to Roof and *Dhero* types of red brick.

Spoilage / Waste / Quality/Bhelli bricks: Kilns consider certain amount of bricks as spoiled based on these three criteria. Average Bhelli bricks for small kilns are 17379, for medium kilns 174921 bricks and for large kilns 482887 bricks.

Table 4: Bhelli orders (*Qisti* bricks vs Non *Qisti* bricks orders)

	Qisti bhelli (Spoil)	Non *Qisti* spoiled	Total
large	61.38394	33.048338	94.432278
medium	23.370211	10.385321	33.755532
small	2.3766136	0.9642991	3.3409127

Usually out of 1000 bricks made 10 to 30 bricks are spoiled due to operation at kilns. It is operational waste. Small kiln operational waste is 16 bricks per 1000, medium kiln 17 bricks and large kiln 20 bricks.

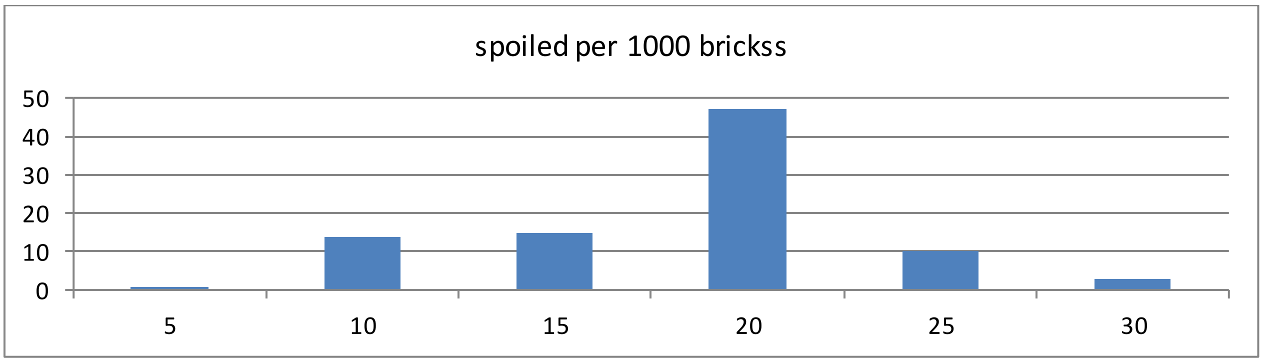

Figure 5: Spoiled per 1000 bricks (spoiled bricks per 1000 Q on X axis) (Kilns Q on Y axis)

Bricks are spoiled also due to rain , horse treading, mismanagement during stacking or carrying etc. spoiled quantity (and orders) of such brick waste is collected /asked in/ by questionnaire form. It is natural waste. Large kiln natural waste is 173529 bricks, medium kiln 101071 bricks and small kiln 5857 bricks.

