

*Full Length Research Paper*

# Applying six sigma to manufacturing processes in the food industry to reduce quality cost

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In recent years, an increasing number of companies have used different types of quality programs in order to increase internal and external customer satisfaction as well as to reduce quality cost. Among all of these programs, Six Sigma is perhaps the most widely-accepted initiative by all a broad range of organizations. The DMAIC (define-measure-analyze-improve-control) approach has been followed here to solve an underlying problem of reducing process variation and the associated high defect rate. This paper explores how a food company in Taiwan can use a systematic and disciplined approach to move towards the goal of Six Sigma quality level. The DMAIC phases are utilized to decrease the defect rate of small custard buns by 70% from the baseline to its entitlement. At the beginning of this project, the defect rate was 0.45% (Baseline), and after the improvement actions were implemented during a six-month period this fell to below 0.141% (goal). The critical successful factors for Six Sigma projects, especially those in the food industry, are discussed at the conclusion of this paper.

**Key words:** Six sigma, food industry, process improvement, DMAIC.

## INTRODUCTION

Since the early 1980s, manufacturing industries worldwide have seen a revolution in the way they operate. Consumers have become more and more demanding, and the key to firm survival is the recognition of the importance of customer satisfaction. Consequently, companies have been forced to enhance the quality of both their processes and products (Efstratiadis et al., 2000). The focus of this study, the food industry, has also become increasingly multifaceted and competitive in recent years (Chong et al., 2001; Knowles et al., 2004; Henchion and McIntyre, 2005; Spiegel et al., 2006; USOCDD, 2007). In this environment, food company managers have to deal with a number of problems. Sales are slowing down and operating costs are increasing, while customers are becoming more demanding and selective (Efstratiadis et al., 2000; Henchion and McIntyre, 2005). Food industry managers must thus consider how to maintain profitability in a shrinking market, while providing increasingly sophisticated customers with high

quality products and efficient service. In attempting to achieve this seemingly impossible objective, firms can pursue two strategic avenues. First, they can focus on ways to improve the operational efficiency of the system. Second, they can take actions to enhance its operational quality.

In recent years, an increasing number of companies have used different types of quality programs in order to increase internal and external customer satisfaction as well as to reduce quality cost. Process improvement has often been accomplished through an integrated approach, using problem-solving techniques such as total quality management (TQM) and classic statistical analysis (Wiklund and Wiklund, 2002). Among all these programs, Six Sigma is perhaps the most widely-applied. There are many documented case studies of organizational applications of Six Sigma, where large-scale improvements in defect and variability in processes to meet the customer satisfaction. (Antony and Banuelas, 2002; Raisinghani et al., 2005; Chen et al., 2005; Antony, 2008; Chung et al., 2008; Nonthaleerak and Hendry, 2008; Leea et al., 2009).

Six Sigma, a statistically-based quality improvement program, helps to improve business processes by

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reducing the waste and costs related to poor quality, and by improving the efficiency and effectiveness of processes (Breyfogle, 1999). Ultimately these measures should lead to improved customer satisfaction and increased profitability (Antony and Banuelas, 2001). Spiegel et al. (2006) indicated that the company shall select and implement specific quality management activities suitable to their situation to increase their production quality. As a business method for eliminating defects, Six Sigma also works well in the food industry. For example, executives at fast-food giant McDonald's started to learn about the management philosophy that General Electric (GE) adopted in the 1990s, and since then, managers have continued to attend GE's program and initiate related projects (Lee, 2005).

## MATERIALS AND METHODS

### Six Sigma

Six Sigma as an improvement program has received considerable attention in the literature during the last few years (Harry, 1998; Hoerl, 1998; Breyfogle, 1999; Bergman and Kroslid, 2000; Hellsten and Klefsjö, 2000; Klefsjö et al., 2001; Chen et al., 2005; Thomas, 2008; Zu et al., 2008; Leea et al., 2009; Kytösaho and Liukkonen, 2009). Motorola launched Six Sigma methods in 1987, and was also the first firm to win the Malcolm Baldrige National Quality Award (MBNQA) in 1988. Today, other companies like Texas Instruments, ABB, AlliedSignal, GE and 3M have been striving to achieve Six Sigma quality, and as a result they have become known as best-in-class companies (Fuller, 2000).

Six Sigma is a useful problem-solving methodology and provides a valuable measurement approach. It has a statistical base and with proper utilisation of methodologies can help to improve the quality of both product and process. In addition to providing data-driven statistical methods for improving quality, Six Sigma also focuses on some vital dimension of business processes, reducing the variation around the mean value of the process (Kanji, 2008). At many companies, Six Sigma simply mean a measure of quality that strives for near perfection. It is a disciplined, for eliminating defects in any process, covering manufacturing and transactions, as well as products and services. The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of specific projects. This is accomplished through the use of two Six Sigma sub-methodologies: DMAIC and DMADV. The DMAIC (define- measure- analyze- improve- control) is an improvement system process for existing processes falling below specification and looking for incremental improvement, and the DMADV (define- measure- analyze- design- verify) apply to the product development and design at Six Sigma quality levels (Linderman et al., 2003). It is a myth that Six Sigma works only in large companies. Six Sigma has evolved into a business strategy in many large companies and its importance in small and medium-sized enterprises (SMEs) is growing everyday (Kumar and Antony, 2008). In fact, the results are quicker and much more visible in smaller companies than in larger corporations (Antony, 2008).

The DMAIC approach has been followed here to solve an underlying problem of reducing process variation and the associated high defect rate. There are many case study apply this methodology to solve the company's underlying problem (Chen et al., 2005; Nonhaleerak and Hendry, 2008; Leea et al., 2009; Kytösaho and Liukkonen, 2009). The DMAIC is a process improvement cycle of Six Sigma program as well as an effective problem solving

methodology. Brewer et al. (2005) indicated that DMAIC is "the primary framework used to guide Six Sigma projects". Six Sigma projects are based on the DMAIC approach and "the role played by DMAIC in gaining the overall success of Six Sigma is equally critical" (Nilakantasrinivasan and Nair, 2005). In this paper, we are going to adopt the DMAIC quality improvement process.

