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Weather Effect on Workflow, and Labor Productivity of Construction Plant

Hatim A. Rashid

***Abstract*— This study discusses a novel study and develop the important climatic data in Iraq and UAE for changes in construction materials plant design. It is difficult to identified reliable and microclimate data and related information.**

There are many types of construction changes and each type can have an effect on labor and machinery productivity. But what is the effect of extreme heat and dust storm on construction industry can occurs either indoor or outdoor work. Construction materials production data from United Arab Emirates region over 2100 productive days period were collected. This study found that the adverse sever summer climate of heat and dust storms lead to a significant reduction in production. An average of week with six days during summers of heat exceeding 46C with high humidity reduces production in the week by 10% on average. A cross the regional companies, severe weather reduce production on average by 7% and delay the deliveries date. While it is possible that companies are able to recover these losses at some later date of summers. Further, even if recovery does occur at some point at very least these shocks are costly as they increase the volatility of production. Also this study concludes useful results for assessing the potential productivity shock associate with inclement weather as well as guiding managers on where to locate a new production facility. We recommend developing of empirical model for Heat Prediction in the region to expect to become more relevant as climate severity and frequent of severe weather.The results of our study also suggest raising the temperature to a more uncomfortable thermal zone lose employers about $2 per worker, per hour,"

***Index Terms*— Heat, Dust storm, Productivity, Construction materials.**

I. INTRODUCTION

It well known that there is a relationships between climate and economic activities of construction industry. It is intuitive that climate can impact outdoor activities of the construction materials manufacturing, agriculture activities, tourism especially g of the projects; lost opportunity profits from projects cannot be pursued; the costs of bidding and managing projects (defensively) and so no. Besides, there are intangible costs; such as personal cost to the careers of people who are enmeshed in acrimonious disputes. Although, the costs there are positive things likes reduce costs or improve its overall lifecycle value.. But the wrong type of the change can increase the cost of the projects and reduce the economic value of a project.

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Hatim A. Rashid, Construction Management Engineering Section, Civil Engineering Department, College of Engineering, Alnaharain University, Jaderia, Baghdad

Obviously, extreme climatic factor such as heat can affect projects in many ways, the most importantly by disrupting and impairing a project's labor productivity. Different types of changes have been studied by research workers: weather, schedule acceleration, and so forth. Postulated that change implemented late in a project will have more unsettling impact on labor productivity than the same change implemented either in the project [5].

A number of papers investigate sourcing strategies when supplies have varying reliability [6]. [7]. [8] while some work investigated disruption empirically by [9]. There are none of these cases are connection made between timing changes and severe weather.

Previous studies exists on the subject of discrete timing impact than on the subject of accumulative impact. Some of the studies are based on scientific research methodologies where empirical data are collected and analyzed, and others are controlled. A study on overtime portrays the effects that extended periods of overtime of 55 hours work weeks for 1-14 weeks have on labor productivity. In the reality of this study [10] is extrapolation of a series of small, independent projects over a 10 year period time. The outcome of the results from this data is imperfect.

The effect of temperature and humidity on productivity study was conducted by [11], [12], [13] tested the effects of schedule acceleration on productivity. [14] examined the amount of change for different project delivery systems.

The impact of timing changes on productivity were not examined.

[14] studied the timing changes on productivity but this study did not prevalence of bad weather which the results can be expected to become more relevant as climate change may increase the severity and frequency of severe weather, particular of construction industry to long –term changes in climate conditions and in the a short-term to changes in the weather is grown concern to many states in the region officials.

The objective of this study is to confirm that weather can be used as an exogenous shock in construction industry timing and production, which is useful in the development of valid instrument for other research. in hot regions. [1] reported that less clear is the impact on climate insensitive section such as manufacturing and services. Changes in production and timing especially when it results in protracted disputes and litigation is a serious and expensive problem for the construction industry. The changes in production and timing were pervasive and added about 6% to the direct cost of 22 government projects [2]. [3] found averages can be deceiving: 50% of the 24 Canadian projects in this data set had cost claims for more than 30% of the original bid value.

These 24 projects also had large claim for time extensions, in some cases 80% of the original contract duration.

[4] reported that the value of construction work put in the place in 1997 was $1.3 trillion. 6% changes in timing and production rate of the value ($1.3 trillion) were direct costs ($78 billion per year. In addition there are indirect costs such as higher insurance rates; delayed commissioning

II. Methodology

This study focuses on the construction industry, which offers several advantages; it is economically significant industry, there are many geographically dispersed assembly plants operated by a number of different companies, and detailed production data is available over a long period of time at the weekly level rather than monthly. However, it is clear which extend these results carry over to other industries with similar weather and depends on the underling mechanism.

