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An application of Soft Systems Dynamics Methodology (SSDM)

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The paper argues that by combining some of systems dynamics (SD) and soft systems methodology (SSM) stages, within the intellectual framework proposed by soft systems dynamics methodology (SSDM), a systemic methodology developed by Rodriguez-Ulloa, much can be gained in a systemic intervention when tackling complex social problematic situations. A framework for comparing the ontological, epistemological and methodological principles of SD, SSM and SSDM is proposed and the synthesizing role of SSDM is advanced. SSDM ten stages are briefly outlined and a full account of an application on a small Peruvian enterprise is presented. A reflection on SSDM as a systemic intellectual tool is proposed and conclusions together with points for further research are suggested.

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1. Introduction

Over the last years there have been concerns and debate, among members of the system dynamics (SD) community, about its links with other systems methodologies and about its philosophical principles, role and position within more wider social theories (Richardson and Andersen, 1995; Vennix, 1996; Vennix *et al.*, 1997a, b; Lane, 1999, 2000, 2001a, b). On the other hand, recent developments in Management Science have indicated the emergence of what is called multimethodology, a practice that combines techniques, methods and methodologies from the same or different systems thinking paradigms, Mingers (1997a, b), Mingers and Brocklesby (1996), Jackson (1997, 1999) among others. Multimethodological practices that combine methods from across the hard-soft systems methods spectrum have been widely reported in Mingers (1997a); Munro and Mingers (2002); Brocklesby and Cummings (1995); Brocklesby (1997); Lane and Oliva (1994) among others.

This paper reports on the application of a multimethodological approach that combines SD and soft systems methodology (SSM) (Checkland, 1981; Checkland and Scholes, 1990; Rodríguez-Ulloa, 2003), called soft systems dynamic methodology (SSDM) (Rodríguez-Ulloa, 1999, 2002; Rodríguez-Ulloa and Paucar-Caceres, 2004). A full account of SSDM theoretical framework was proposed in Rodríguez-Ulloa and Paucar-Caceres (2005); the present

paper outlines that framework and provides a full account of an SSDM application. Essentially, SSDM can be regarded as a synthesizing and dialectical methodology that emerges from the combination of two widely used systems-based methodologies from two different systems thinking paradigms, SSM and SD. The methodology, through its careful application, aims to demonstrate that much can be gained in a systemic intervention. In this paper, this methodology, widely used in Latin American settings, is formally re-visit and its stages briefly outlined, emphasizing that this constitutes a new, flexible and creative intellectual framework that has emerged from combining some of the stages of SD and SSM. To some extent, SSDM underpins the SD approach by the SSM philosophical principles, concepts and steps; and this, in a way, resonates with Lane's claims when he describes to be working in the agent/structure SD paradigm and with his 'Holon Dynamics' or 'Interactive Dynamics approach' (Lane, 1999, 2001a, b). The framework that SSDM proposes can also be seen, in general, in line with the works of other system dynamics academics and practitioners (Lane and Oliva, 1994; Morecroft and Sterman, 1994; Vennix, 1996, 1999; Vennix *et al.*, 1996; Vennix *et al.*, 1997a, b; Andersen and Richardson, 1997; Rouwette *et al.*, 2002).

To those in the systems community interested in the application of a combination of systemic methodologies, the main SSDM's contribution is that it advances a general framework, with clear steps to follow, which not only helps the analysts (ie decision makers) to make sense of the problematical situation but also to model the real world under what it can be called the feedback paradigm and to intervene in the implementation of systemically

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desirable and culturally feasible changes in the real world culminating with a learning process from all the experience including the implementation of those changes in the real world.

The structure in this paper is as follows: (1) the SSDM paradigm is explained using a framework for comparing the ontological, epistemological and methodological principles of SD, SSM and SSDM and the synthesizing role of SSDM is proposed; (2) the SSDM ten stages are outlined; (3) an application of SSDM based on a systemic intervention carried out in Peru is described in detail; (4) from the experience of this intervention, a reflective analysis on SSDM is advanced; and (5) conclusions and learning points for further research are suggested.