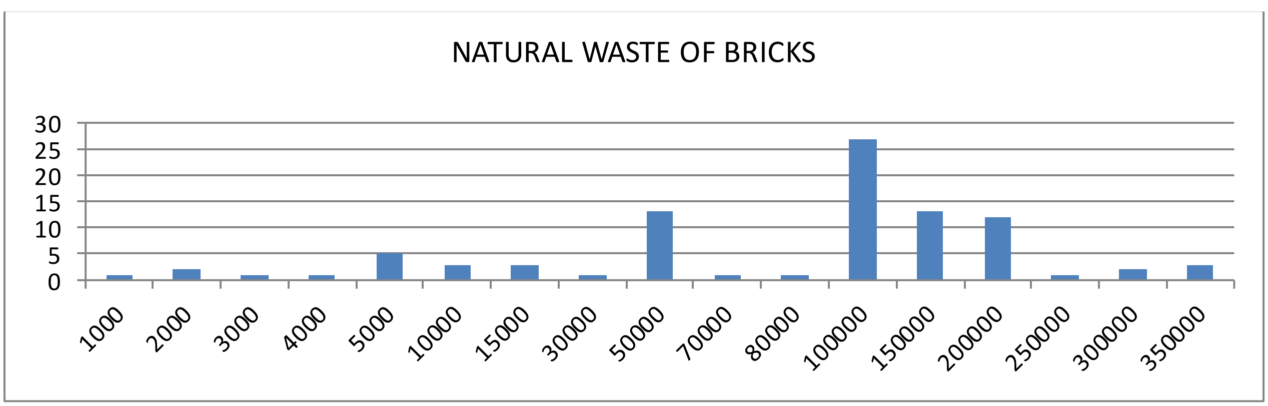

Figure 6: Natural waste of bricks (Natural waste on X axis)(Kilns Q on Y axis)

Bhelli bricks are inferior bricks produced during each chakar. *Bhelli*bricks are inferior bricks which are either overly burnt or less burnt in the process. Only bhelli bricks of *Qisti* type bricks are sold though they fetch smaller price as compared to good quality *Qisti* bricks. Bhelli Bricks of Roof, *Dhelo* and *Nav Sha* are actually waste cost for the kiln managers and such bhelli bricks are disposed off as waste because those are not in demand in the market. Data of assumed waste of bhelli orders of *Nav sha, Roof* and *Dhelo* bricks are asked in questionnaire form or calculated based on the spoilage rate told by survey participants.

Table 5: Bhelli and assumed waste

Kiln Type	orders	*Qisti* % bhelli	orders	Non Qisti % (assumed waste)
Large	61.3	64.97774	33.04	35.02226
Medium	23.4	69.4362	10.3	30.5638
Small	2.3	70.55215	0.96	29.44785

Total waste Cost is sum of operational, natural and assumed waste costs at the kiln.

Table 6: Total brick waste cost

kiln type	per 1000	horses etc waste	bhelli with assumed	total waste at kilns
Large	144117.6	173529.4118	482887.447	800534.5058
Medium	42696.43	101071.4286	174921.131	318688.9881
Small	3852.143	5857.142857	17379.5	27088.78571

Following is the district wise profile of total waste cost.

Table 7: District wise total bricks wasted/spoiled

District	per 1000	horses etc waste	bhelli with assumed	total waste at kilns
khairpur	78923.18182	122015.1515	270970.7757	471909.1
Larkana	27700	57400	104620.5	189720.5
Sukkur	90089.28571	114285.7143	362706.9643	567082

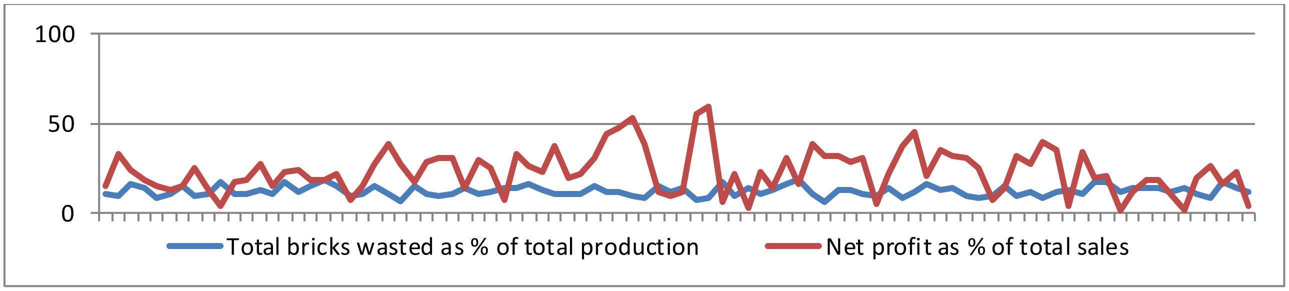

Figure 7: Relation of total waste % with profit %)

Relation between waste cost and net profit is as,

Table 8: Relation between waste cost and net profit

Kiln Type	(Average)Total wasted bricks %(final)	Average NP %
Large	11.29%	29.54%
Medium	12.83%	20.76%
Small	12.10%	15.02%

There are two types of the bricks made at the kilns i.e. Bhelli (Inferior) and Good / Superior quality bricks. Following is the relationship between fuel quality and Bhelli bricks production.