This study data has been collected over five year's period. The first is weekly production of construction materials plants. The second includes the daily weather conditions at gulf regional samples. A disputed and no disputed manufactures have now been benchmarked from 22 contractors in four different locations at the region. The manufacture samples are public and private sectors. The manufacture size ranges between $300 million and $3 billion. The projects are light and heavy building materials. Both types are commercial and industrial.

Manufacture production, labor hour, cost were selected at 20, 40, 60, 80, 100% milestones of design and construction phases. Regression analysis was done for the available data.

Productivity values analyzed here are cumulative; end the manufacture productivity can be calculated As follows:

$$P = (P_{uim})(WH_{uim}) + (P_{im})(WH_{im}) / (WH_{uim}) +(WH_{im} \qquad (1)$$

Where P_{um} is unimpacted production,
WH_{unim} is unimpacted work hours
P_{im} is the impacted
Wh_{im} is the impacted work ho

Weather Variables	Description
Heat	Number of days with high ambient temperature above 40 degrees Celsius
Dust storms	Number of days dust storms with high winds speeds

able 1: Weather variables included in the empirical study

Location	Iraq ,Min/week	UAE, Min/week	Iraq Time/week	UAE, Time/week
≤ 10m	34	25	0	0.001
≤ 100m	450	360	0.009	0.007
≤ 200m	660	550	0.013	0.011
≤ 300m	806	780	0.016	0.016
≤ 400m	1370	2150	0.028	0.044
≤ 500m	2900	2100	0.059	0.043

Table 2. Average of visibility at the locations.

It defines the main weather variable used in our analysis. Heat is the number of days in a week in which the extreme temperature for the day exceeds a threshold40 Celsius. Heat is included because it could influence ambient temperature within the plant or employees that must work outside . Many of variables, such heat directly capture extreme weather shocks. Wind &dust storms are numbers of days in a week in which a wind & dust storm advisory was issued by the region weather stations offices

Long term dust storm data were recorded in four locations. The aim of collecting visibility data is to use the available data to estimate the effect dust storm of construction industry production. Table 2 shows an average time per year for which visibility was deduced base on five years dust at construction companies. Visibility was calculate as follows:

$$V = \frac{0.9}{Ca^{0.8}} \qquad (3)$$

V is the visibility,
Ca is dust concentration mg/cm^3 at 180 cm height.

III. Results

The projects located in the different locations in the same region and similar segment could still have different in their production patterns. The production patterns are related to the weather then this could generate a bias in the casual effect which try to estimate. We can mitigate this kind of bias, then we propose a third set of controls which captures seasonal average weather patterns specific to a project.

Table 3 represents the heat, dust storm and both variables, the coefficient shows the percentage drop in weekly production when the corresponding weather event occurs during a given week as any production recovery that might occur in each study week. For heat waves during May through September with 6 or more of days high temperature. For dust storm, the coefficient measures the percentage drop in weekly production in addition day with the indicated high wind speed. To put the impact of weather in respective, the productivity lose during the first week slab(construction materials) is introduced in 36% , similar in magnitude to the combined impact

Location	Heatlose %	Dust storm lose%	Productivity lose %
Iraq	9.22	0.86	10.08
UAE	5.69	0.63	6.32

Table 3. Ranking of average total productivity lose.

Table 4 represents the frequency of heat and dusty storms. Because the number of days with high temperature and dust storms advisory alert are relatively infrequent levels for this variable were defined based on visibility.

Three levels were presented with ≤10, ≤ 100 ≤ 200 ≤ 300 ≤ 400 and ≤ 500 m visibilities. The levels of visibility distance level count the number of days with minimum visibility on each level's range. The region weather used to be hot and humid in almost 85% of the summers.

Location	Heat lose %	Dust storm lose%	Productivity lose %
Iraq	9.22	0.86	10.08
UAE	5.69	0.63	6.32

Table 4 Average frequency economic impact of severe weather variable,

The average reduction is not statistically different across region locations it is possible to observe a statistically significant differences for the impact of heat and dust storms across the different locations. To estimate the economic impact , we measure the expected production reduction which combines the like hood of the weather incident with impact estimated in Table 4.

The impact of weather on production is measured in relative terms (% of production) rather than in absolute terms. The covariates in the regression can be grouped into three categories, Factors related to project weather, seasonal variables and other productivity related factors. The model can be used as follows:

$$P_{log} = W\mu + S\alpha_a + PF\alpha_b + \beta_i + \rho \quad (5)$$

Where W is project local weather, S, seasonal factor, PF, project productivity, $\beta_{i,}$ the project average net production and ρ is the error factor.

Weather Variables	Iraq	UAE
Heat	0.24	0.283
Dust storm	0.008	0.004

Table 5. Mean standard Deviation of heat and wind storm variables by region.