2. Soft system dynamics methodology (SSDM)

SSDM arose as a product of an action research project started by the end of 1992 at the Andean Institute of System (IAS), Lima-Peru. Reflecting on the SD approach it was noticed that concepts coming from SSM, which are important for understanding real-world problem situations, were not considered explicitly in the formal analysis of SD. It was thought, then, that *combining* both approaches could allow the emergence of a synergistic intellectual tool for systemic studies of complex situations.

SSDM paradigm

During the 1990s there has been a great debate in the systems community around issues concerning the use of more than one methodology (combinations of them or parts of them) when intervening in complex situations. The general term of multimethodology (Mingers, 1997a; Paucar-Caceres, 2002) has been coined to group systemic practices that combine and link various methodologies or some stages of two or more methodologies. Mingers (1997a, 1999) argues that critical systems thinking and total systems intervention (Flood and Jackson, 1991; Jackson, 1992, 2000, 2003), are only one particular form of multimethodology and takes the view that any intervention should gain benefits from being approached with a variety of management science methodologies in what he calls 'strong pluralism' arguing that agent(s) (ie person(s)) intervening in the situation would benefit if the intervention is tackled using a 'blend of methodologies'. In Mingers' view the following arguments favour an application of a multiplicity of methodologies: (1) any situation is in itself complex that not a single methodology can claim to be able to tackle it completely, rather we should pay attention to three aspects involved in any intervention: material, social and personal. Some methodologies will bring more enlightenment to some of the three aspects; (2) an intervention is not a discrete event but continuous and therefore some

methodologies are more suitable to certain phases of the intervention. We should not disregard the possibility of combining methodological stages, methods or tools from different methodologies serving to different paradigms; and (3) finally there are practical reasons in favour multi-paradigm multimethodology: many systems practitioners have already started to practice it. Mingers provides numerous examples supporting his claim and uses five dimensions to characterize the different types of multimethodology practice: (a) one/more methodologies; (b) single/multi paradigm; (c) same or different intervention; (d) whole/part methodology; and (e) imperialist/mixed (Mingers, 1997b). We argue that SSDM will be a particular case of (b) and (d) that is multiparadigm and multimethodology.

There have been attempts to merge these two approaches (Lane and Oliva, 1994) and although some SD academicians and practitioners have been already working in the arena of messy problems (Lane and Oliva, 1994; Morecroft and Sterman, 1994; Vennix, 1996, 1999; Vennix *et al.*, 1996, 1997a, b; Andersen and Richardson, 1997; Lane, 1999, 2000, 2001a, b; Sterman, 2000; Rouwette *et al.*, 2002; Warren, 2002), we argue here that SSDM contribution lies on in the elucidation of a methodological framework (ie ten clearly defined steps are proposed), where the principles, concepts, philosophies, techniques and technologies from both sides are taken into account and put them to work together in a flexible way. SSDM, thus, is an intellectual tool that can be regarded more than just a merging between SD and SSM but a synergistic systemic framework that builds from the fusion of these two methodologies. Table 1, based on Rodríguez-Ulloa (1999) and Mingers (1997b) shows a comparison on the ontological, epistemological, and methodological foundations between both approaches (SSM and SD) and those of the emerging one (SSDM).

3. The ten stages of soft system dynamics methodology (SSDM)

The ten stages of SSDM (Figure 1) work across of what we call three *worlds*: (1) the real *world*; (2) the problem-situation oriented system thinking *world*; and (3) the solving-situation oriented system thinking *world*. We argued that SSDM when applied provides a dialectical view of the real-world situation. This becomes clear when it is applied to a real-world intervention. Thus the first approach when intervening in the real world (called here, World 1) using SSDM is to appreciate the problem situation and to understand its behaviour in a holistic manner (called here World 2). On the opposite (dialectical) side, after having understood the way the problem-situation behave, then, systemic thinking of ways to 'solve', 'finish' or 'alleviate' the problem-situation are studied and proposed in the solving-situation system thinking world (called here World 3).