Table 9: Relation (Bhelli percentage vs Quality of fuel used 1st 2nd 3rd)

	1st Quality	2nd Quality	3rd Quality
primary fuel type	% bricks total waste	% bricks total waste	% bricks total waste
Furt	11.4	12.44	12.14
local wood	12.41	13.77	9.85
Tootaar	11.34	12.52	11.19
Dung	-----	16.08	----
Bakas	------	11.06	-----

Following is the relationship between fuel type and Bhelli bricks production.

Table 10: Fuel relation with waste bricks

Fuel	% Bricks wasted(full)
Tootar	11.06
Bakas	11.9
Furt	12.01
local wood	12.63
Dung	16.08

4.4. Finding reasons of unwanted stoppage of kiln production:

Kiln labour daily wages are less than normal market labour. This has decreased demand of labour at kilns. This gap is filled only by generational kiln labour bonded there at most kilns.

This kiln industry / construction sector is highly dependent on seasons. This can be seen in graph that 35 kilns out of 90 don't produce bricks in winter.

Health issues at kilns cause disturbances in production. Rights of kiln labour including health insurance, protective gears, masks, proper latrine, shelter from sun heat during work, etc. and that are missing. They work for long durations. 33.5% (67 out of 200) of the participants hastold about following six problem prevalent in the kiln labour.

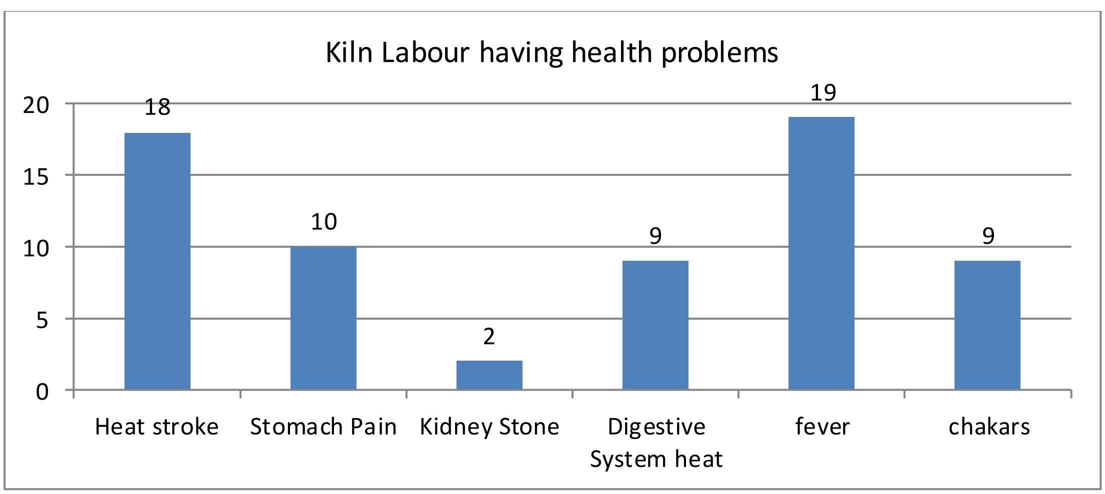

Figure 9: Kiln Health Problem chart

Spoilage of bricks by rain, donkeys etc cause undue delay in cycle to complete.Other reasons of unwanted stoppage of brick production include

- Input availability
- Quality of input
- Water availability
- Monsoon / windstorms/ heat
- Too much wastage
- Cash receivables stoppage
- Transport problems
- Cooling bricks takes time
- Faulty technology (tools etc)
- Managing seasonal production

Table 11: Summer and winter production

Summer production			Winter Production		
Chakars	Average production	Kilns	chakars	average production	kilns
2 to 5	1594911	45	0	0	35
6 to 10	3060000	17	1	374464.3	28
11 to 15	5420833	12	2	341071.4	14
15 to 20	7590000	16	3	300000	2
			4	423888.9	10
			6	400000	1

4.5. Cutting cost per brick, finding optimal product mix or quality of production

Efficiency for Inventory usage is as,

Table 12: Efficiency for Inventory usage

Ending Inventory	200k	150k	100k	300k	40k	25k	20k	5k	10k	30k	15k	50k	0k
efficiency	-0.87	-0.32	-0.16	0.3	0.37	0.5	0.53	0.66	0.68	0.7	0.76	0.77	1
Quantity	3	6	5	1	3	1	22	2	11	4	10	4	18

EI usage efficiency for Khairpur is 57%, for Larkana 60% and for Sukkur 27%. Following district table was generated for three types of the kiln.

