

# **Six Sigma Evolution within Transitional Economies. The Argentinean Case.**

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## **Abstract**

During 2004, the Argentinean Institute for Quality conducted an investigation highlighting significant aspects of Six Sigma programs and how they were applied at several companies in Argentina. The current study builds upon the results of the previous work, showing the changes, issues and challenges experienced by companies with mature Six Sigma methodologies in place. Instead of focusing on the “synchronic” aspects of Six Sigma, i.e. the situation at a certain point of time for a given company, our research studies the “evolution” of the methodology. We think this investigation can provide insight on what to expect of the deployment of Six Sigma over the long term, particularly in transitional economies experiencing high growth.

## **Introduction**

During 2004, the Argentinean Institute for Quality conducted an investigation highlighting significant aspects of Six Sigma programs and how they were applied at several companies in Argentina (Firka,2004). The main goal was to see whether the comprehensive application of the methodology can act as a catalyst for local and national economical progress, mainly in transitional economies like Argentina. The outcome of the investigation was presented at the 48th European Quality Congress in Moscow.

The current paper focuses on what happened over the last three years. Instead of focusing on the “synchronic” aspects of Six Sigma, i.e. the situation in a certain point of time for a given company, our research studies the “evolution” of the methodology,

Most of the bibliography about Six Sigma describes critical success factors for the “kick-off” and deployment, giving less attention to critical factors for the maintenance of the initiative. One reason for this emphasis could be the implicit belief that as the company develops a solid infrastructure through “rotation” of Black Belts and a strong linkage with Business Strategies, there will always be new opportunities for projects with financial justification appropriate for the DMAIC process.

Consequently, the “roadmaps” usually finish after the deployment as if there is a steady state after the “transition phase”. M. Harry (Harry, 2000) argue that when the Quality Level reaches 4.8 sigma (about 500 defects per million opportunities), the focus should move to the redesign of processes through DFSS (design for Six Sigma). Although we found two companies that followed the road of DFSS with different degree of success, in both cases the original Six Sigma Program also mutated considerably.

To show the environment under which the organizations develop their businesses, we'll describe the evolution of the socio-economical landscape in Argentina during the period 2004-2007. The information for the description is based on interviews with two macroeconomists and three government officials.

## Summary of the previous investigation

In 2003/2004, we decided to investigate whether the promotion of Six Sigma could act as a catalyser for local and national development. To that end we interviewed 13 companies of different sizes and industries. Most of them were already applying Six Sigma for at least two years, and we found the following benefits:

### Short Term

- Financial benefits from the first projects that help to payback the investment in training and consulting.
- Development of an execution infrastructure oriented to continuous improvement.
- Training in statistical tools for quality, and establishment of rational criteria to select the right tool for a specific problem.

### Mid Term

- Orientation to team work
- Management by fact
- Emphasis on the customer, internal and external
- Project management skills

### Long Term

- Better leadership style
- Learning organization, reaching the level of auto-training with Master Black Belts.
- Culture with more participation and integration.
- Enterprise alert to find opportunities to improve

For the current paper, we studied whether the findings of the first investigation hold after three years. Our expectations were to find a similar infrastructure with changes in the amount of belts and the kind of projects being active. As we will describe, that was very far from what we found.

## Methodology

This paper could be classified as a qualitative study of multiple cases thorough interviews and a longitudinal study of the temporal evolution of Six Sigma. The first set of cases comprised 13 companies. For this investigation we were able to interview key Six Sigma players in 8 of those companies to contrast the results with the original interviews made in 2004. The factors analyzed were:

- Current and Previous infrastructure.
- Temporal evolution in the amount and scope of projects.
- Resources involvement over time.
- Perception of Six Sigma
- Knowledge management and knowledge transfer.

The sample size precludes any statistical validity, but it can shed light on the complex entanglement of factors that guides the evolution in implementations that once upon a time were canonical examples of Six Sigma.