Table 1 Ontological, epistemological and methodological comparison of SSM, SD and SSDM (after Rodriguez-Ulloa, 1999, and Mingers, 1997b)

	SSM	SD	SSDM
Ontological principles	<ul style="list-style-type: none"> – Systems are not assumed to exist in real world; social world of attributing meaning 	<ul style="list-style-type: none"> – Systems exist in the real world – Describe the real world in ontological terms (use of nouns) 	<ul style="list-style-type: none"> – Systems are not assumed to exist in the real world. The social world has meaning for the observer
Epistemological principles	<ul style="list-style-type: none"> – Interpretivist, phenomenology and (possible) hermeneutical claims. – Describes the real world in epistemological terms (use of verbs) – Separation of the real world and systems thinking world; systemicity is in the process; 	<ul style="list-style-type: none"> – Mainly positivistic assumptions – Describe the structure underlying the real world in terms of flows and rates (verbs, nouns and adverbs) – Separation of real world and systems world is not very clear 	<ul style="list-style-type: none"> – Interpretivist, rationalistic, phenomenological and hermeneutical assumptions. – Describes the real world in epistemological and ontological terms (verbs, nouns and adverbs) – Separation of real world and systems thinking world is clear; Divides SSDM systems thinking world into two: <ol style="list-style-type: none"> (1) problem situation-oriented systems thinking world; and (2) solving problem situation-oriented systems thinking world
Methodological stages	<ul style="list-style-type: none"> – Systemic approach based on 'logical' linked human activity systems – Seeks for cultural feasible and systemically desirable changes in the real world – It is a problem and solving oriented methodology – Unable to measure and assess the possible changes by itself through the time – Clearly establishes the 'what' and 'how' transformation process performed or to be performed in the real world, to 'improve' it – It is not a dialectic approach – It finishes with a learning process from the application of the whole methodology in an informal way 	<ul style="list-style-type: none"> – Systemic approach based on 'rational' cause-effect relationships – Does not mention explicitly this important issue – It is a problem-solving oriented approach – Able to measure and assess the changes by itself through time – The 'what' and 'how' transformation process implemented or to be implemented in the real world is not clear – It is not a dialectic approach – It finishes with a learning process of the model-building process in an informal way (interactive dynamics, holon dynamics, group model-building, modelling for radical learning) 	<ul style="list-style-type: none"> – Systemic approach based on 'logical' linked human activity systems and 'rational' cause-effect relationships – Looks for cultural feasible and systemically desirable changes in the real-world – It is a problem and solving-oriented methodology – Able to measure, assess the problematic and improved situation by itself through time – Clearly establishes two transformation processes <ol style="list-style-type: none"> (1) which explains 'what' is the problem situation and 'how' it behaves; and (2) which explains 'what' and 'how' should be the transformation process to 'improve' or 'alleviate' that problem situation and 'how' the improved situation should behave. – It is a dialectic approach – It finishes with a formal process of learning from three positions: <ol style="list-style-type: none"> (a) from the problematic view of the problematic sit (SSDM's World 2); (b) From the solucionatic view of the problematic sit (SSDM's World 3); and (c) From the Implementation process in the real world (SSDM's World 1).

