Technology-enabled organizational innovation in the Barcelona Subway: A counterintuitive example of improved commitment and performance

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Abstract

The adoption of a technological innovation at the Barcelona subway has given management an opportunity for not only improving the day to day efficiency of the transportation infrastructure, but also for organizing its exploitation in a radically new way, including the design of new work practices and routines, and the deployment of an organizational structure which at least (i) facilitates employee development and motivation, and (ii) improves efficiency and effectiveness beyond the obvious first-level consequence of train automation. A reflection on the underlying phenomena suggests further insights regarding how technology-based innovations can, counter-intuitively, produce results exceeding the customary shallow intuition that tasks’ automation leads to impoverishment of job content and structure, and consequently to employee de-motivation and lack of commitment. The underlying organizational culture is of course relevant, and it can get reinforced through the innovation adoption process if properly designed, managed and deployed.

Introduction: Some problems with the "old way of doing things" at the Barcelona Subway

The operation of the Barcelona Subway ("Metro") is typical in many aspects. A network of interconnected lines are managed in order to give public transportation service to the inhabitants of the greater Barcelona metropolitan area. The day to day process involves making sure that trains run according to schedule in an inter-line well coordinated way, that safety is guaranteed in both tracks and stations, that stations are properly kept and managed (including activities like shops, ticket spending and checking, etc.), and so on.

Traditionally, the Metro operation was organized following a clear “labor division” approach where train drivers played a central role requiring specialization and expert training. In addition there were inspectors in charge of ensuring that passengers ride with the appropriate tickets and that trains run according to schedule; station managers, responsible the one hand of looking after the security of passengers as they get in and out from trains and, on the other, of looking after the company’s interests in the exploitation of station shops, etc., typically subcontracted to third parties; ticket sales clerks, still present in a number of stations in spite of the generalized use of automatic ticket machines just to make sure that tickets were available under any conditions at least during peak hours; etc.

Beyond these very visible day to day operations, there are, of course, other important activities that go on “behind the scenes”: route planning and scheduling; trains’ and tracks’ maintenance and repair, stations’ cleaning and infrastructure maintenance of such elements as escalators, lifts and ticket spending machines; responding to trains’ malfunctions and handling re-scheduling requirements in response to accidents or break-downs, and the like.
One fundamental activity is the assignment of staff to operations in various places and times, in particular train drivers to trains in the different lines in accordance to pre-established schedules that take into consideration expected number of passengers at different times during the day, convenient connections in stations where lines cross, etc.

**Technological innovation: Opportunities for improved efficiency and new working practices and responsibilities**

Technological innovations opened up the possibility of making these operations more efficient and effective. In particular, “automatic train driving systems” permit to operate the trains with less specialized personnel. As of today, all trains in the Barcelona network need only a train operator in charge of opening and closing doors at each station stop. All other driving tasks can be triggered and automatically controlled through a central real-time information system that gathers and process relevant information and takes appropriate action, for example regarding trains’ speed and stop-and-go’s as appropriate under varying traffic conditions.

With this technology in place, many Metro employees working in stations and trains can act as train drivers too: inspectors, security personnel, manual ticket sales people, etc. can also “drive” trains. On the other hand, traditional train drivers can of course devote some of their time to other activities. Eventually, polyvalent employees could bring about more flexible work practices, unlocking in turn a potential for increased efficiency in terms of passenger-km operated per employee. Of course, harnessing such potential implies, among other things, re-training employees so as to make them skilful in activities different from those they had traditionally done, which could also involve re-negotiating working contracts under new terms and conditions.

An interesting consequence is that somewhat counter-intuitively, increased automation doesn’t necessarily lead to impoverishing task content and structure; on the contrary, if conveniently deployed it can result in polyvalent employees precisely because of its task simplification effect (on train driving in this case). Essentially, task simplification allows polyvalence because an individual’s “capacity” can encompass a larger number of simplified tasks than the number of more complex ones that (s)he could handle before.

In addition, as we discuss below, polyvalence can lead to both improved efficiency and better “organizational life quality” for employees, in such a way that a virtuous circle can spark off which produces both increased performance and commitment, making the whole process a sustainable, self-improving one. This, of course, provided that it is consistent with (i) the underlying policies and organizational culture and thus supposedly with management objectives and style, and (ii) with employees’ interests and stance.