Table 13: inventory usage efficiency (with respect to Ending inventory)

	Large	medium	small
Khairpur	27	81	69
Larkana	90	54	51
Sukkur	15	32	0

Type (size) of Bricks: Regularly bricks are made in four types i.e. *Qisti, Roof (12/6), Dhelo/Dhero, Nav Sha (9/6)*. Sometimes brick order with a specific design is receive at a kiln. For this they have to make special moulds. All brick types can be spoiled at kiln in the process.48 kilns make 4 types of bricks and rest 3 types.

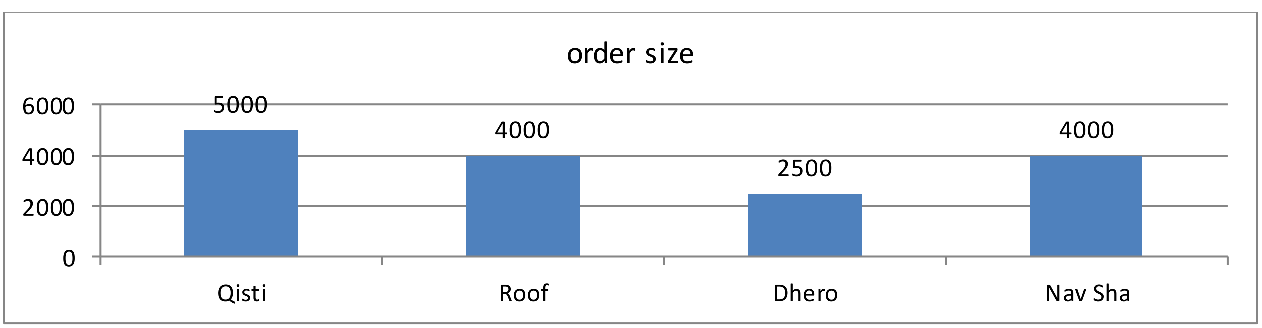

Figure 10: Average Order size for different types of bricks

Percentage of the Kilns making different types of the bricks is as,

Table 14: Percentage of the Kilns making different types of the bricks

	Qisti	*Roof*	*Dhelo*	*sha nav*	*Total*
Large	65.36	18.38	8.26	8	100
Medium	68.7	21.16	7.45	2.69	100
small	69.8	20.06	7.57	2.57	100

Average orders for different type of kilns

Table 15: Average orders for different type of kilns

Kiln	Q	Qisti	% of kilns making	Roof	% of kilns making	Dhero	% of kilns making	Nav Sha	Q	% of kilns making
large	34	900.1323	100	252.0263	100	110.7043	100	112.0185	32	94.11765
medium	42	329.9477	100	101.9907	100	35.10522	100	11.4735	16	38.09524
small	14	32.78131	100	8.996765	100	3.238689	100	0.996333	6	42.85714

Total Wasted bricks with respect to production level

Table 16: Total Wasted bricks with respect to production level

Production in Lakhs (100000s)	Average % of bricks total wasted
50.1-100	10.53
5.1-10	11
2.1-5	11.34
101-200	12.04
10.1-20	12.32