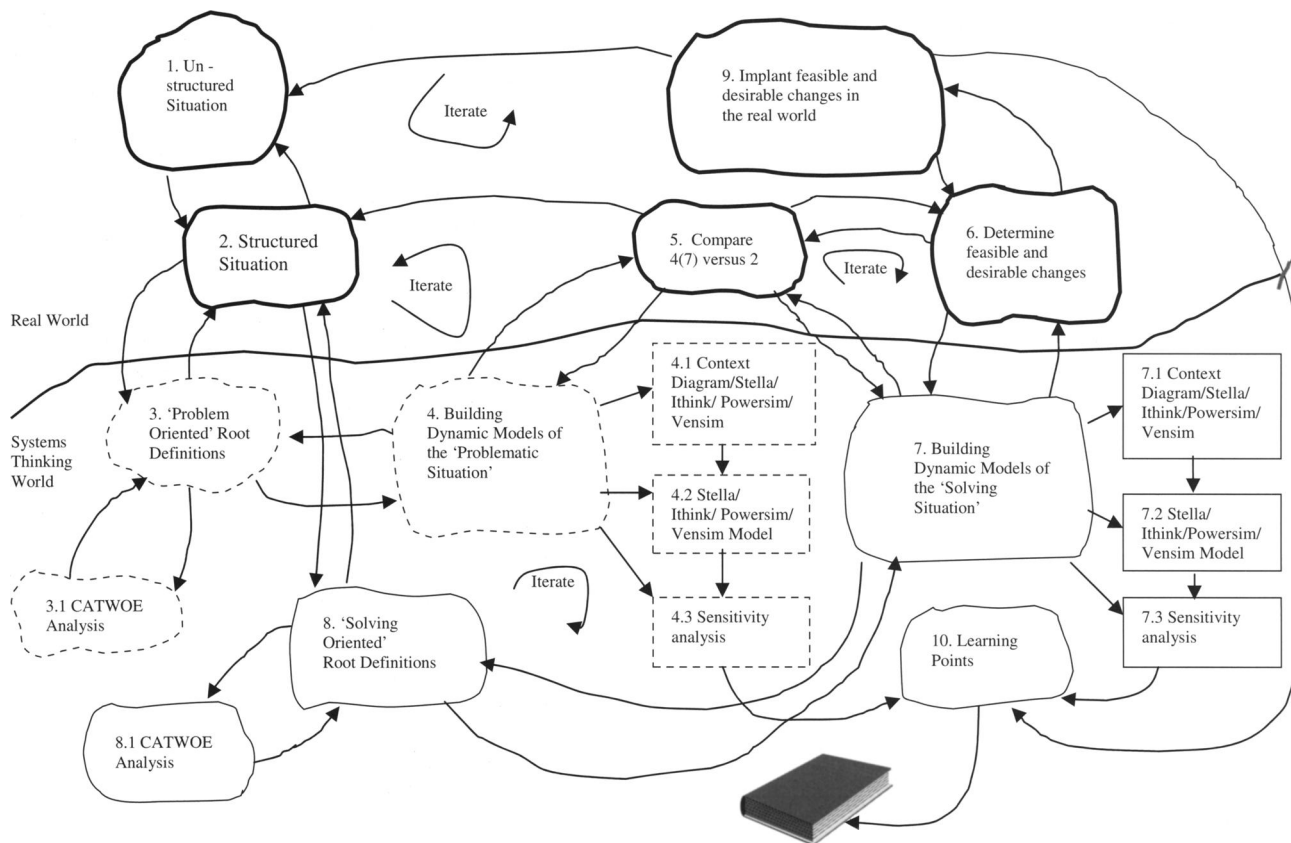


Figure 1 Soft system dynamics methodology (SSDM): a general view (after Rodríguez-Ulloa, 1999, 2002).

Figure 1 shows the ten stages of SSDM. The three ‘worlds’ are clearly illustrated in SSDM: (1) *Real World* (thick line steps); (2) *problem situation-oriented systems thinking world* (dashed line steps); and (3) *solving situation-oriented systems thinking world* (fine lined steps). The ten stages of the methodology are iterative (feedback is recommended and encouraged) but for illustration purposes, it helps to think that the first pass (what we called here the ‘first loop’) is to do with the ‘problem situation-oriented systems thinking world’ and the ‘second loop’ deals with the ‘solving situation-based systems thinking world’. In the following sections these stages are briefly outlined; a detailed description of the methodology steps can be found elsewhere, (Rodríguez-Ulloa, 1999, 2002; Rodríguez-Ulloa and Paucar-Caceres, 2004; Rodríguez-Ulloa and Paucar-Caceres, 2005)

3.1. Real world: Stage 1 (unstructured problem situation) and Stage 2 (structured situation)

SSDM’s Stages 1 and 2 are borrowed from SSM. It has been acknowledged that the first two SSM stages: (1) Looking at the unstructured problem situation; and (2) Structured problem–situation or ‘rich picture’) are powerful steps to help to understand and comprehend of the phenomena and

events occurring in a system of reference (ie a portion of the real world, defined and delimited by the analyst for purposes of systemic study), where something is not working ‘well’ and something needs to be done to ‘improve’ the problem situation.