Due to time and resources availability the interviews were focused on critical aspects and experiences, without delving into excessive details. This approach allowed us to grasp the main concerns and findings of the firms, with the involved risk of disregarding particular aspects and detailed in-depth discussions more suited to single-case studies.

The eight companies that participated in the current investigation belong to the following vertical markets:

1. Service Company: Telecommunications
2. Service Company: Financial Services.

3. Manufacturing Company: Automotive
4. Manufacturing Company: Chemical
5. Manufacturing Company: Petrochemical
6. Manufacturing Company: Consumer Products
7. Manufacturing Company: Energy
8. Manufacturing Company: Chemical

Company size varied between 100 and 3000 employees; all of them were local subsidiaries of global corporations, which allegedly add bias to the investigation. This situation is due to the circumstances of the first set of interviews (2003/2004). Back then Six Sigma wasn't yet a popular methodology in local corporations, which restricted our sample frame to representatives of global firms.

## Country Environment and Evolution

Firstly let's present a brief sketch of the country that provides the environment under which this investigation takes place. Argentina, a country located in the southern tip of South America, is going through the fourth year of high continuous growth after experiencing its worst socio-economic crisis ever.

The crisis, which erupted at the end of 2001, left half of the population under the poverty line (47,8%<sup>1</sup> in 2004), and almost thirty percent of the economically active population with employment problems (30.8%<sup>2</sup> in 2004). Currently those figures have improved significantly: unemployment rate went down to 9.8%<sup>3</sup>, albeit 31% of the population remains under the poverty line.

Externally, the structure of exports is still mainly based on primary products, i.e. soybeans. Those commodities are usually subjected to price cycles and restrictions in the international markets. Hence, the current export bonanza is only providing a temporal relief threatened by these volatility factors. In addition, this orientation to primary exports makes the internal market sensitive to exogenous shocks. To modify this exports' structure the Ministry of Foreign Affairs developed a program to promote high value added products in international markets<sup>4</sup>.

The external debt also constitutes a critical concern. In 2002 it was larger than the gross domestic product (129% of GDP<sup>5</sup>) decreasing to 49% of GDP in 2007<sup>6</sup>. Since 2003, the industrial sector is growing at an average rate of 10.8%<sup>7</sup>, inducing exports with the aid of a favorable exchange rate. Exports doubled its amount between 2004 and 2007, generating repayment capacity for the external debt.

Another factor to consider is institutional instability. Decades of irregular government changes, by democratic or dictatorial means, are frequently accompanied by extreme fluctuations of economical conditions. The irregularity of these political events creates an atmosphere of uncertainty, undermining long-term planning. As an example, there are many decisions being postponed because this year (2007) is an electoral year. Although certain uncertainty is always present in democratic processes facing a change of leadership, in Argentina the perception is that nothing, not even fundamental tenets of macro economical policy, can be held immutable for next year. This situation leads to short-term and fleeting decision making processes almost as a socio-cultural characteristic.

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<sup>1</sup> INDEC (National Institute for statistics and census): 2<sup>nd</sup>. Semester of 2003

<sup>2</sup> INDEC (National Institute for statistics and census): 4<sup>st</sup>. Trimester of 2003

<sup>3</sup> INDEC (National Institute for statistics and census): 4<sup>st</sup>. Trimester of 2003

<sup>4</sup> Cancillería: "Integral program of commercial promotion and development of external markets".

<sup>5</sup> Central Bank of Argentina (BCNA)

<sup>6</sup> [www.trading-safely.com](http://www.trading-safely.com)

<sup>7</sup> Ministry of Economy: [http://www.industria.gov.ar/cep/industrial/actualidad\\_industrial.pdf](http://www.industria.gov.ar/cep/industrial/actualidad_industrial.pdf)

During the last decade, following strict IMF and Washington Consensus recommendations, the State was seen as a monster that has to be stripped of most of its companies as quickly as possible (Stiglitz, 2002). This led to a State lacking human and technological resources, surrounded by an inefficient bureaucracy intertwined with corruption.