### The phase of Six Sigma implementation

In order to reduce process variation and the associated high defect rate, Six Sigma focuses on improvement methodology application, then the DMAIC is mentioned most frequently now and a lasting improvement method (Starbird, 2002). The representative's meanings of five English letters are as follows:

#### Define

The top management shall identify the problem according to customer feedback, strategy and mission of company, define customer requirements, and set goal.

#### Measure

Measurement is a key transitional step on Six Sigma road, one that helps the project team refined the problem and being the search for root causes which will be the objective of Analyze step in DMAIC. Therefore, the project team needs to validate problem/process, refine problem/goal, and measure key steps/input.

#### Analyze

In analyze stage, the project team shall use data analysis tools and process analysis techniques to identify and verify root causes of the problem. For the reason, the project team needs to develop causal hypotheses, identify vital few root causes, and validate hypothesis.

#### Improve

The goal of the improve stage is to find and implement solutions that will eliminate the causes of problems, reduce the variation in a process, or prevent a problem from recurring. So the project team needs to develop ideas to remove root causes, test solutions, and standardize solution/measure result.

#### Control

Once the improvement has been made and results documented, continue to measure the performance of the process routinely, adjusting its operation. It is very important for the project team needs to establish standard measures to maintain performance and correct problems as needs. Without control efforts, the improved process may well revert to its previous state.

### Case company

The case company was founded in the early 1970s, based on exporting frozen prepared eel food products. It then shifted its focus into the domestic wheat flour processed foods and snack market, and successfully launched a range of pork buns. Since 1985, the case company had been certified as one of Taiwan's Good Manufacturing Practice (GMP) food companies, and has attained

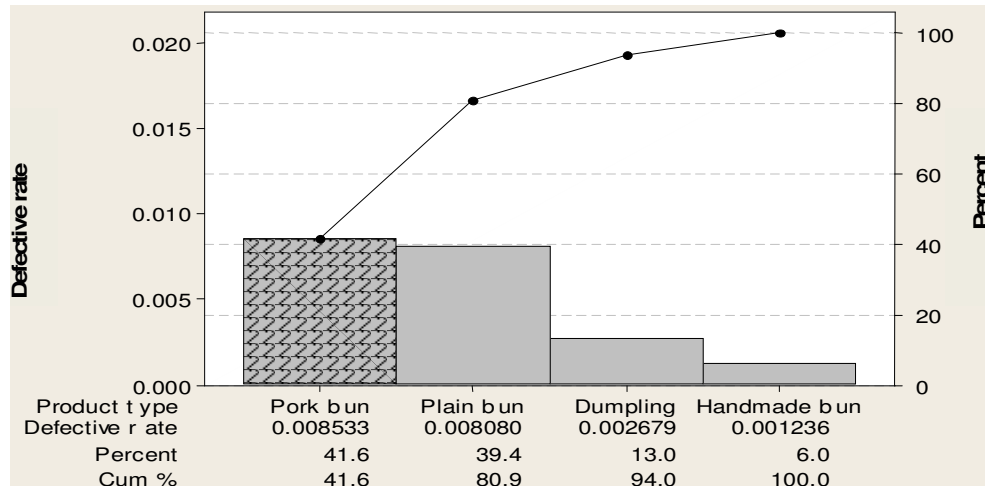


Figure 1. Pareto chart of product type.

several other international food processed certifications.

Although the employees' general level of education is not high, the case company still decided to implement some Six Sigma projects in order to reduce its operational cost, to improve its financial performance and to better face an increasingly competitive market situation. A Six Sigma committee was established to facilitate the implementation process, including building infrastructure, proposing and selecting projects, tollgate review and decisions related to rewards.

As there were many aspects to be improved, the projects were first prioritized systematically and two projects were selected in the first year. Champions, usually the leaders of all the departments and supporting units, were then in charge of monitoring progress and ensuring the success of each selected project. Every year, all the champions had to propose some candidate projects according to their department's KPI (key performance index) and submit them to the committee to be approved. Several important issues, such as improving customer satisfaction, reducing the A.R. (accounts receivable) collection cycle, lowering product defect rates, reducing recruit cycle time and shortening new product development time were discussed in the committee. Every possible alternative was prioritized by using the C&E (cause and effect) matrix. Criteria being considered to select the most critical projects included the effects on KPI, impact on customers, data accessibility, project hard savings and the time needed to reach the improvement goal.

Among all these candidate projects, lowering product defect rates was considered the most critical, as it is highly correlated to KPI and customer impact. During the frozen bun manufacturing process, buns must be steamed thoroughly and then frozen to be stored and transported. The buns are then steamed again by the customer before eating. However, during the re-steaming process, customers encountered some problems with the product such as shrinkage, foreign material, crack, and so on. Consequently, a project to address this issue was eventually approved by the Six Sigma committee. We acted as consultant to coach the project team members to implement project.

## RESULTS AND DISCUSSION

### Define phase

After this project was approved, the champion of this project had to select an appropriate Black Belt and form a

Six Sigma team to deal with the improvement. Three tasks must be undertaken during the define phase: Refining feasible project scope, setting up project goals and estimating project hard savings. Because the time period of each Six Sigma project is limited to not longer than six months, a suitable scope for each project is very important if they are to be successfully completed on time. By using a three-layer tree diagram (Figure 4) and three Pareto charts, the project scope was narrowed down. The first layer narrow down was to decide what product defect rates should be improved. Because buns encountered the most serious defects among all the company's frozen food products, it was chosen to be the project product (Figure 1). Although there were numerous defects with the buns that could have chosen to work on, it is important that any project does not become unwieldy or too complicated. Therefore, the main customer complaint, that the buns had a tendency to shrink, was chosen as the focus of the project in the second layer narrow down (Figure 2). However, the company produces a range of different bun, all which with shrinkage rates, and thus the third layer narrow down decided to put the focus of the project on the firm's 32 g small custard buns, as it was the most prone to this problem (Figure 3).

