

Original Article

Supply-Side Impact of Heatwaves on Open Market SMEs in Jaipur

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Abstract - Heat waves are increasingly common in the Indian subcontinent, particularly in Rajasthan's Thar Desert. Research links heat waves to climate change and their adverse effects on labour productivity, firm profitability, and global economic well-being. If left unaddressed, climate change-related heat waves could lead to a global GDP decline of around 1.4%. This paper focuses on the economic impact of heat waves on small firms in Jaipur, combining quantitative climate and economic data with qualitative stakeholder surveys. It explores how heat waves affect economic outcomes and decision-making. The findings confirm a direct link between higher temperatures and reduced labour productivity, reinforcing earlier research. The surveys also highlight the wide-ranging impact of heat-related health issues, which can ripple through the economy. The study reveals that the impact of heat waves varies depending on specific firm characteristics. In conclusion, it emphasises the need to address heat wave challenges often overlooked by small firms face to maintain economic productivity. By synthesising prior research with empirical analysis and qualitative insights, the study provides actionable recommendations for policies and initiatives aimed at mitigating heat waves' detrimental effects on economic performance.

Keywords - Climate change, Economic well-being, Health, Productivity, Profitability.

1. Introduction

The introduction should be succinct, with no subheadings. Climate and weather events impact the daily lives and the long-term activities of human beings [1]. Heat waves are one such increasingly frequent weather event where temperatures and, oftentimes, humidity rise to exceedingly high numbers for an extended period of time in the summer season [2]. These often occur in countries near the equator and with an oceanic climate, primarily Afghanistan, Papua New Guinea, and most of Central America, but also countries like India. It is obvious that heat waves have an adverse effect on human health relating to health hazards, but there is also a loss in economic labour productivity seen from a heat wave hit. Labour productivity is contingent on labour satisfaction, skill, and health, two of which are impacted by heat waves. Studies indicate that the economic loss from decreased labour productivity will be greater than any other climate change-related phenomena, as heat waves will consume over 2.2 percent of total working hours globally, equivalent to 80 million full-time jobs and US\$2400 billion in terms of Purchasing Power Parity. Health-related hazards, drop in incentives, and unfavourable working hours in peak heat hours are only a few factors which influence labour productivity [3].

Labour productivity is not the only thing at risk. Capital infrastructure is also put at a higher risk of malfunction and maloperation, seeing as the heat compromises its structural

and operational integrity [4]. Expansion resulting from heat may make it difficult to fix physical disturbances, and heat tolerance levels for heat-sensitive capital may be exceeded, such as for electrical appliances. Electric power infrastructure reliability is decreased in the long term as electric grid components may malfunction and cause an indirect risk to the electrical infrastructure, but a direct risk may also be posed relating to heat-related thresholds causing power outages [4, 5]. Moreover, lost working hours and capital may result in a deadweight loss globally, ameliorating the decrease in GDP. In agriculture, the economic loss of output is estimated to be 5 to 10 times larger than estimated by conventional models when heat waves are accounted for [6,7].

In India, heat waves tend to last over the summer months of April to June and primarily occur in central and northwest India due to the presence of the Thar Desert and prevailing winds [8]. Over the past few years, the number of heat waves and frequency of warm spells has increased dramatically, with the 2010 Indian heat wave being recorded as the "largest hot episode in the country's history" [9]. Rajasthan, in particular, recorded an abnormally high temperature of 50 degrees celsius in its Churu district in 2019, and the following years, regularly till 2022 and 2023, have seen a heat wave, which has triggered a drinking water crisis. Jaipur, the capital district, has experienced temperatures as high as 47 degrees celsius, which has had a



severe economic impact on the cluster markets of old Jaipur, namely markets such as Johari Bazaar. It has been observed that the effect of heat waves is seen to be greatest in highly populous locations, generally also resulting in a relatively higher mortality rate [10].

To support this, however, it was seen that there is a lack of statistical research aimed specifically at cluster markets such as those in areas like Jaipur. Moreover, there is little economic insight that has been documented in the literature pertaining to heat waves. This results in a knowledge gap when narrowed down to Jaipur. All current literature is focused on the health and physiological impact of heat waves on labour, but not the supply side as a whole, thus the need for this research.