**Making it happen**

Change does not happen spontaneously, however. For it to take place, explicit and purposeful organizational actions are needed. In addition, it is fundamental to initiate and nurture that virtuous circle so that it unfolds “naturally” and coherently; this is facilitated when a minimum of employee development and learning goals are embedded in the prevailing organizational culture, which is precisely what happened at the Barcelona Metro as we describe below.

Management at TMB (the Barcelona Public Transport holding organization that includes Metro) had been pursuing a de-centralization and empowerment policy for
several years. As a matter of fact, they had been able to make more progress in the bus company than in Metro partly because of the less flexible work practices and organization prevailing in the latter, a consequence of stronger profession traditions and inertias typical of railway operations. Nevertheless, a culture of subsidiarity and resourcefulness characterizes TMB at a degree, in our perception, well above what could be expected in such an organization.

In such a context, it is not surprising that the organizational initiatives put in place by management in order to harness the possibilities open by the implementation of the automatic train driving system had an aspiration of enriching employee work experience to the extent possible. In particular, the polyvalence dimension was explicitly considered as a lever for this purpose. The idea was as follows: A strongly specialized work force (particularly in terms of train drivers) had traditionally been at the root of constraints for the task assignment problem, with the result of working conditions susceptible of improvement mainly in two areas:

a) As an implicitly accepted rule (and also because of legal limitations) driving could only be done by specialized drivers. Deciding how many to have in the company’s work force and assigning them to driving tasks left almost no room for flexibility if one wanted to be reasonably efficient; the result was very tight schedules and a large number of uncomfortable assignments through the year (a lot of week-end assignments per driver, inconvenient timetables in vacation periods that often made good family vacation planning impossible, etc.), and

b) Tight schedules also meant very few degrees of freedom for reacting to unanticipated incidents –for example, drivers calling out sick at the beginning of the working day. This implied starting operations, typically at peak hours, below full capacity and hence delivering deficient service until replacement drivers could be located and brought to the stations where trains had been left unassigned.

A more polyvalent work force could help to address both these problems. Improved flexibility would follow almost automatically provided that scheduling and task assignment could be done more often than a few times a year, thus allowing employee availability to be more effectively matched to operational needs –for example giving higher priority to having all scheduled trains running at a given time than to, say, deploying the ideal number of inspectors on a specific line at a specific time.

In order to do that, however, a new scheduling approach had to be designed and deployed. To begin with, polyvalent employee scheduling could benefit from centralization because several advantages derive from considering all of them at the same time for task assignment purposes (i.e., not only train drivers to train driving, etc.), as assigning drivers to trains becomes more flexible when more “effective drivers” (albeit not specialized) are available. This entails an organizational innovation that goes hand in hand with the technological one and which was facilitated in this case by the fact that Metro owned the rights to exploit the complete infrastructure (tracks, trains, stations, accesses, etc.)

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1 I.e., the task assignment problem was virtually a closed one, with almost no room for alternative solutions. This was the reason why it was solved only a few times a year, typically in response to rather predictable, seasonal and aggregate transportation needs. Employees were thus used to seasonal or even yearly assignments, with practically no possibility for adjustments even in response to major personal problems such as unexpected family events unless they could be resolved by negotiating directly with colleagues on a case by case, ad-hoc basis.
Also, an additional although minor technological innovation was needed: a system capable of quickly computing a complete schedule for all employees’ activities, so that scheduling could be completely done agilely and much more often, for example daily.

The immediate expected consequences thus were

(i) a better “weighted service level per employee” ratio (“weighted” in the sense of taking into account that some components of service can dynamically become more important than others), and

(ii) reduced overall labor costs while maintaining the operation in the appropriate intervals for safety levels, etc.

In addition, as suggested above, out of the improved scheduling flexibility one could also expect to achieve better employee task – preferences fit (for example in terms of making it possible to assign week-end work to more employees preferring that, or of improved vacation days and employee preferences matching), and so on. In the end, all this would amount to better “organizational life quality” for more employees.