After the project, scope was specified clearly, various goals needed to be set, namely the project, financial and consequential indices. The project index is also called the primary index, which indicates the measurement and goal of the improvement target based on related time series data. In this case, the primary index was shrinkage defective of 32 g small custard buns, and the goal of this project was to reduce the shrinkage defect rate. Time series data for the shrinkage defects of the bun was collected and is shown in Figure 5. It shows that the defect rate was low in the beginning and then began to rise. The average defect rate was 0.405%, which forms the project baseline. The best situation, also called the entitlement of the project, was 0.028%, which happened

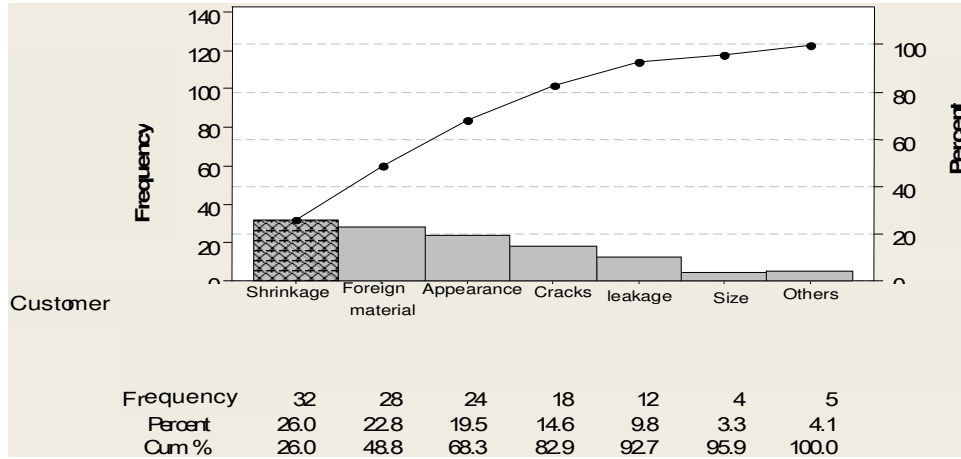


Figure 2. Pareto chart of customer complaint.

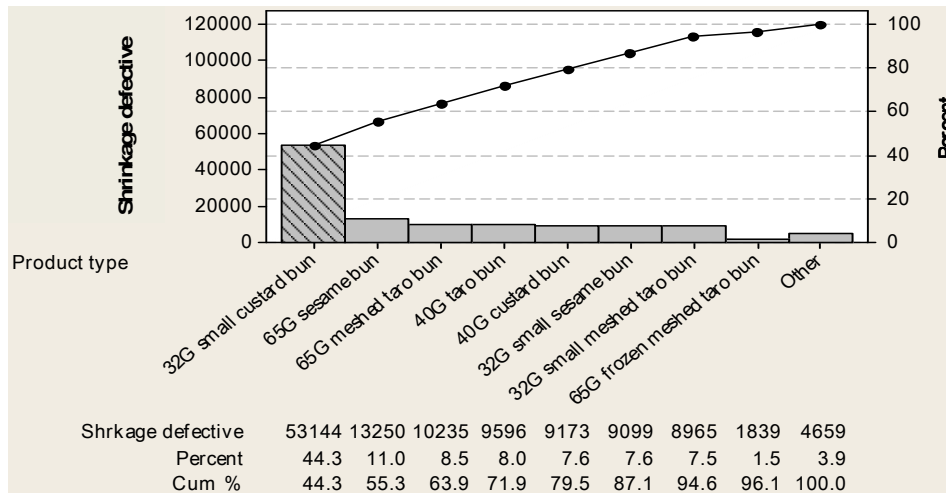


Figure 3. Pareto chart of bun type.

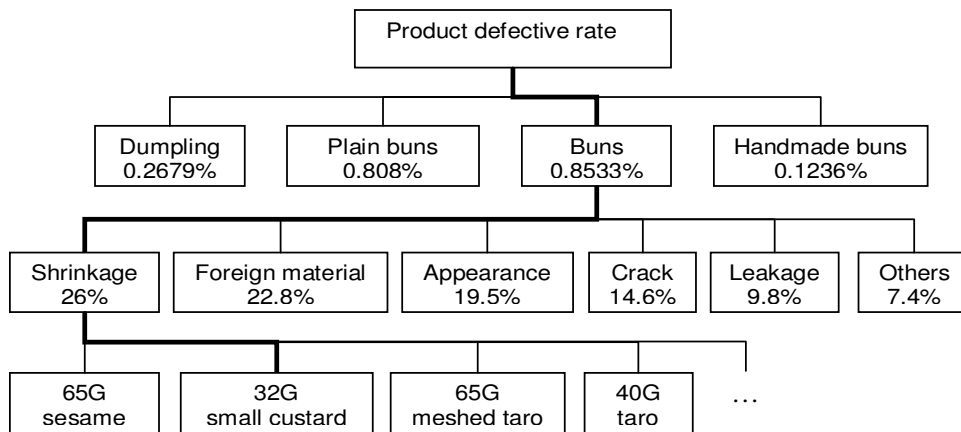


Figure 4. Project selection tree diagram.

in January. The objective of this Six Sigma project was to decrease the defect rate by 70% from the baseline to its