2. Materials and Methods

2.1. Research Aim

A descriptive phenomenological qualitative study was used to understand the experience of small firm producers during heat waves. The purpose of using this type of study was to gauge different perspectives and experiences regarding how different people are economically affected by the phenomenon. This type of study allows us to gather the actuality of the situation, also allowing us to explore the issue with a greater depth of real-world understanding. The credibility of the study may be improved this way as well.

2.2. Data Collection

A survey was sent out to collect data from people in traditional markets in Jaipur with firms ranging from clothing to electrical appliances to food. All producers above legal working age (18 years old) and producers from all firm sizes were considered. The survey was designed to be inclusive this way, with no groups of people being excluded or given preference in the survey. Convenience sampling was used to send the survey to eligible people through a physical form they had to complete on paper and submit. Consent was taken before giving the survey to allow us to use the results in the paper.

2.3. Data Analysis

The information gathered was graphed and analysed using percentage and frequency data distribution for clear interpretation.

2.4. Ethics

The researcher's bias was eliminated by pre-identifying the potential biases possible and removing them. In collecting primary data, all participants were assured of the anonymity and confidentiality of their personal details, along with their voluntary participation and ability to withdraw at any time they wished. All results produced are original results collected by means of surveys in the markets.

3. Results and Discussion

3.1. Significance of Study

Heat waves in Jaipur have been shown to be extremely frequent, with a wave hitting the markets every year in the peak summer months of May and June [11]. In 2023, several places experienced and crossed average temperatures over 40 degrees celsius [12]. Results from this phenomenological study are comprehensive, having been conducted through a door-to-door questionnaire in the primary open market of Jaipur - Johari Bazaar. Prior literature capitalises on technical methods and formulas used for calculating monetary and economic impact, but this survey provides a more detailed qualitative perspective on the problem being investigated. The gap between theory and practice is decreased as the assumptions about the causes and consequences of decreased worker productivity, monetary problems faced by firms, etc., are substantiated by the personal experience of firm owners and experienced workers. They can also provide insights which are otherwise unavailable in literature or elsewhere.

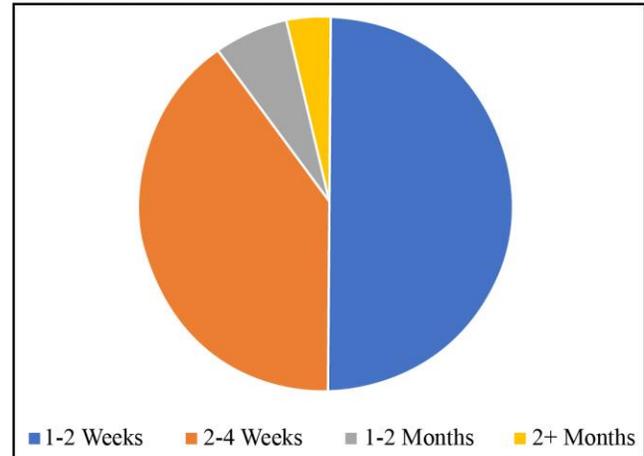


Fig. 1 Pie chart depicting the response to the duration of heat waves experienced by vendors

According to firm owners and as shown in Figure 1, the range of heat waves has ranged from 2 weeks to over 2 months, suggesting that firms' classification of heat waves differed. Speculatively, this differs due to the differing access to cooling facilities and duration of the firm in the market. Participating firms also indicated that heat waves are, in fact, a more prevalent and frequent phenomenon in Jaipur than was previously suggested, with temperatures rising to a drastic 4-6 degrees above normal temperatures. Due to this, they observed phenomena relating to worker productivity and loss of economic output for a variety of reasons. These reasons include but are not limited to decreased physical work performance due to heat stress and absenteeism [12]. On the hottest days, the working hours of employees in outdoor industries decrease by up to 13% [13]. These reasons differ from firm to firm, but with a clear distinction that has emerged.

As shown in Figure 2, the three main categories of firms that were prevalent and responded to the survey were jewellery, clothing, and food:

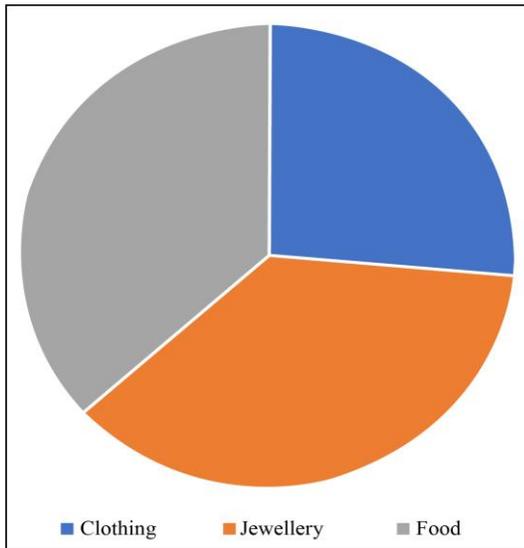


Fig. 2 Pie chart depicting the response on different types of business

Thus, this allows for a categorical and comparative study between the three types of businesses and how they are impacted differently by the natural phenomenon. These also represent the three primary categories of businesses present in the cluster markets of Jaipur but may vary from place to place. There are also more minor types of firms present, such as electrical appliances and two-wheeler vehicles, but there was seen to be a less dramatic impact on these types of firms because of natural phenomena. These types of firms typically had a larger scale of operations, which allowed them to have air-conditioned stores and workshops. Workers' productivity indoors during a heatwave is not impacted as much as outside workers. The clothing category consists of shoe businesses as well, while the food category is inclusive of food and drinks. Thus, the three types of firms were investigated further.

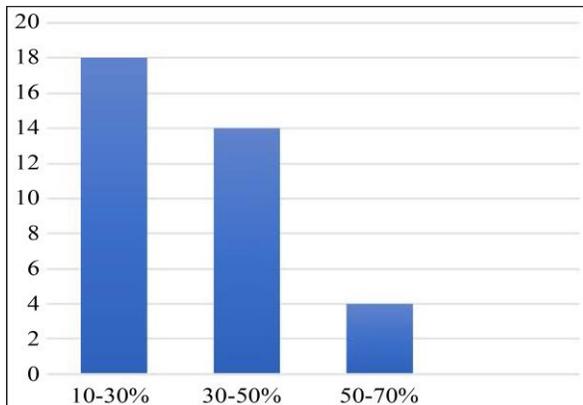


Fig. 3 Bar graph for response on approximate percentage of decrease in worker efficiency, measured by the output produced and sales made

3.2. Physiological and Economic Impact of Heat Stress on Workers

Since the effect of heat is considered to be a negative externality upon workers' productivity, it is unsurprising that firms reported a majority 10-30% decrease in labour productivity during the period of a heat wave. Heat waves have a physiological impact on workers - including exertion, potentially fatal heat strokes, and injuries - and affect their ability to produce output by limiting the value they can provide in the same number of hours worked [14, 15]. Moreover, as heat waves interfere with rational-decision making, this problem is further ameliorated, and the useful output from the already fewer hours of work supplied decreases [16]. Even if the impact of heat stress is not instantly noticeable, the cumulative effect of working in a heat wave can lead to decreased productivity over time, as employees can experience diminished physical and cognitive performance. Physiological models of heat exposure from Europe and Australia estimate and suggest that labour productivity may take an overall hit of 11-27% in Asia in the long term as hotter summer months follow [17]. Globally, these numbers may reach 20%. In the context of RCP8.5 (Representation Concentration Pathway 8.5), the rise in temperature-induced decreases in workforce efficiency led to an average contraction of 1.4% in the worldwide gross domestic product by 2100 compared to the baseline scenario unaffected by climate changes. Hence, a substantial portion of "global mitigation efforts" to achieve climate change objectives could be counterbalanced by addressing the societal and health-related challenges posed by heat waves that can significantly affect economic productivity [18].

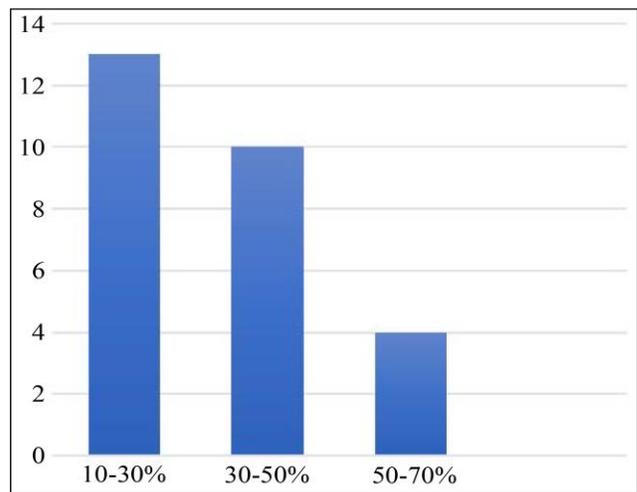


Fig. 4 Bar graph for response on approximate percentage of increase in rest times and leaves from work

Heat-related health issues may result in a higher degree of absenteeism among employees in Jaipur's small firms, affecting daily operations and potentially leading to higher costs related to healthcare and temporary staffing. Labour

shortages caused by health-related issues may result in supply shocks, critically affecting the day-to-day business conducted by small firms [19]. Figure 4 indicates that most workers tended to display a 10-30% increase in absenteeism and rest time, translating to less hours of work supplied. Regular work schedules of businesses are impacted, and they may have to compensate with overtime pay.