According to SSM, in order to study the problem situation in a holistic manner, the problematic situation must be regarded in an open manner and trying not to see the situation as a system itself (not to see the real-world as systems yet!); the use of a rich picture as an epistemological device is important to capture the real situation. These two stages were incorporated as part of SSDM, in more or less the same way they are established in the SSM seven-step mode of application.

3.2. First SSDM systemic loop: problem-situation systems thinking world

3.2.1. Stage 3 (problem-oriented root definitions). SSDM’s Stage 3 (root definitions) has also been borrowed from SSM because of its importance for describing transformation processes and situational changes that arguably are made in the real world. SSM step has been used here: root definitions usually describe human activity systems that perform transformation processes oriented to

‘improve’ the problem situation encountered in the real-world.

3.2.2. Stage 4: Building system dynamics models of the ‘problematic situation’. Once Stage 3 has been completed, each root definition of a ‘problematic situation’ serves as the basis for starting the modelling process where, a *problematic* context diagram of the situation is built up at a first resolution level of complexity. This context diagram must correspond to a particular *Weltanschauung* (W) that the observer has emphasized in a particular problematic root definition, at Stage 3.

After considering the SD context diagram, the structure of the problematic situation in a more detailed way is modelled, using a system dynamics approach with the support of an *ad-hoc* software (ie Stella, Ithink, Dynamo, Powersim, Vensim, among others).

This process can be replicated *n* times according to the number of root definitions the observer has elaborated at stage 3. Thus different problematic system dynamics computerized models can be obtained which will allow to have a variety of interpretations on the behaviour of a problematic situation.

3.3. Real world

3.3.1. Stage 5: Compare stage 4 (stage 7) against 2. Stage 5 consists, on the comparison, in the first SSDM systemic loop, of the problematic-oriented system dynamics models against the rich picture built up at Stage 2. The comparison emphasizes observing and validating, if possible, the problematic system dynamics models (problematic context diagram and detailed causal—loop models, originated by each problematic root definition) compared to the rich picture description, observing at the same time if the outcomes of the sensitivity analysis reproduce the behaviour of the problematic situation.

Stage 5, also consists, on the comparison, in the second SSDM systemic loop, of the solving-oriented system dynamics models, against the rich picture built at Stage 2. The comparison in this case, emphasizes in observing and validating, where possible the solving system dynamics models (solving context diagram and detailed causal-loop models done at Stage 7), compared with the rich picture, observing if the outcomes of the sensitivity analysis reproduce the behaviour of a solving situation for the problem situation being studied and if the changes proposed, can be culturally feasible and systemically desirable.

3.4. Second SSDM systemic loop: solving-situation systems thinking world

3.4.1. Stage 6: Determine culturally feasible and systemically desirable changes. After stage 5 has been done, we look at this stage for obtaining culturally feasible

and systemically desirable changes, in terms of which variables (at the context as well as in detailed levels of the models done at Stage 4) and links have to be removed, varied and/or added (if possible all of this) in order to ‘improve’ (ie change) the problematic behaviour of the situation encountered at SSDM’s stages 3 and 4.

As this analysis of feasibility and desirability is not possible to do without seeing the effects through time, it is necessary to go to SSDM’s stage 7 in order to simulate the prospective ‘solving’ alternatives that the analysts can propose to the problematic situation encountered.

3.4.2. Stage 7: Building system dynamics models of the ‘solving situation’. In this stage it is possible to delineate and prospect possible courses of action to ‘improve’ the problematic situation, proposed by different assumedly feasible and desirable changes obtained at stage 6.

Thus, doing stage 7 means building up a context diagram and system dynamics models on the solving-oriented approach to be implemented in the real world, doing sensitivity analysis to observe the outcomes according to the variations of the causes and/or their relationships (desirable and feasible changes). This again gives to the observers, important insights about the diverse consequences and sequels of the ‘solutions’ provided by them.

3.4.3. Stage 8: Solving situation-oriented root definitions. In SSDM terms, this stage aims to express in a solving-oriented root definition, the transformation process needed to make ‘improvements’ of the problematic situation. It is important to do its CATWOE analysis in order to elucidate, clearly, what is the ‘solving-oriented’ transformation process that the computerized model proposed in stage 7 is promoting to undertake in the realworld, as the basis to build up this solving-oriented root definition.