Through the 90s, indiscriminate opening of the economy in the context of overvaluation and inefficient measures to combat disloyal practices resulted in small pools of high productivity, concentrated in a few products and certain geographical regions, dispersed over a desert of inefficiency and low yields. These inequalities are detrimental to systemic competitiveness and currently efforts are under way to restore whole value chains providing robustness to the macro-economical landscape.

The last government administration represents a departure from the free-market orthodoxies of the 1990s, with a more interventionist role for the state, especially with regard to infrastructure and energy.

On the strengths side, Argentina has a well-educated labor force and an advanced technological infrastructure, product of the currency conditions of the 90's and the privatization of public services.

## Six Sigma

Since the early 90's Six Sigma has been gaining momentum as one of the most effective improvement methodologies among a large number of companies worldwide, and its adoption still shows an upward trend.

Nevertheless there is criticism and concerns regarding certain aspects of the methodology, such as proved financial results and effects of Six Sigma over innovation (Hindo, B, 2007; Howard, V. 2007; Morris, B., 2006)

Notwithstanding the efforts by some organizations -ASQ (CSSBB certification), ISSC ([www.isixsigmacouncil.org](http://www.isixsigmacouncil.org)), etc.-, there is no normalization body that could give a standard definition of Six Sigma. We found that the meaning and particular deployment paths usually depend on the consultant hired for the deployment.

A discussion of what is the best definition for Six Sigma is outside the scope of this paper, but insightful information can be found in Linderman *et al* (2003), George (2002), Eckes (2001), Nonthaleerak, P (2005). Lately, Brady & Allen (2006) proposed the following definition:

*"Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates.*

*The Six Sigma method only fully commences a project after establishing adequate monetary justification.*

*Practitioners applying Six Sigma can and should benefit from applying statistical methods without the aid of statistical experts.*

*The Six Sigma method for completed projects includes as its phases either Define, Measure, Analyze, Improve, and Control (DMAIC) for process improvement or Define, Measure, Analyze, Design, and Verify (DMADV) for new product and service development".*

In order to analyze the results of our work, we'll arrange our findings according to the Critical Success Factors identified by Banuelas & Antony (2002), which are in line with subsequent papers on the subject (Byrne, G., 2003; Lucas James, 2002, Blakeslee Jr, 1999, Brewer & Bagranoff, 2004, Carnell, 2004):

- Management Involvement & Commitment
- Cultural Change
- Communication

- Organization infrastructure:
- Training
- Linking Six Sigma to business strategy
- Linking Six Sigma to customers
- Linking Six Sigma to human resources
- Linking Six Sigma to suppliers
- Understanding tools and techniques within six sigma
- Project Management Skills
- Project Prioritization and Selection

## **Analysis and Results**

### ***Management Involvement & Commitment***

The commitment of top management was considered critical by all of the interviewees, especially during the initial stages of deployment. In three companies, this top-down “push” as a critical requirement not only established Six Sigma in the agenda of middle management, but also produced a kind of “Hawthorne Effect”.

The Hawthorne Effect is named after a series of studies conducted at the Western Electric Corporations’ Hawthorne plant around 1920. The experiments were planned to study the impact of lighting levels on worker productivity. The first set of experiments revealed the expected result that as lighting increased, so did productivity. However, researches then did a parallel experiment in which lighting levels were decreased, surprisingly finding that productivity also went up as the light decreased. The researchers concluded that productivity was not as much influenced by the lighting level, but as a result of the attention being received by the workers. This phenomenon is attributed to the principle that, at least in part, work is a group activity in which employees strive, among other things, for a sense of belonging.

Applied to our investigation, the effect was seen as increased productivity simply in response to the increased amount of attention received from managers during the first years of their company’s Six Sigma implementation. When the program slowly vanished from the executives’ agenda, productivity levels returned to normal while financial expectations sometimes stayed at high levels, which in turn created the perception of diminishing returns for the whole initiative.