A common pattern observed through the study indicates that it is common for workers to demand more medical and health-related leave, even though their productivity has not seen a decrease of that magnitude. Research shows that the monetary cost of worker absenteeism is greater than medical financial burdens [19]. From another perspective, it is possible that more absenteeism allows workers to recuperate and work at full productivity during the working hours they supply. In the long run, this proves to be beneficial, but for financially struggling firms in the short run, this can be potentially fatal for the firm. Firms that run on a day-to-day sales basis lose their access to daily revenue when workers are on leave. The employer is left short-handed in organising and managing the firm. Even for other firms, this is still financial damage, as the leaves granted tend to be paid leaves. Absenteeism due to health-related issues can cause small firms to incur healthcare costs for treating heat-related illnesses.

Additionally, a firm falls liable to worker compensation claims if a worker suffers a workplace injury or illness, including medical expenses, lost wages, and potential legal costs. The Indian Workmen Compensation Act of 1923 ensures that all firms are liable to pay the medical costs incurred by employees while working in the workplace [20]. Therefore, a long-run heat health action plan is required for firms [21].

3.3. Differences in Firms

Jewellery businesses, in particular, were showcased to be more financially stable and well-off than other types of firms. There is a greater provision of cooling devices such as air conditioners. Nevertheless, these businesses also reported more rest times and leaves being taken by employees regardless of the favourable work conditions in heat waves. Following market trends, workers have a disincentive to work as they see other firm employees having the provision of paid leave. This presents an added cost for firms.

The results indicate that even though there are no other specific added costs with labour, it is considerably important to consider that the amount of output produced generally decreased over all domains of firms except drinks. In order to cope with an inflated demand for cold drinks, producers have to match it with the supply, thus having no room for lack of efficiency. As reported in the survey, rink shops, in particular, have a greater provision of ice boxes and cold

water, keeping worker morale in a stable place and ensuring the continued motivation of workers. However, additional costs for more financially well-off firms, such as jewellery, indicated that the electricity bill was significantly higher since cooling devices have a higher active time.

The diversity of clothing businesses observed shows that the industry follows no particular pattern. Jaipur's textile and clothing industry is internationally known for using natural vegetable dyes to create indigenous designs on pure cotton fabric, deeply rooted in community-driven enterprises [22]—the markets of Jaipur house small shops as well as bigger air-conditioned showrooms: SMEs. Prior studies indicate that these SMEs already face economic challenges, such as a lack of supply of labour due to a high equilibrium wage rate for workers in the textile industry. Firms are disincentivised to employ workers at such a high cost, although this harms the line of production as the firms become more prone to supply shocks and are affected more by high interest rates [22]. Heat stress acts to increase the equilibrium price of workers as firms become liable to higher fringe benefit payments and trade unions negotiate a higher minimum wage for workers. Although research suggests that governments provide the industry with tax rebates, subsidies, and ease of material procurement [22], figure 5 indicates that all respondents only had access to subsidies on electricity.

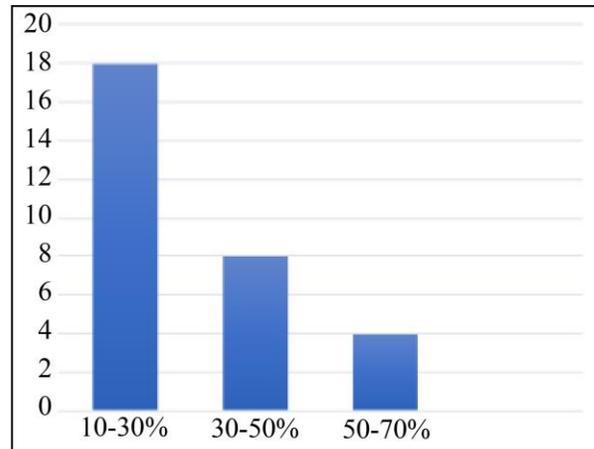


Fig. 5 Bar graph for response on approximate percentage of subsidy provided by the government as a percentage of firms' total cost