Weekly mean of daily average weather factors data for the project locations in the study period. The weather and climate factors measurements were arranged based on probability distribution for a given time period and project location. The number of days of above specific absolute threshold of heat or number of dusty days then the comparisons was made between the project regions. The impact of weather factors variation were discussed base on the statistical tests. Table 5 shows summary statistics for the weather variable. Four regions were defined that cover the location of the projects in the study; Iraq, United Arab Emirates, Kuwait and Kingdom of Arabia Saudi.

Table 6 shows the results for the four locations in our study. The weather is almost no significant differences between the locations because all location are within same region (Arid region, similar natural environment). The results indicated that the productivity lose percent due to the weather factors is not statistically different across the region it is possible to observe a statistically significant difference for impact of heat waves and humidity across the region.

Weather Variables	a Interception	b Slope	R^2
Heat x P%	0.3963	0.9803	0.98
Dust storm x P%	0.2628	0.2759	0.86
Both heat & dust storm x P%	0.6591	1.2562	0.982

Table 6. Correlation values of weather variables

The measured construction materials production lose % and the heat for the recording weekly period were shown in Fig.1**.** The figure shows that the linear relationship exists between the values. By fitting the data points in the figure, the following equation was formed with a high correction coefficient, $R^2 = 0.98$.

$$\%P_{lose} = 0.9803(heat) + 0.3963 \quad (6)$$

The measured construction materials production lose % ($\%P_{lose}$) and dusty days for the recording weekly period were shown in Fig.2**.** The figure shows that the linear relationship exists between the values. By fitting the data points in the figure, the following equation was formed with a high correction coefficient in both regression types, $R^2 = 0.86$ and $R^2 = 0.88$.

The calculations for the weather variable that have a statistically significant effect on production as reported in The Table 4 and Fig 1-3 as we cannot reject the null hypothesis that the effect of the weather factors heat is larger than dusty storms. In this analysis than both weather factors tend to have significant economic effect on overall construction industry production.

$$\%P_{lose} = 0.2759(dusty\ storm) + 0.3963 \quad \text{(Linear Relationship)} \quad (7)$$

$$\%P_{lose} = 0.6^{e0.1349}(dusty\ storm) \quad \text{(Exponential)} \quad (8)$$

IV. Discussion

The projects are rank ordered according to the time when either formally recognized a change formal recognition in this case is when one party notifies the other. The concept of managing construction projects
is deeply embedded in the traditional building procurement system. Designers argues that, cost and quality are the principal feasible objectives of the client in any construction project. Although it is
claimed that time, cost and quality are incorporated in the management of construction
projects, research has shown that in fact a time-cost bias exists.

Quality may be defined as one of the components that contributes to “value for money. the integration of all functions and processes within an organization in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction." Furthermore, in order to achieve successful project quality management three separate drivers to quality management must be managed, namely: Integration of the project team so as to have a single objective and a common culture A customer focus for the team thereby facilitating the provision of products an services that will meet the clients needs A process of continuous improvement in the management of the construction project . When these three components are successfully integrated, the project will begin to realize significant, measurable and observable improvements in the attainment of the clients' objectives. We argue that an efficient way to address these shortfalls is to recognize the 'human 'and quality. An analysis of the perceptions held by clients, contractors and building professionals, concerning client objectives relating to time, cost and quality management will allow this proposition to be explored. This is done through an opinion survey.

Timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants alike. Newcombe et al. (1990)
note that there has been universal criticism of the failure of the construction industry to
deliver projects in a timely way. The client's objectives can be achieved through a management effort that recognizes the interdependence of time, cost and quality.

Cost clients have been increasingly concerned with the overall profitability of projects and
the accountability of projects generally. Cost are frequently identified as one of the principal
factors leading to the high cost of construction (Charles and Andrew, 1990). Research to date has tended to focus on the technical aspects of managing costs on construction projects in the attainment of
client objectives. There is little evidence in the published literature of a concern for the
organizational, social and political problems that are inherent in the management of
construction costs and the ability of the project team to meet the client's needs in
terms of cost.
But if there are already aware of these effects like companies managed by government and includes our study projects, they may have already implemented all cost effective mitigation strategies. The studied region is characterized as arid region hot to very hot with dusty storms during summers, so it is difficult to follow the option to move production to more weather friendly location. Of course, moving production is costly and raises a host of other issues-labor costs, access to supplies, etc.

V. Conclusion

If this construction industry authorized people can do better job managing confront severe weather by underlying alternative mechanisms. Part of construction materials manufacturing was done outside particular companies in Iraq,. It is possible that disruption to employee's performance is a major cause. In this matter could mitigate this factor by avoid the time of heat waves during summer and increasing work time by doubling the shifts. This approach goes against the just in time solution of lean inventory and ensuring a smooth production flow, bur avoiding production losses due to weather may justify a more flexible operating strategy. Some companies has absenteeism employee problematic because the severe weather such as heat or dusty days due to health and/or transportation problems especially, houses are not provided by plant (e.g. Iraq). In this case it is hard to develop mitigating strategies.

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