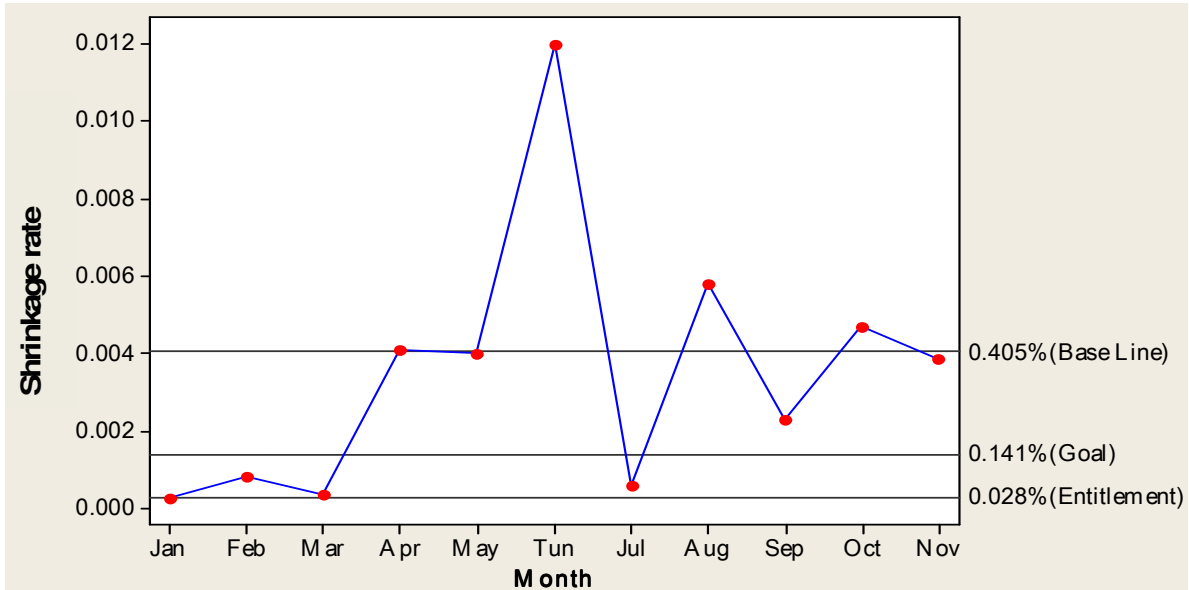


Figure 5. Time series data for shrinkage defect rate of 35 g custard bun.

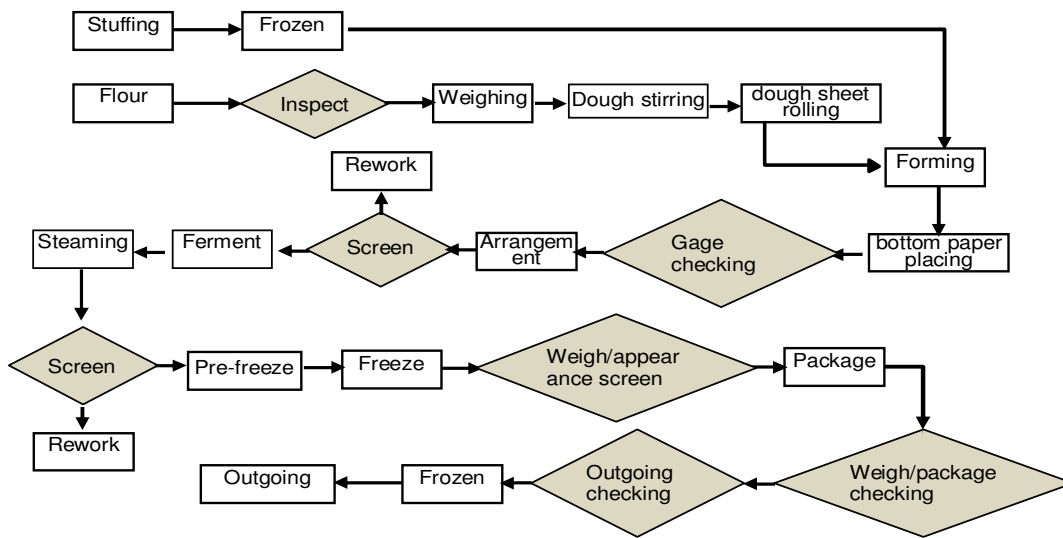


Figure 6. Process flow diagram of custard bun.

entitlement, and the goal was set at 0.141%. After the project goal was set, financial index was calculated accordingly, assuming that the goal could be achieved. Finally, the consequential index considers side effects that may occur when attempting to reach a project's goal. For example, a longer cycle time is one possible side effect in a defect rate reduction project, and this should thus be monitored.

**Measure phase**

The major activity in the measure phase is to understand

the whole situation of the project, including process mapping, defining potential factors (also called Xs) that affect the project index (also called Y), measurement system analysis (MSA) and process capability analysis. Generally, a process flow diagram (PFD) is used to discuss the related process flow of a project, and then a detailed process map to consider inputs and outputs of each process step is prepared for the subsequent cause-and-effect analysis. Figure 6 shows the process flow diagram of the custard bun product.

Based on the PFD and detailed flow diagram, the project team members discussed factors that may cause a custard bun to shrink after re-steaming by using