In hindsight, two companies described a lack of real commitment from Top Management, although there was the talk of Six Sigma, the “walk” was absent. According to one interviewee:

“Top management wasn’t convinced. Six Sigma started as a way to fulfill the mandate of the corporation, rather than as an intrinsic commitment of the local subsidiary. The consulting firm didn’t refuse to deploy in spite of the lukewarm circumstances, maybe because of lack of expertise or because they didn’t want to lose the customer”.

### ***Cultural Change***

Cultural change is one of the most elusive terms to define and properly translate to a measurable dimension that we can compare among cases. During the first set of interviews, for most companies the cultural change arising from Six Sigma was an expectation, because the experience accumulated was not enough to show clear modifications in cultural patterns. Now, after three years, not all companies saw evidence of cultural change. In the word of one of the interviewees: “Six Sigma didn’t change cultural behaviours or our silo mentality; we keep a short-term orientation, with heroes trying to break organizational barriers”

However, six companies reported that the organisation was becoming more data driven after years of DMAIC projects, and this tendency to use measurable data for decision making was credited to the rigorous approach of Six Sigma. This change in mindset was positively correlated to the initial deployment scope, i.e.: broader scope of the deployment produced more impact over a culture oriented to statistical thinking.

The concept of incorporating Six Sigma into the DNA of the organization was referred to by three companies in a way that shows how Six Sigma loses its original characteristics as knowledge and experience accumulate within the organization. According to this view, Six Sigma cannot be seen as a static object that can be implemented once and forever. Instead, is a gradual process (after the initial deployment) by which the organization changes, and not all the projects are treated as DMAIC projects, the role structure loses its purity and foreign improvement tools are added. If we analyze those companies through the canonical lenses prescribed by the gurus (Pande, 2000;, George, 2002; Harry,2000; Breyfogle,1999; Pyzdec, 2003; Eckes,2001), none of them can be said to adhere 100% to any of those authors.

Even in the companies that consider Six Sigma as part of the Organizational DNA, the perception is that there is still a long way to go as far as top management commitment and wise application of the methodology.

### ***Communication***

In one company, as Six Sigma became more engrained in the day to day business of the corporation, the communication strategy started to be less focused on new development, and more focused on the usual metrics such as amount of projects, number of belts, savings accumulated, etc. This process of decay in the amount of explicit communication about the program was experienced by most of the companies. One company stopped producing its internal magazine formerly dedicated exclusively to Six Sigma news. Even though in one company the vertiginous growth over the last years generated many improvement opportunities for Six Sigma projects that kept the methodology alive, it was never back in the limelight.

Less successful experiences ascribed part of their frustration to inflated initial expectations communicated thorough the corporative channels. After those expectations didn't materialize, rejection followed suit, and this even led to react against the term "Six Sigma", as one interviewee stated:

"If I were to start a fresh new deployment [of Six Sigma] I would not put a name to the methodology, I will integrate it to the actual projects without an explicit name"

Two companies declared that the low image of the program motivated a "reaction" to the participants: people with Six Sigma roles trying to be released as soon as possible from the "Six Sigma" label that was adjudicated to them.

### ***Organization infrastructure:***

In big corporation with outstanding results, the Six Sigma formal structure played a key role, establishing rules and procedures that were certainly fostered by a culture oriented to continuous improvement. Those factors promoted Six Sigma sustainability and the continuous push to insert projects in a knowledge database that slowly increased in scope and quality.

A lot of diversity was found in the IT infrastructure developed to sustain the program. The software was generally seen as a Project Tracking system rather than a Knowledge Management tool, reducing the perceived value as a way to share experiences and learn from mistakes. Several causes were involved, such as:

- In several cases the software was written in English, or the information had to be typed in English, making search for information harder for Spanish speakers.
- There was a bias toward "finding our own solution" instead of relaying on foreign experiences that can reduce the perceived value of the innovation for the project leader (originality was more rewarded more than learning from other experiences)

## ***Training***

The disciplined process of DMAIC and the quantitative tools taught in most Six Sigma training facilitated the acceptance in manufacturing areas. Service companies and transactional areas of manufacturing companies found it harder to incorporate Six Sigma tools. This specially applies to the maintenance phase of the methodology, after the “low hanging fruit” has been gathered and is harder to find suitable projects. Interestingly, some of the same companies were very happy with the results in the service areas during the first set of interviews, but the excitement faded away after the first wave of projects.