Implementing change: Operational and organizational improvement

The changes described in the preceding section are for the most part implemented in the Barcelona Metro today. Doing so has required personnel training, convincing a number of persons that they were capable of carrying out new activities (in particular “driving” trains; still a number of them weren’t convinced and thus they are not yet part of the project), and negotiating new contracts accordingly. Also, a new scheduling system has been developed, capable of computing a complete schedule for the whole Metro operational work force in a matter of minutes.

The result is a complete new way of doing things, which in general can be described as follows:

1. Every Metro employee is assigned, in principle for a year, a specific station in which (s)he is supposed to show up at a definite time to begin each working day, “registering” through an ID card which is automatically read upon arrival.

2. His/her “presence” is then transmitted to a central scheduling location. Employees are scheduled to end their working day at the same station at given times.

3. At specific times during the day, all registered employees participate in a “scheduling round” which in a few minutes produces, for each one, a detailed schedule for his/her working day. A detailed schedule can include, for example, driving a specific train for three rounds at a certain line, get off and work as a security inspector for a specific time period in the same or another line, then proceed as an inspector, and so on.

4. Since different activities can now effectively be given different priorities, the resulting aggregate schedule can ensure, for example, that daily operations always start with all trains running even when last minute no-shows of (used-to-be-specialized) train drivers occur.

The results have been very much in line with expectations. Some of them have taken some time to attain because management decided to avoid immediate lay-
offs. However, although the Metro operation has increased the number of km-hours offered since the changes were implemented, relatively less personnel has been necessary than the previous arrangement and work practices would have required.

In addition, many employees have explicitly expressed higher satisfaction with their work, accruing for example from more alternatives available for vacation scheduling, week-end work etc., which allow for better fit with their personal preferences, life style or constraints.

Although not explicitly documented, this is believed to clearly contribute to employee morale and commitment, with the consequential influence on performance and pro-activity, in turn reinforcing the kind of organizational culture actively pursued at TMB.

In summary, better service, increased efficiency and higher employee satisfaction, commitment and work life quality.

A conceptual reflection

The foregoing considerations about how technological innovations initially considered for efficiency reasons can be deployed in such a way that they end up influencing the governance structure of a firm, including its level of vertical integration boundaries in general, can benefit from a discussion inspired by current theoretical stances in the field. For this purpose, a number of interdependent approaches seem relevant as we briefly discuss below.

For example, Jacobides and Winter (2005) discuss how the vertical scope literature (Williamson 1975, 1985, 1999) following Coase (1937) and the one on resource- and capability-based view of the firm (Penrose 1959, Wernerfelt 1984, Barney 1991, Conner and Prahalad 1996), including dynamic capabilities (Teece, Pisano, and Shuen, 1997) have started converging. In this context they consider what they call “the co-evolution of capabilities and transaction costs” and argue that

“capability differences are a necessary condition for vertical specialization; and transaction cost reductions only lead to specialization when capabilities along the value chain are heterogeneous”.

In addition, the observation by Cacciatori and Jacobides (2005) that organizational capabilities are individually-based (in the sense that specialized individuals are coordinated in order to obtain them) enlightens from this standpoint the “construction” of polyvalent employees that is at the origin of some of the phenomena of interest in this paper. This perspective may uncover new ways of leveraging the firm’s capabilities.

A number of reflections are possible in the backdrop of these conceptual contributions. In the Metro case, the development of polyvalent employees ends up making their personal capabilities more homogeneous –from this standpoint, the observed tendency towards centralization would seem to confirm Jacobides and Winter’s predictions.

From a slightly different standpoint, as these same authors argue that

“...the cycle pushing toward specialization gets reversed when new and superior capabilities arise from knowledge bases that are misaligned with the existing vertical structure”,


we interpret that a similar phenomenon is at work in the Metro case when “superior capabilities” in scheduling make sense in the context of a more centralized, larger scale firm. We could thus talk about economies of scope in scheduling in this sense.

In this respect, it is interesting to note a proposal by Santos and Eisenhardt (2005) that broadens the traditional transaction cost economics perspective taken in organizational boundaries research, suggesting four different boundary conceptions (efficiency, power, competence, and identity), indicating relationships, both co-evolutionary and synergistic, among them. In particular, the identity conception seems especially relevant for our interest here: It explicitly bases itself on considerations about the organization’s members, so that firm boundaries are seen as partly dependent on individual perspectives, in search for coherent “social contexts for sensemaking” (Weick 1995). In the Metro case this could have an effect on “more generous” firm boundaries to the extent that higher employee satisfaction and eventual commitment can result from potential improvements on “organization life quality” (Andreu 2009), made possible by a larger scheduling scope in turn based on employee polyvalence.