3.5. Real world

3.5.1. Stage 9: Implementation of feasible and desirable changes in the real world. Once a good balance has been found among stages 2, 8 and 7, then it is the time to return to stage 6 where the ultimate culturally feasible and systemically desirable changes have been reached. Done this, changes are ready to be implemented in Stage 9: implementation of feasible and desirable changes in the real world.

3.5.2. Stage 10: Learning points. The last activity of SSDM is Stage 10, where all learning points have been collected and compiled for study and reflection from time to time and future interventions. The learning points came from the sensitivity analysis of modelling the

'problematic situation' (Stage 4) as well as the 'solving situation' (Stage 7) and the proper implementation action in the real world (Stage 9). The aim is to orient to people involved in the analysis and design of social systems (ie problem solving system) to the learning paradigm, since a self analysis, synthesis and reflection of real-world concrete interventions.

4. An application of SSDM in a small Peruvian enterprise: Tubos S.A.

An application of SSDM in a specific problem situation is described in the following sections. Some information, mainly quantitative, has not been included for brevity, but the reader can be referred to the source (Rodríguez-Ulloa, 1994), where he/she can find the complete description (in Spanish) of this case.

4.1. Stage 1: Unstructured situation

Tubos S.A., is a small Peruvian company dedicated to commercialize national and imported steel products. Its clients are companies from the construction, mining, petrol, fishing and industry sectors, among others. It is managed by a directory composed by four persons: two partners and directors, Mr Martinelli (D1) and Mr Ampuero (D2), and two directors and managers (Mr Zapata and Mr Merino).

Outside information is managed and processed by director D2, who, as well, does the strategic decisions of the enterprise. This attitude provokes conflicts with director D1, generating personal resentments between them, blocking the formal communication channels of the company. This situation also re-feeds the domination willing of director D2 creating the conditions for the conflictive relationship with director D1.

The informal communication (originated by the poor relationships between the directors), generates, as well, the lack of strategic plans and a low degree of organization in the company.

The external environment is characterized by scarcity of foreign currency, credit restrictions and a deficient legislation generating negative effects in the market conditions, as well as, in the strategic plans of Tubos S.A., with the exception of the last variable (legislation) which can produce positive or negative effects in the strategic plans (more or less market regulation, rigid or flexible labour legislation or a mixture, deficient juridical codes which provoke delay in the justice's administration processes where the firm is involved, etc).

Improvement in the competitiveness of Tubos S.A., on the other side, could create the adequate market conditions allowing the increment of the goods' demand. The purchase of lots of products to be offered to the market could increase

sales which generates more incomes and profits for the company as well. The net profit generates the distributed earnings and the benefits which when increasing allow to increment the goods buying and the investment in the quality of management (for example, increasing the salaries of managers) and their specialization. The improvements could increment the productivity and the overall efficiency of the company. Management efficiency increases the competitiveness of Tubos S.A. More efficiency contributes also to lower costs as well, generating the possibility to decrease the prices, which could cause the increment in the demand, then sales, should augment.

To break up the dominating power position of director D2 over director D1 something needs to be done, otherwise the internal situation of Tubos S.A. could collapse. One way could be the implementation of participative planning. This could allow to unite efforts between both partners, reducing the resentments in between them. Re-establishing the communication channels and the formal procedures (structure and functions manual) within the company would allow to improve the coordination of activities and the information flows, impacting in the development of management, the productivity, efficiency, competitiveness and net profits. Increment in earnings reinforces the participative planning as well.

Finally, an increase in the formal communication channels generates more competitiveness due to the formalization of the strategic plans.

4.2. Stage 2: Structured situation

Figure 2 shows a consolidated rich picture of the problem situation at Tubos S.A. based on the information obtained at Stage 1 of the SSDM.