## ***Linking Six Sigma to business strategy***

One of the successful companies has a very rigorous approach to align Six Sigma projects to the Business Strategies. Opportunities trickle down from a top level scorecard identifying “Super-Ys” that are translated to project down the hierarchy according to the scope. During the past years new concepts were added as Super-Ys; for example New Product Development and Customer Relationship, that created the need of new tools – DFSS, Lean Techniques, etc.- complementing and enhancing the already established Six Sigma practices.

Validating the savings was a critical requirement because it helped to incorporate financial thinking in the continuous improvement project. On top of that, the financial criteria brought better visibility of the results using a language that can be easily understood by the business.

## ***Linking Six Sigma to human resources***

Those companies that stated positive results described a progressive adaptation of Six Sigma to their organizational idiosyncrasies, learning which tools to use and the scope that the projects should have. In two cases paramount importance was given to the personal leadership of the Master Black Belt and the Champion.

Although Six Sigma implementation was considered positive in most of the interviewees, in two cases the resources assigned were considered more than necessary to obtain the experienced results, five to seven years after the initial deployment.

Only three companies kept Black Belts as full time employees. For the other five cases, it was very hard to keep full time commitment, in agreement with the results found by Hendry (2005). However, part time Black Belts were prone to get trapped by operational activities that distracted them from the projects. Reversion of this adverse situation was influenced by:

- Maturity of the methodology: experienced Black Belts knew how to balance their work load to care for their projects, and mature Process Owners understood the importance of not delaying the projects.
- Rigidity of the gateway process for projects: strictly enforced milestones fostered the sense of urgency to commit time and work on the projects.
- Closeness between the project and the Black Belt activities: projects attacking problems closely related to their operational activities were easier to pull through.

## ***Linking Six Sigma to customers & suppliers***

Apparently the interest to push Six Sigma to Customers and Suppliers is a characteristic of the first years of deployment, when the methodology is in the spotlight. This situation was mostly seen with the first set of Interviews, when companies were just finishing their initial deployments.

We found during the second set of interviews that after the methodology matures internally, the interest in outward promotion fades away, but what usually persists is the principle of involving suppliers/customers to solve specific problems arising through DMAIC projects or Lean Manufacturing techniques.

One of the companies used its experience in Six Sigma to establish trust relationships with a customer, participating in improvement projects that created knowledge transfer related to the methodology. This experience increased links with the customer and established new communication channels that eventually led to commercial opportunities.

### ***Understanding tools and techniques within Six Sigma***

Three of the companies evolved to an eclectic mixture between Lean Techniques and Six Sigma. Within those companies, the Six Sigma implementation instituted a change in mindset and a focus on data that simplified the adoption of Lean principles.

Two companies declared having difficulties in extending the methodology to non-manufacturing environments. Among the causes identified where:

- Senior management involved in Six Sigma came mostly from manufacturing.
- Difficulty to assess the financial impact of many transactional and top-line projects.
- Cross-department projects need a lot of support that in some organizations is hard to acquire years after the initial deployment.

Another issue to consider is the risk of forcing the tools. Two of the companies reported that during the first waves of training, some Black Belts spent a lot of time trying to figure out how to apply all the tools that were taught, many far beyond the real requirements of the project. Employee productivity and perception of usefulness of Six Sigma were severely damaged when this happened. One solution found was to adapt the training curricula focusing on the tools most used, and adding workshops for more advanced tools less frequently needed.

### ***Project Management Skills***

The rigorosity of the DMAIC approach was helpful to cope with complex problem, providing an ordered pathway plus analytical skills. In particular, Measurement System Analysis was noted as a tool that was easily bypassed before Six Sigma. According to Greg Watson (Watson G., 2006) the sequencing and interlocking of the tools in the DMAIC process is the largest contribution of Six Sigma to the continuous improvement methodology.