The argument is subtle but relevant: We are not talking only about economies of scope measured in strict, immediate economic terms; the issue is about economies of scope in terms of increased employee motivation, which makes particular sense in the context of an organizational culture that emphasized precisely these kinds of values as was the case in Metro.

Finally, the idea of finding new ways to leverage a firm’s capabilities also makes sense in the case studied here. Specifically, we can talk about new, more efficient organizational capabilities made possible by coordinating (through the planning activity) several domains at the same time (i.e., in the context of a centralized operation), because polyvalent employees (in turn viable owing to the fact that task-simplifying technology permits “filling” employees “capacity” with a better variety of individual task performing capabilities) are potentially more appropriate “inputs” to such process.

The consideration of the individual employee level of analysis which we find so relevant in this case seems important, as very often capabilities are considered at a more aggregate level (see for example Argyres 1996), thus excluding from the analysis, at the very outset, potentially relevant phenomena. But it is precisely at the individual level that commitment concerns start to develop and unfold. In fact it has been argued that it is at this level that management considerations having to do with motivation and commitment should be meaningfully brought into play (see for example Foss, 2007).

**In retrospect: What can be learnt from this experience?**

This case study illustrates a causal chain of events that can be summarized in a simplified way as follows:

- **Deploying technological innovations in an empowerment context** → (allows) →
- **A number of employees to become polyvalent** → (who thus can assume) →
- **New, more flexible (and thus “more homogeneous”) work practices** → (which in turn make possible) →
- **New (centralized) organization schemes** → (that are instrumental to achieve) →
- **Improved effectiveness and efficiency** → (while at the same time allowing) →
- **Increased employee satisfaction, morale and commitment** → (which reinforces) →
The kind of culture desired by the organization → (and it all implicitly causes) →

The re-definition of firm boundaries.

In summary, the impact of technological innovations at the operational level shows itself in a variety of interdependent dimensions that can be harnessed in order to improve not only efficiency, but also effectiveness and employee morale and commitment thus setting up a virtuous loop that reinforces the organization culture which inspired the whole process in the first place.

As a consequence, the previous working equilibrium between work practices, management processes, organizational structure, employee satisfaction and even firm boundaries was re-designed so as to reinforce the aforesaid loop, taking advantage of certain generic and in principle operational technological innovations and setting off a process which required the development of further, more specific, innovations.

From a general standpoint, understanding a generic need to re-equilibrate an interdependent set of organizational elements in response to the deployment of technological innovations is of course not new. However, doing so by exploiting the influence of the innovations at the individual employee level, making them more polyvalent and ascertaining the associated potential for better employee organizational life quality uncovers a less well-known phenomenon which in turn can trigger (or at least make explicit the need for) organizational innovations That reinforce the whole process in a way consistent with the prevailing organizational culture.

In a way consistent with the McGregor (1960) tradition, the self reinforcing loop could, in principle, be stoked up in two opposite directions:

(i) The one used in TMB, consistent with the underlying organizational culture, that took into consideration the effects on employees’ working conditions by deliberately pursuing their improvement, avoiding the impoverishing of tasks so as to appeal to the kind of employee profile which had been purposefully been developed through specific policies in recent years, or

(ii) A more myopic one, which could have put all the emphasis on sheer short term efficiency through almost complete task automation and tight control and command, thus sending the contrary message to employees; this could have likely caused the loop to set off in the opposite direction, fostering a much less empowering organizational context and, as a result, employee dissatisfaction, lower morale commitment, worse client service and eventually lower performance.

Both have, in addition, the feature of putting in motion a self-selection process for employees: as time goes by, the intrinsic dynamics of the situation motivate the ones who like the reinforced culture to stay and others to leave. It is apparent that the process set forth at TMB is more likely to appeal to pro-active profiles that at the end are precisely the ones required to make the policies of the company work better.