1.1-2	12.4
20.1-30	12.98
30.1-50	13.07

All final costs (at kiln) are calculated and observed on one brick level

Table 17: One brick cost break up (Rupees)

	small	medium	Large
Labour cost	1.932622	1.775174	1.649771
Capital cost	0.220727	0.093475	0.089153
land cost	0.162335	0.070423	0.03747
Maintenance Cost	0.163372	0.06659	0.044176
Clay cost	0.152513	0.129637	0.107269
Total Fuel cost	0.778202	1.694588	1.805679
Transport cost	0.55544	0.442083	0.370204
Water cost	0.066695	0.045819	0.021772
FOH Cost	0.820709	0.544526	0.395438
Sum(Average Cost of a brick)	4.84	4.86	4.52

4.6. EPQ (Economic production quantity) (Bricks):

EPQ is optimum lot size that is to be manufactured in a production unit (chakar) to avoid unnecessary blockage of funds and excess storage costs. EPQ is 169286, 756556 and 630234 bricks per batch /cycle for small, medium and large kiln. It suggests 1.5, 0.7 and 0.31 times more production per cycle to meet potential production level at small, medium and large kilns.

Table 18: Final EPQ Calculation Table

Kiln Type	Average production	Potential production	Difference	Possible % increase in Production (Chakars)		Chakar production	EPQ
Large	7147059	9339806	2192747	0.306804	15.5	488767.1	630234.6
Medium	2465476	4234455	1768979	0.7175	6	461726.2	756556
Small	230428.6	581596.7	351168.2	1.523978	3.5	68952.38	169286.1

5. Conclusion

Best kiln production is at district *Sukkur* as most chakars per year (13), most winter producing kilns, most working days in year (240), average total production (46 lakh bricks).

This kiln industry / construction sector is highly dependent on seasons. This can be seen in graph that 35 kilns out of 90 don't produce bricks in winter as it is difficult to dry and demand is also low.

Kiln operators / managers / *munshis* calculate profits on basis of number of successful completion of chakars. Rule of thumb production is followed but not beneficial for kiln owners. Large kilns work better with respect to economic production. Net profit is 281808, 3647403 and 14908971 Rs for small, medium and large kilns calculated in income statement.

There are two types of the bricks made at the kilns i.e. *Bhelli* (Inferior) and Good / Superior quality bricks. Average Bhelli bricks for small kilns are 17379, for medium kilns 174921 bricks and for large kilns 482887 bricks. As kiln size decreases *Bhelli* brick production, as % of total production, increases. Kiln size is inversely related to Bhelli production. It is easy to make *Qisti* brick as compared to *Roof* and *Dhero* types of red brick.

Kiln labour daily wages are less than normal market labour. This has decreased demand of labour at kilns. This gap is filled only by generational kiln labour bonded there at most kilns.

Health issues at kilns cause disturbances in production. Rights of kiln labour including health insurance, protective gears, masks, proper latrine, shelter from sun heat during work, etc. and that are missing. They work for long durations. Six health problems are prevalent at kiln labour i.e. heat stroke, stomach pain, kidney stone, digestive system heat, fever and head *chakars*. Mostly fever and heat stroke are reported.

EPQ is optimum lot size that is to be manufactured in a production unit (chakar) to avoid unnecessary blockage of funds and excess storage costs. EPQ is 169286, 756556 and 630234 bricks per batch /cycle for small, medium and large kiln. It suggests 1.5, 0.7 and 0.31 times more production per cycle to meet potential production level at small, medium and large kilns.

6. Recommendations

Time to complete one cycle / *chakar* at kilns need to be reduced to manage ordering and holding costs. There should be no unwanted stopping of production at kilns.

There is a sweet spot where holding costs and ordering costs are the lowest. Sometimes this is achieved in a cycle, or in a season or in a year.

Kilns need ROP (Reorder Point) management before fuel/clay runs out. For this they have to reduce ordering cost. Quantity, quality and timing of order have to be optimum. Similar orders at kilns need to be given to suppliers at same time. Improve logistics with better maintenance of assets.

Holding cost can be optimized with focus on storage, cycle time, tracking of inventory and sale management. If the sales price is low it is to be decided by the kiln management to either sell or hold inventory. Year ending inventory must be minimized.

Kilns can be economically efficient and productive when they match their input with output via a system of check and balance. This improves economic production quantity.

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