4.3. Stage 3: Problem-oriented root definitions

Among diverse problem-oriented root definitions that can be generated, it has been chosen the following as an example:

'A human activity system owned by a private company, which sells steel products to the construction, mining, petrol, fishing and industry sectors of the internal Peruvian market with competitive disadvantages not satisfying its clients' needs, due to internal problems in the company's general management, motivated by personal interests and conflicts between the owners and the lack of a good communication among them and the other directors and managers of the company. This situation leads to the implementation of an informal management and culture at different hierarchical levels of the company, affecting the good management as well as the marketing and financial results of the enterprise as a whole. This HAS is being done under diverse external constraints, product of the environment existing in the country, like credit restrictions, scarcity of foreign currency and deficient legislation'

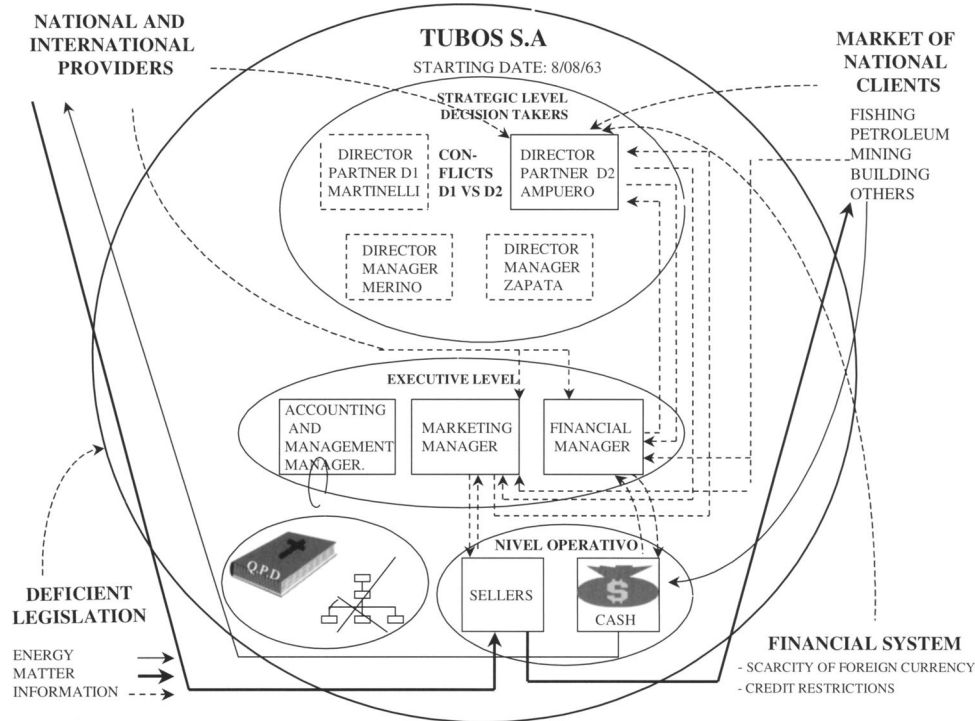


Figure 2 SSDM's stage 2: rich picture of the problem situation (after Montbrun and Porras, 1998 and Rodríguez-Ulloa, 1999).

CATWOE analysis

Clients: Directors, managers, workers, clients, providers of Tubos S.A., the Peruvian state.

Actors: Directors, managers, workers

Transformation: Unsold steel products to sectors of the Peruvian market with competitive disadvantages T Sold steel products to sectors of the Peruvian market with competitive disadvantages

Owners: Director D1 (Martínelli) and D2 (Ampuero), managers (Mr Zapata and Mr Merino)

Environment: Credit restrictions, scarcity of foreign currency, deficient legislation

4.4. Stage 4: Building system dynamics models of the 'problematic situation'

The context diagram and the system dynamics model are built here, which express the structure (the mental model) which is generated from the problematic root definition defined at Stage 3. Each pair of context diagram and system dynamics model correspond to each problematic root

definition generated at stage 3. It is important also to emphasize that the context diagram is based on the way in which the concept is used in SSM, describing the real-world in systemic and epistemological terms; thus the use of qualified verbs in the diagram, instead of 'nouns' and substantives used in DS. The relationships are of three kinds: causal relationship, matter flux and information flux.

Figure 3 shows the problematic context diagram and Figure 4 the problematic causal diagram of the particular interpretation of the problem situation based on the problematic root definition presented at stage 3 in this example.