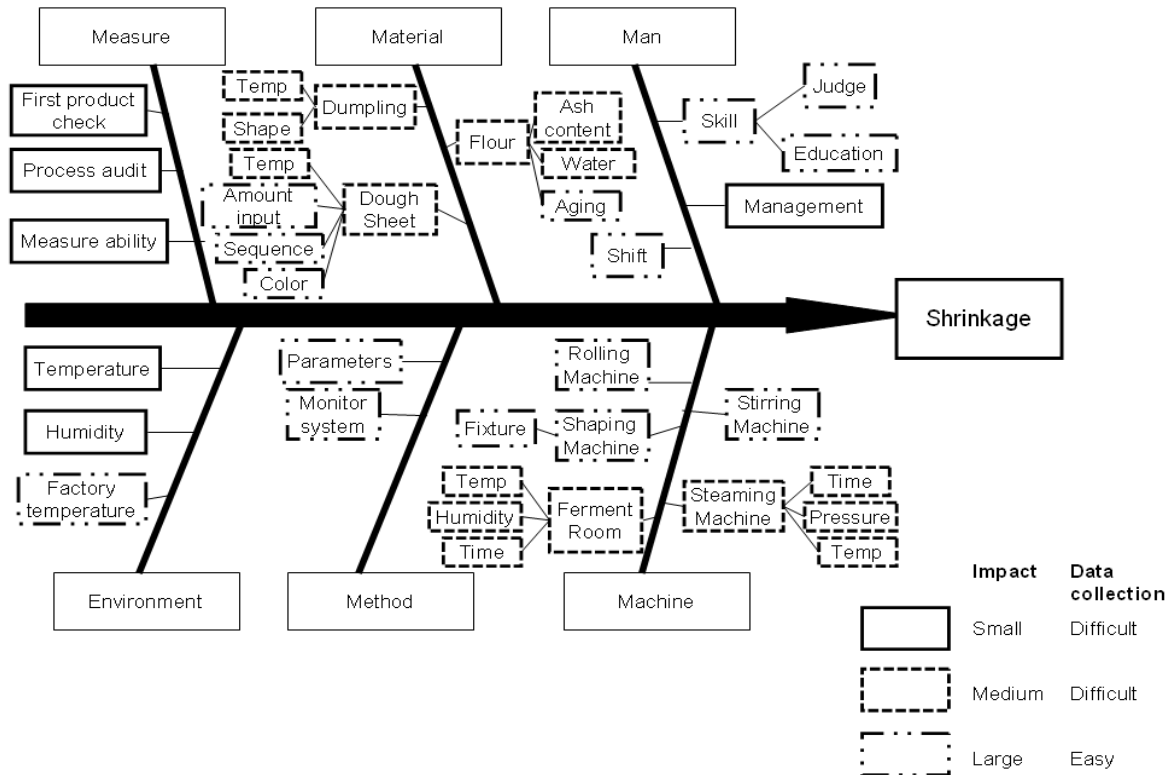


Figure 7. Fishbone diagram of shrinkage defective.

Table 1. Attribute gage agreement analysis plan.

Method	Sampling
Three inspectors looks at 30 sample buns, with two inspections for each sample. Buns were inspected to see if they shrank or not	Randomly sampled three from 12 inspectors 15 shrinkages and 15 standard buns

brainstorming, and summarized all the factors in the cause-and-effect diagram (also called a Fishbone diagram, because of its shape). Factors were further categorized into three kinds, major, medium and minor. Figure 7 shows the Fishbone diagram of this project.

A very important characteristic of a Six Sigma project is that improvements are made based on data analysis, usually statistical analysis, so the reliability of the data collection system is very important. If the data does not precisely represent the true situation, then the results of the analysis would be useless. There are two kinds of measurement system analysis, the use of which depends on the type of collected data, gage repeatability and reproducibility (also called GR&R) analysis for metric data, and attribute gage agreement analysis for attribute data. In this project, the shrinkage defective was judged by an inspector and the outcome is binary data, so attribute gage agreement analysis was performed to verify the reliability of the measurement system. To perform the agreement analysis, three inspectors were selected

randomly among the complete group of 15. Thirty small custard buns, 15 good and 15 defective were arranged randomly to be judged by the inspectors twice; Table 1 shows the agreement analysis plan and Table 2 shows the results. The final screening effective score vs. attribute was 83.33%, as shown in Table 2. The score shows the probability that all three inspectors made the same correct assessment of a bun, giving an identical attribute value. This score is higher than the recognized standard for an attribute gage agreement analysis of 80%, so the conclusion is that inspection for shrinkage defects is suitable for further analysis.

The next job in the measure phase is to explore potential influential factors for bun shrinkage. From the process flow diagram and the cause-and-effect analysis result, numerous factors from the related process were scrutinized using the cause-and-effect matrix (also called an X-Y matrix), which weighs each factor by three indexes: Data collection difficulty, impact on defect and controllability of factors. Table 3 shows the X-Y matrix.

**Table 2.** Attribute gage agreement analysis result.

Sampling		Operator #1		Operator #2		Operator #3		All operators agree within and between each other	All operators agree with standard
Sample	Attribute	Trv#1	Trv#2	Trv#1	Trv#2	Trv#1	Trv#2	Y/N agree	Y/N agree
1	y	y	y	y	y	y	y	Y	Y
2	y	y	y	y	y	n	n	N	N
3	n	n	n	n	n	v	v	Y	Y
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
29	n	n	n	n	n	y	y	N	N
30	v	v	v	v	v	v	v	Y	Y
<b>Appraiser score<sup>(1)</sup> ≥ (%)</b>		<b>100.00</b>		<b>100.00</b>		<b>100.00</b>			
<b>score v.s attribute<sup>(2)</sup> ≥ (%)</b>		<b>100.00</b>		<b>100.00</b>		<b>83.33</b>			
<b>Screen effective score<sup>(3)</sup> ≥ (%)</b>								<b>83.33</b>	
<b>Screen effective score vs. attribute<sup>(4)</sup> ≥ (%)</b>								<b>83.33</b>	

**Table 3.** X-Y matrix.

No	Process steps	Priority factor	Data collection Impact on defective Controllability			Total
			5	5	7	
1	Weighing	Weight	1	1	1	17
2	Dough stirring	Quantity	1	3	1	27
3		Color difference	5	5	3	71
4	Dough sheet rolling	Thickness	3	5	3	61
34	Outgoing	Shift	5	5	1	57

Nine potential factors were selected, including: color of the dough, number of times the dough sheet is rolled, temperature of stuffing, ferment time, steaming pressure, volume of ice water input, steaming time, type of steaming box and production shift.

### Analyze phase

In the analyze phase, two types of analysis were performed. One was the analysis of variables for which data can be readily collected, and then statistical analysis was used to test whether these factors (Xs) had an influence on the project's index (Y) or not. The other analysis was for variables that data are hard or even impossible to collect, and for which the failure mode and effect analysis could be performed. For the statistical analysis, the small frozen custard buns were sampled one from each containing plate, which contained 49 buns, 30 times during a two-week data collecting period. Each bun was re-steamed to evaluate whether or not it would shrink. Figure 8 shows the main effects plot for each factor with regard to shrinkage. Among these, type of steaming box

and steaming pressure were collected at only one level in that period. For all the other factors, Color difference of dough, number of times for dough sheet rolling, ferment time, volume of input ice water, steaming time, and shift seemed to be influential to the defect rate. The same data were analyzed by statistical method ANOVA (Analysis of Variances). Table 4 shows the tested result. Except for X4 and X5, 5 factors were concluded significant.