In summary, several dimensions need to be made coherent for harnessing the full potential of technological innovations. Organizational culture and employees’ profiles are two such dimensions that can not be ignored (Gruys et al. 2008; Pastoriza el al. 2008). A pro-active culture that fosters initiative and learning requires a context of trust and employees who appreciate these traits and feel comfortable and willing in order for the complete picture to make good sense to all
(Puranam and Vanneste, 2009). Setting off the technology adoption process in a counterproductive direction is rather easy because the immediate, “standard” effects attached to automation are more visible and often greedy. For these reasons it becomes very important to act decidedly so as to ensure that it all starts in the right direction and that it keeps going and gaining momentum as the process dynamics unfold.

**A final overview and conclusion**

One interesting aspect of the above discussion has to do with how to view the role and implications of deploying what in principle appeared as just a basic, technological innovation affecting only operational efficiency.

A “naive view” is depicted in Figure 1, taking the standpoint of the technological innovation potential for task simplification, efficiency and productivity improvement as its immediate and virtually only effect. When deployed without any emphasis on its potential for enriching employees’ jobs, these get in fact impoverished through low level task specialization. Sooner or later this makes motivation to weaken. Eventually, there will be a negative effect on productivity, which short sighted management might be tempted to correct through shallow incentives. At the end, be it through decreased motivation and productivity or through increased costs owing to whatever incentives are implemented, or both, the results are likely to be worse than expected.

![Figure 1](image-url)

The view in Figure 1 considers that optimization for efficiency purposes is done at the single task level without taking into account the possibility of “integrating different tasks on a single (polyvalent) employee“, which can give rise to alternative, very different approaches (see below). Even from a standpoint so strictly rooted on efficiency, the approach in Figure 1 is likely to be dysfunctional when considered from a dynamic perspective: Operational incidents such as train malfunctions, accidents, or unexpected staff unavailability can produce either higher costs or poorer service.

The fundamental drawback, however, stems from the high potential for job impoverishment that goes with this approach. Out of very simple task repetition, machine-like behaviour and employee boredom is likely to develop, leading to de-motivation, decreased “natural” willingness to contribute and commit, endangering service quality and eventually productivity, thus ironically defeating the original goal.
An alternative outlook, closer to the Metro case, is depicted in Figure 2: In the context of a culture that cares for employee empowerment, development and fit between tasks’ characteristics and employees’ preferences, the very same operational technological innovation opens the door for employee polyvalence, job enhancement potential (as opposed to impoverishment) and increased motivation. In order to make this chain of events possible, a scheduling innovation is “induced” by the organizational milieu. Once developed and deployed, the whole set becomes self reinforcing, achieving both the anticipated productivity improvement and at the same time nurturing an even stronger culture in which context the reinforcing process can develop further.

Figure 2

Here, fostered polyvalence encourages the development of a “global scheduling optimization” scheme, which emerges due to the will to take as much advantage as possible of the situation in an environment where the aforementioned values and culture dominate. As it turns out, the adoption of the new scheduling system has also an effect on efficiency through a likely better use of resources deriving from a more aggregate scheduling standpoint, which with employee polyvalence allows for improved dynamic flexibility as well.

Again, however, the fundamental phenomenon occurs at the individual employee level: Since part of the improved flexibility is in fact “shared” with employees in the form of better task – preference fit (better week-end and vacation assignments, say) thus improving their “organizational life quality”, this acts as a natural incentive (Andreu 2009) leading to increased intrinsic motivation (see for example Pérez López 1991), higher commitment, to the appearance of non incentives-based of suggestions for improved performance and service, and to the closing of the mentioned positive loop. The result: better employee satisfaction, client satisfaction, and improved company’s results, a well known consequence (see for example Culbertson, 2009).

What makes de difference? In a fundamental way, management determination to effectively set up, foster, harness and deploy an appropriate organizational culture.
In general, thus, we conclude that at least three main components have to be coherently coordinated in order to harness the full potential of technological innovations in the context we have discussed:

1. The underlying “management philosophy” (on which organizational culture is based),
2. New work practices / relations that harness technological potential (polyvalence and global scheduling), and
3. New ownership arrangements or conditions upon them that permit appropriate governance structures to evolve in the context of fitting organization boundaries.

The result, we could say, is a kind of “new firm” capable of exploiting operational technical innovations well beyond their obvious, immediate efficiency improving effects.
REFERENCES