3.4. Government Measures

The responses show that even though the government has provided support by subsidising electricity to some extent, the accessibility to this subsidy differs. Jewellery firms responded well to the subsidies, indicating their impact to be higher than that of others. Due to the small time frame within which the subsidies have been made available, and provided that some firms lack the necessary infrastructure to take true advantage of the provision, it is yet to be proven truly effective. Air-conditioned businesses have a higher affinity to electricity consumption, making it

obvious that a subsidy targets their benefit to a greater extent. It is important to note that firm speculation has increased as several respondents noted their perception of the reason behind the sudden subsidy provision: the elections of 2023. Due to the "rushed" nature of the implementation, as mentioned by a clothing firm owner, it fails to achieve its intended financial and psychological impact.

3.5. Community Support

The majority of the SMEs reported close to no support from the community, with some exceptions, such as shared areas for air conditioning services and internal friendliness of firms guiding consumers to certain firms. Complying with previous research, a lack of informal support from relatives and friends is prevalent in the market [22]. Lack of community support is a direct contributor to impacting the profitability and footfall of a firm during a heatwave event.

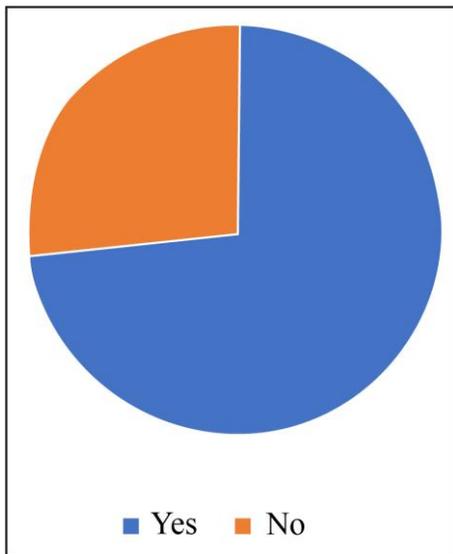


Fig. 6 Pie chart for response on if the frequency of machine breakdown increases during a heatwave

Substantiated by the survey, all firms apart from food reported a decrease in profitability, regardless of how the footfall changed. In some observed cases, even though footfall and revenue changed, the profitability decreased regardless due to the dramatic production cost increase. However, most firms indicated that footfall decreased too, which is unsurprising considering consumers would obviously prefer visiting a market in better weather conditions. It is important to note that some firms were able to preserve their profit margins due to the provision of a subsidy, although this would be selectively true for financially well-off firms. Also, firms enjoying economies of diversification were able to reap profits from a domain which did not require physical consumer visits. An internal technological infrastructure has played a crucial role in

helping a firm maintain its profitability during a heat wave event.

However, technological infrastructure was reported to be more damaged in hotter environments. Electrical appliances were shown to break down more and require more frequent repair visits to the store. Similarly, work done by a reliable machine is not considered reliable, seeing a higher requirement for mechanical fixes, as shown in Figure 6.

4. Conclusion

The results indicate that the primary consequence of heat waves in Jaipur is on labour productivity and, therefore, firms' profitability. However, this varies across different types of firms. All SMEs except food and drink shops have shown a dramatic negative economic impact. Textiles and clothing, already facing labour shortages, have become more prone to supply shocks. While literature suggests that the government has provided aid in several forms to the industry, and firms reported that this aid is either not available to them or they lack awareness about the provision. Food and drink shops have shown a cushioned impact, with drinks even reporting more profitability.

The advantages of shared community air conditioning areas have helped maintain worker morale and labour productivity. For jewellery firms, even though footfall remained steady due to the generally higher provision of air conditioning for consumers, production costs drive profitability down due to more absenteeism and labour shortages.

Due to the small sample size, the research has a limitation in generalising the study to all firms in Jaipur. However, the study is functional for those surveyed and in a general context. The exact monetary impact is not measured as well.

The study indicates a call for action by the policymakers in order to combat the economic impact of heat waves; considering that loss in labour productivity and firm profitability will have a drastic impact on the GDP of the nation in the long run, it is best to use sustainable and targeted measures to combat the effects of global climate change. It is also necessary to address the problems associated with previous policy measures targeted at aiding SMEs in Jaipur.

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