Failure mode and effect analysis (FMEA) is the task of finding possible faults in a system and evaluating the consequence of the fault on the operational status of the system. It's a method of reliability analysis intended to identify failures which have consequences affecting the functioning of a system. In other words, FMEA can be explained as a group of activities intended to recognize and evaluate the potential failure of a product or process and its effects, to identify actions that could eliminate or reduce the chance of the potential failure occurring, and to document the process. In a FMEA, manufacturing steps are listed by project members and all potential failure modes are identified in each step. All possible failure modes are then discussed with their respective effects and the severity (SEV) regarding every effect, the cause

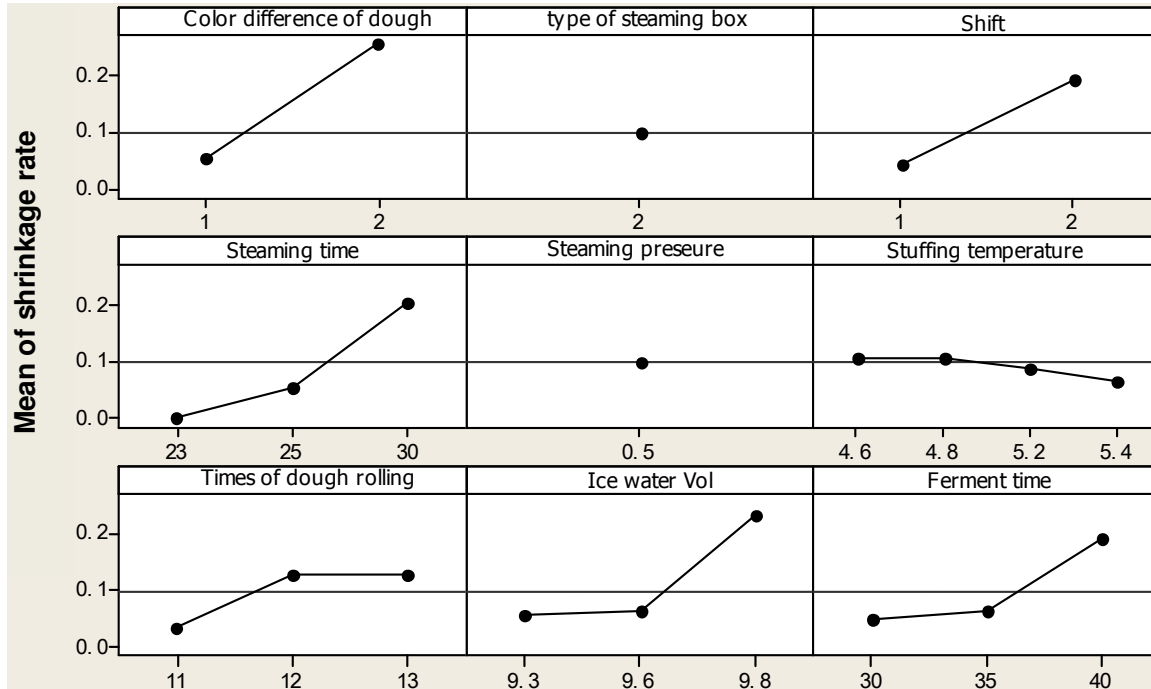


Figure 8. Main effects plot for each factor to shrinkage.

Table 4. ANOVA tests for each factor.

Variable	Variable name	Conclusion
X1	Stuffing temperature	P=0.043<0.05 significant
X2	Color difference of dough	P=0.000<0.05 significant
X3	Shift	P=0.003<0.05 significant
X4	Ferment time	P=0.078<0.05 marginal
X5	Times for dough rolling	P=0.061<0.05 marginal
X6	Steaming pressure	Not enough data
X7	Volume of input ice water	P=0.015<0.05 significant
X8	Steaming time	P=0.001<0.05 significant
X9	Type of steaming box	Not enough data

of each failure and the occurrence rate (OCC) regarding each cause, and a measure of the ability to detect cause in this process (DET). According to the data gathered in the analysis, all failure modes are ranked by the risk priority number (RPN), which is calculated by multiplying SEV, OCC and DET. The higher the RPN of a failure mode is, the more urgently this failure must be considered for remedial action. Table 5 shows the preliminary FMEA of this project. The three most critical failure modes are listed according to their RPN values. Table 6 shows their respective remedial actions and RPN values after these actions have been taken.

**Improve phase**

After factors with an impact on the project index were

found, we still did not know what level of each factor would comprise the best solution for the shrinkage rate. Therefore, a series of integrated experiments was proposed to investigate the best recipe, a plan that we call design of experiments (DOE). In this project, stuffing temperature, times for dough rolling, ferment time, volume of input ice water and steaming time were selected to proceed with a “five factors, two levels, 1/2 fraction ( $2^{5-1}$ ) and two replicates” factorial design. As for the shift and color difference of dough, a non-DOE qualitative improvement was proposed via brainstorming techniques. In the DOE analysis results, the most critical factors were found and the best level for each factor was derived according to the experimental data. Figure 9 shows the factor effect Pareto chart. Among the five factors, input ice volume was the most critical factor. By using an optimization tool in the statistical software, the best recipe for minimizing shrinkage rate was also estimated.

In addition to quantitative factors, which can be optimized by using DOE, there are still some factors that can be measured but cannot be controlled, such as different shrinkage rates resulting from different shifts, and even factors that are immeasurable, such as those discussed in FMEA. So even though one of the core concepts of Six Sigma is data driven improvement, brainstorming method is often still quite useful.