On the negative side, in some cases the whole development of a Six Sigma project came up with the same solution a quickly focused meeting like a Kaizen Event would provide, so the amount of time and resources involved did not justify the outcome of the project.

During the years after the national economic crisis, the unusual growth in some companies brought new project opportunities, but also decreased the time allotted to work in those new projects, affecting the perceived efficiency of the whole methodology.

### ***Project Prioritization and Selection***

As we described above, during early stages of deployment, in two companies the main concern was the quantity of projects and the amount of tools used, which led to the use of tools no matter how applicable they were. The more advanced the tool, the better it was considered to show management the new way to solve problems scientifically. Sadly, this strategy proved counterproductive: it was easy to show that similar results can be reached through simpler tools discrediting the whole methodology. In successful companies there was a change of focus; instead of looking at the amount of projects, the concern shifted to how the Pareto of projects is built; either supporting business strategy (top-down) or arising from operational problems (bottom-up).

Regarding Project scope, in most cases there was a shift to projects of smaller scope and less magnitude more adapted to the typical definition of GB projects. However, in one of the companies there was a decrease in the amount of projects by green belts, because they were too busy due to production increases. Therefore the majority of Six Sigma activities relied on extremely busy Black Belts, creating islands of Six Sigma practice that diminished the corporative reach of the methodology.

Financial savings was usually the first priority in project selection at the beginning, but that emphasis changed over time to encompass quality improvement and other topics. That change was not always beneficial: in one company it produced a diversification of the effort. In other case the financial requirement acted as a bottleneck because the controller in charge of validating the savings wasn't able to allocate the time needed to rationally analyze the projects.

### ***Interactions between Factors and Evolution***

As stated in the Introduction, several factors affected the evolution of the methodology, which makes it difficult to deduct unique recipes or suggestions.

It is easy succumb into a "slide bar" mentality assigning paramount importance to just one factor, thinking linearly that a change in that factor will automatically pull the other factors as concomitants (usually this powerful factor is identified as Top Management Commitment or Leadership Culture). However, as in any multifactor environment, it is critical to study the interactions between factors that can have positive or negative effects on the outcome.

Furthermore, although in the first set of interviews we verified a common set of characteristics by which the companies were referring to Six Sigma, the evolution during these three years slowly separated the various Six Sigma distinguishing features, i.e., the methodology slowly mutated and lost its comparability with other experiences by getting embedded into organizational practices.

In six cases there was a complex interaction that slowly eroded the methodology after its successful deployment: a slowdown of top level push (due to different reasons such as a new CEO of the corporation, a change in strategic priorities, or the sale of the subsidiary to another corporation, etc.), that simultaneously interacted with an decrease of "easily found" high yield project ("low hanging fruits"), creating a perception of exhaustion. This interaction had negative effects over the maintenance of the original implementation. In cases when this harmful situation was surmounted, it was through some of the following actions:

- Modification of the implementation structure: one company claimed that it concentrated its efforts on Black Belt projects, leaving Green Belts as team members. Paradoxically, three other companies followed the opposite way: shifting the focus to Green Belt projects of less scope but fast and concrete results.
- A stricter control on which projects are fed in the project queue: using past experience to filter out more project, choosing only those which according to the knowledge accumulated during the first waves will be more suited to Six Sigma DMAIC methodology.
- Changes in the techniques applied: Increased use of lean techniques and kaizen events.

Three organizations reported a gradual discredit owing to complex interactions between factors such as:

- Partial or "fake" support from some areas of the organization, affecting how commitment is perceived by the employees.
- Subtle but steady transformation of the implementation in a win-lose game (if some players win, that results in others players' defeat), resulting in a less than optimal adversarial relationship between the advocates of the methodology and their contenders. For some personalities this situation created a

symbolic battlefield that was challenging and stimulating, but in overall the resulting outcome was a bad reputation for the methodology.

- Cultural effect of scepticism that deteriorated the commitment as seen by the participants. Whenever this scepticism was not disclosed through clear communication channels it led to negative attitudes toward the whole program and the development of the projects.