**Control phase**

After the improve phase, actions that could address the

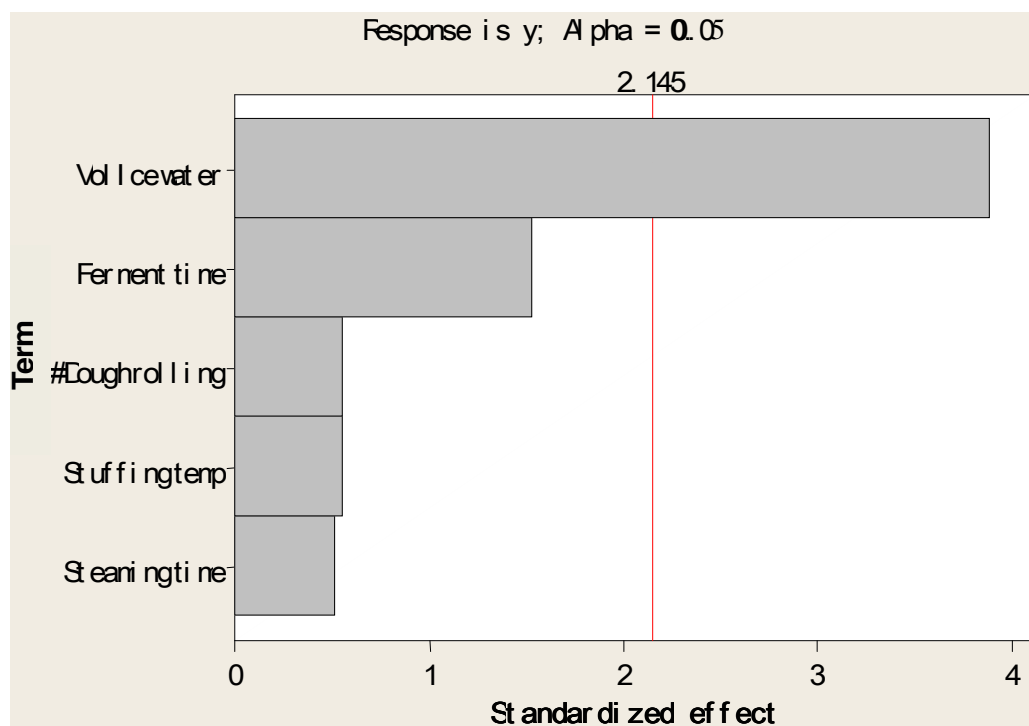


**Table 5.** Preliminary FMEA

Process function	Potential failure mode	Potential effects of failure	SEV	Potential cause(s) of failure	OCC	Current process controls	DET	RPN
Ferment	Ferment defective	Sink after re-steaming	7	Stuffing temperature too high	7	Temperature control	6	294
Stuffing preparing	Stuffing leakage	Leakage defective	7	Stuffing not well mixed	6	Pre-process of custard	6	252
Dough sheet rolling	not well rolled	shrinkage defective	6	insufficient rolling times	5	minimum 10 times	5	150

**Table 6.** Remedial actions and RPN values

Recommended action(s)	Responsibility and completion date	Action results	SEV	OCC	DET
Automatic temp control		Keep stuffing temp under 5 <sup>o</sup> C	6	5	4
Stuffing mixing SOP		Well mixed	4	5	4
Auto rolling timer setup		Well rolled	4	4	4

**Figure 9.** Effect Pareto chart of factors in DOE analysis.

factors causing the shrinkage of the buns were proposed. All these actions were implemented sequentially in the manufacturing process, and the results were monitored in control phase. In the improve phase, the most important mission is to keep the achievements obtained after undertaking D, M, A and I phases sustained for a long time. A revised FMEA was produced to form the 'control plan' for this product (or process), and this is usually the

major tool employed in this stage. Other tools, such as Poka-Yoke (mistake-proof), SPC (statistical process control) charts, SOP (standard operation procedure) documentation and training plans are also used frequently in some steps with regard to factors found in previous phases. In this project, a 'control plan' that integrated all the counteractions was proposed, and this included training and certifying machine operators and other

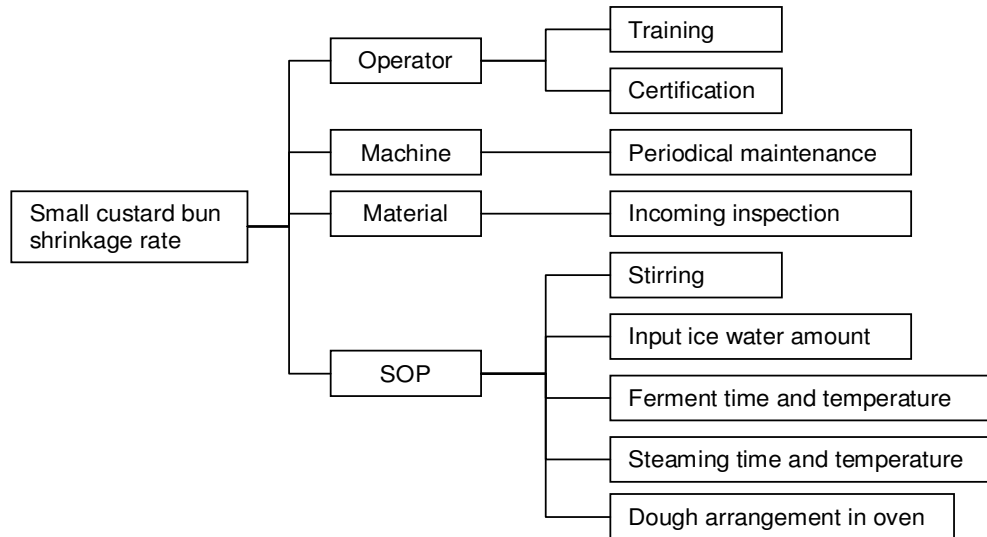


Figure 10. Counteraction plan for shrinkage.

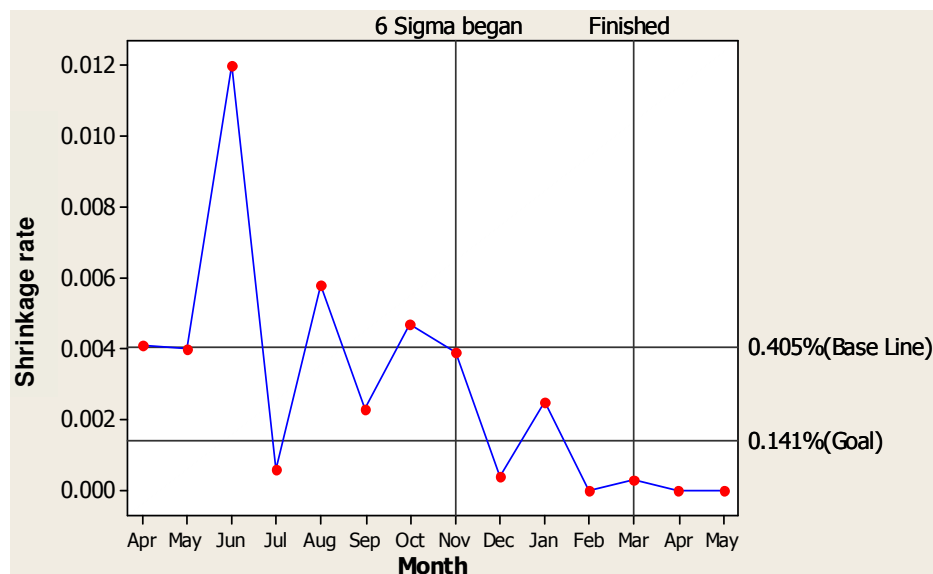


Figure 11. Shrinkage rate after actions taken.

employees, a periodical maintenance plan, incoming material inspection, a revised operation SOP and SPC control charts were all included in this plan, with details shown in Figure 10.

In Figure 11, we can see that the average shrinkage rate for the small custard buns was 0.405% (baseline) at the beginning of this project, and decreased to below 0.141% (goal) after the actions were implemented. Therefore, we can conclude that factors affecting the shrinkage defect rate were captured in this project, and some useful actions were proposed and efficiently implemented, and we achieved quite impressive results that went beyond the goal we had set.

## DISCUSSION

This was the first time that the case company had deployed an improvement project systematically. Due to a lack of experience and insufficient of employee capability, the case company was afraid of failure at the beginning. Only two projects were selected. However, these projects were both extremely successful. For the shrinkage rate project, the final results was even better than the original goal, and thus the case company decided to continue implementing Six Sigma projects over the long run. Five features are worth noting from this project.

First, the projects were carefully and systematically

chosen to coincide with the company's long-term development. From the champions' first proposed projects according to their department's KPI, the projects most important and relevant to KPI were selected. On one hand, the success of these projects can be coincided with the strategy of the company. On the other, resource could be committed because the coincidence with KPI and the improved process can be assured to proceed.

Secondly, project teams were formed to work with these projects. Appropriate Black Belts and also cross function teams were chosen to work with collective wisdom and concerted efforts. In addition, these projects were important opportunity to train the BBs how to be better leaders in this context.

Thirdly, a SMART (Specific, Measurable, Aggressive yet Achievable, Relevant to corporation goal, Time-bounded) goal was set in each project. The objective of this project was set at 0.141%, which intended to decrease the defect rate by 70% from its baseline to its entitlement. The entitlement defect rate had its best performance in the 12 months before this project, so it was an aggressive action to use this index as a target to improve. Setting a 70% improvement means that it is achievable during a six-month project period. After the project goal is achieved, another project can be initiated to continuously improve quality of the same product.

Fourthly, the pursuit of the true causes of the defects was systematic and data driven. The DMAIC stages were employed, and statistical data analysis was used to find the reasons for the defects.

Lastly, a long-term monitor and control process was implemented to ensure the improvements could be maintained for a long time. Relevant SOP and documents were collected and distributed, possible error-proof measures were carried out, and an integrated process control was made and applied.

## Conclusions

If Six Sigma helped make General Electric Co., one of the most successful businesses in the nation, why can not Six Sigma work in the food industry? That is what executives at fast-food giant McDonald's asked when they started to work with Stamford-based GE Commercial Finance's Franchise Finance unit to learn about Six Sigma (Lee, 2005). The commercial food processing industry has a strong link to quality practices. However, the food processing industry has also been characterized as being conservative and slow to change. Understanding the quality practices in food processing requires an understanding of how the consumer, the nature of food, and the regulatory environment interact to affect the industry. In most of Taiwan's food processing companies, quality improvement initiatives usually encounter difficulties due to lack of experience, low level employee ability and unfamiliarity with quality improvement tools. Take the case company for example, this Six Sigma program was the

first time that the case company had undertaken a formal quality improvement project on a large scale. In addition, the educational level of most of its workers is below senior high school, and thus many of them do not know how to perform quality improvement activities and are unfamiliar with statistical analysis tools. Despite these hurdles, by a systematic application of the Six Sigma system, significant improvements were made.

First, a well-organized Six Sigma infrastructure is necessary for an organization to carry out the related improvement projects. The case company prepared a Six Sigma deployment plan, including CEO training, champion training and a company-wide employee three-hour course about Six Sigma ABC. A Six Sigma core-team was set up to discuss and build related HR (human resource), finance and IT (information technology) plans. Rules such as how to select a DMAIC project, how to select a BB candidate, how to calculate financial savings and how to reward the project members were proposed at the very beginning of the process.

Secondly, integrated BB training according to DMAIC stages was prepared and carried out. Compared to traditional improvement projects that tools are selected depending on personal familiarity with some tools, DMAIC methodology solves problems systematically. There are lots of tools needed to be performed. Project members, including BBs and team members, were thus all scheduled to complete a 15-day training program in five stages.

Thirdly, a project-driven management system was also critical for the success of implementing Six Sigma program. After projects were proposed and approved by the Six Sigma committee at the case company, teams were built up for each project and BBs were assigned. The tasks that needed to be accomplished at every stage were set up and announced in the training class of each stage. Tollgate reviews were then held to monitor the progress achieved. Project team meeting records were kept for every meeting in every stage. Every project was arranged to be completed within six months. In this way, the champions can know the progress of their own projects and give necessary help when needed.

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