A marked difference between the first and second set of interviews was related to exogenous factors: during the original set of interviews the crisis environment led to more references to the macro-economical environment and its influence on decision making. In those cases Six Sigma was seen frequently as a “light at the end of the tunnel” that embedded hope and allowed to concentrate in a better future in spite the unfavourable circumstances. On the other hand, the second set of interviewees saw fewer references to the macro-economical indicators, as the prosperous economical landscape allowed firms to increase its internal focus regarding Six Sigma and lessen the attention given to the macro environment.

## Six Sigma as $Y=f(x)$

Many Six Sigma training programs emphasise the description of a process as a transfer function, where the outcome  $Y$  is related to a series of causal factors  $X$  ( $Y=f(X)$ ), and one purpose of the Six Sigma project is to discover this relationship generally at the M (measure) and A (analyze) phases.

We can apply this concept to the Six Sigma environment of a company. When we reach a post-deployment state the initiative can be described by an equation like:

$$Y_t = f(Y_0, Y_{t-1}, Y_{t+1}, x_1, x_2, \dots)$$

Where

$Y_t$ : The Six Sigma reality in the organization at point of time  $T$ , encompassing:

- Amount of resources dedicated to Six Sigma at
  - o Strategic Leadership
  - o Middle management
  - o Workers and line teams
- Benefits arising from Six Sigma projects.
- Knowledge embedded and distributed thorough the Six Sigma organization.
- Amount and quality of projects

$Y_0$ : The initial deployment of Six Sigma:

- Characteristics of the first BlackBelts and GreenBelts selected
- Success of the first projects
- Initial top management commitment.

$Y_{t-1}$ : The history of Six Sigma within the company

- Evolution of the visibility of Six Sigma
- Situation of past Black Belts and Green Belts in the company
- Effects of changes in the top management over the initiative.

$Y_{t+1}$ : The future of Six Sigma within the company

- The planned strategy about next steps regarding Six Sigma
- The subjective perception (real or fictitious) of the actors about what would be the next steps.

$x_1, x_2, \dots$  The various Critical Success Factors as described by the copious literature on the subject. Each  $x_i$  should be affected by a weight factor  $w_i(t)$ , so that the relative weight of each factor changes over time.

According to this formulation, Six Sigma depends on its own history, which has the following consequences:

- It is almost impossible to “start again” after a bad experience. As one of the interviewees said:

“The bad experiences in the first projects generated frustration and resentment very difficult to revert. One of the most negative factors was the interruption of projects due to lack of support at higher management levels. It made it impossible to incorporate critical resources for the projects”

- It makes sense to communicate successful stories as early as possible to buttress the future perception and support of the program.
- Open communication channels should be established in order to perceive the “pulse” of the deployment.

However, the results of the methodology also depend on the perceived future, which makes it difficult to control its evolution merely by using past experience. Therefore other factors to consider are:

- The degree of internalization of Six Sigma tools, measured through the amount of projects that implicitly use DMAIC concept and tools, even outside the proper Six Sigma organization.
- The perceived future of the methodology as understood by management and employees. This insight can aid to overcome resistance and better understand actual experiences.

## Key Findings

- I- Four to six years after the deployment, the diversification of experiences makes it hard to speak of “one size fits all” definition of Six Sigma. The amount of factors interacting on each organizations and their relative weight creates a very unique development path for what they call “Six Sigma”. As a result, comparability between companies is prone to errors of reductionism.
- II- particularly in the context of transitional economies, we found new factors added to the already complex web of influences over Six Sigma:
  - a. Macro-economical instability with a cyclical economy and adaptation of actors’ behaviour based on the perception of the progress of economical indicators.  
In the words of one of the interviewees: “In a stable economy, Six Sigma can render better results, instability has the effect that a lot of effort is used to ‘not being worse’ rather than ‘being better’”.
  - b. In some cases -depending on organizational factors such as size, nationality, maturity of management practices, etc. - a leadership culture with excessive focus on short term results.
  - c. Implicit distrust or scepticism based on
    - i. Previous experience on improvement programs like Zero Defects, Reengineering, etc. abandoned or which didn’t fulfill expectations.
    - ii. Exogenous socio-cultural factors (corruption seen or perceived in different levels of society, lack of commitment to established laws, “back doors” for many situations that ease the complex official bureaucracy, etc.) which are internalized by the actors and harms any improvement initiative.
- III- Despite the diversity of evolutionary paths, certain tenets were seen in the majority of the interviewees:
  - a. Development of a Project Selection Process better suited to the need of the organization. The experience is unique for each company and leads to defined criteria about whether a particular problem should be treated with the DMAIC methodology.
  - b. Growth in the available toolbox of statistical and process improvement tools, as ANOVA, FMEA, etc. Specifically Measurement System Analysis was seen in two cases as a healthy newcomer in the manufacturing environment.

- IV- No company described negative effects of Six Sigma, and in the cases of suspension of the program the only negative side effect was an increase of scepticism about quality methodologies proposed as business saviours.
- V- Top Management Commitment is critical during early phases of the deployment, ensuring resource allocation and tactic alignment when Six Sigma is a future-oriented proposition. But when Six Sigma has been around for more than five years, the Project Selection Criteria starts to shine as the main factor during the maintenance stage, because improvement projects are the nutrition that feeds the actual and perceived results of the ongoing Six Sigma effort. We can say that a way to measure the maturity of Six Sigma implementations is by how new DMAIC projects are selected.

## Conclusions

It is common to see in the bibliography phrases such as “Six Sigma is [group of characteristics]...” or “That is a Six Sigma company”, but what we found is a dynamical process whose behaviour is sometimes chaotic, in the strict scientific sense that small changes in certain factors could produce enormous consequences over the evolution of the methodology in the organization (what is usually called “Butterfly Effect”)

Many times Six Sigma is exposed as an object that a company can purchase and install, like a recipe book or “do it yourself” furniture. The results of our investigations point to a process much more complex that invalidates this simplistic view and also makes complex to find a unique definition of Six Sigma beyond the initial deployment.

Moreover, aside from traditional factors such as top level commitment and training curriculum, a critical factor found is the specific method in which Six Sigma core concepts are consciously incorporated in the organization through a planned path that doesn’t end after the first wave of Black Belts. Considering the temporal dimension is crucial because it modifies the relative importance of the various endogenous and exogenous factors.

According to what we can learn from the cases studied, the factors that have to be constantly monitored to “calibrate” Six Sigma are:

- **Endogenous**
  - Organizational culture,
  - Perception of the methodology,
  - Economical results of projects
  - Knowledge transfer from projects to company knowhow.
- **Exogenous**
  - Market,
  - Tools that can be incorporated through training to be used in projects

It was surprising to find such a diversity in the evolution of the methodology, encompassing a whole spectrum, from clearly negative experiences in two organizations, through slightly negative experiences with some learning but slow fading of visibility for Six Sigma (two organizations), two slightly positive experiences (still using the original plan but changing the leadership structure and the administration process) and finally two clearly successful cases with positive results.

It is important to understand the limitations of this research. The complexity of the methodology plus the amount of factors that can influence its evolution makes it very difficult to calculate a statistically valid sample size that could create a valid picture for a whole range of business environments. Using SS jargon, if we see SS as the Y and we try to find the Xs influencing it, we can be overwhelmed by the amount of critical factors that affect the outcome.

Companies that are starting Six Sigma implementations should consider which concerns they will need to address after the initial peak of excitement. For organizations which are currently in the process of deployment we hope this paper will help to anticipate problematic situations and veer toward a wiser implementation of the Six Sigma principles.

As in the first investigation, we are convinced that this methodology creates an excellent opportunity to improve the competitiveness and leadership culture. Its promotion could be one of the factors that lead the emergence of a new country, providing a small but significant aid to solve the apparent conundrum of national development in transitional economies.

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