The problematic context diagram (Figure 3), indicates that some activities (ie human activity systems (HAS's) in SSM language) are managed under several non-desirable conditions, so that there is the need to change them. The same could be said to the problematic causal diagram (Figure 4). For example, in the case of the problematic context diagram the company's selling activities is being done under disadvantage conditions which, as it is observed in Figure 3, causes the dissatisfaction of the clients. Also the disadvantages at the selling process are caused because the marketing activities are carried out in inadequate conditions as can be seen.

The problematic causal diagram (Figure 4), shows that the conflicting relationship between directors D1 and D2 is creating important impact in the informal organization of the company, due to the existence of informal communication as a product of this conflicting relationship. The

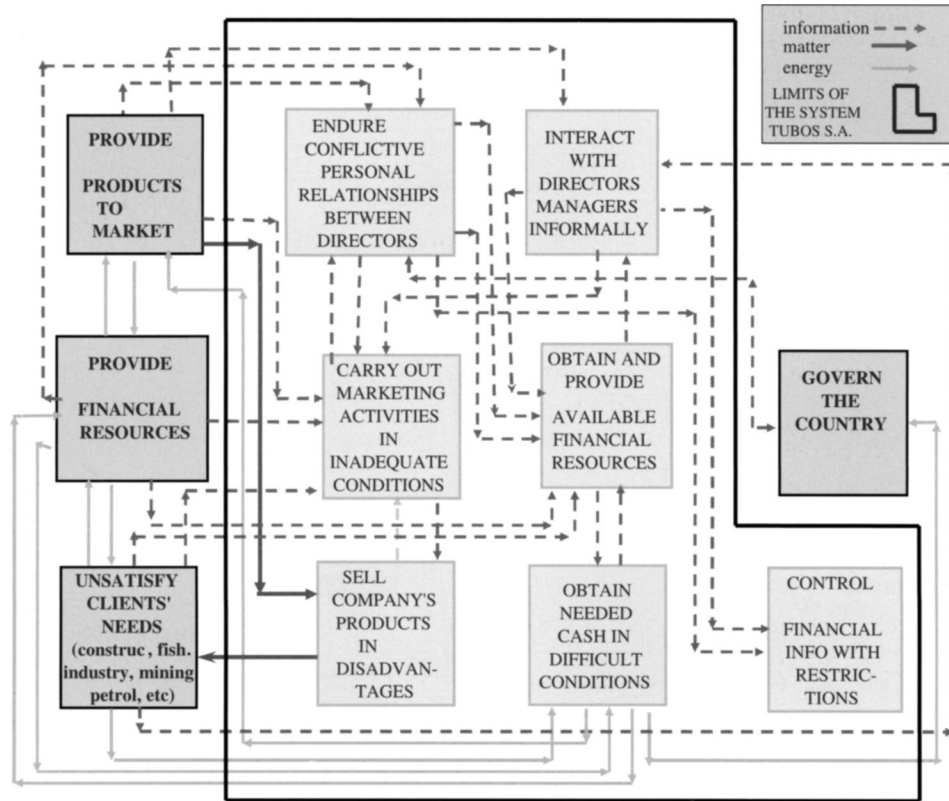


Figure 3 SSDM's stage 4: an example of a problem-oriented context diagram of the problem situation based on a problem-oriented root definition (after Montbrun and Porras, 1998 and Rodríguez-Ulloa, 1999).

informal organization of Tubos's activities brings difficulties in its strategic planning, general management, competitiveness and so on. In consequence, there are several aspects expressed in the context as well as in the causal diagram that are affecting the adequate performance of Tubos S.A.

4.5. Stage 5: Compare stage 4 ('problematic' situation system dynamics model(s)) or 7 ('solving' situation system dynamic model(s)) against stage 2 (rich picture)

In the first iteration of SSDM (World 2) a comparison is made between Stage 4 (problem-oriented system dynamics model(s) *versus* stage 2 (rich picture). From that comparison some findings can be detected, the aim being to validate the 'problematic' system dynamics models. The criteria of validation are the same of SSM (in this case the validation is concerned to probe that the inadequate behaviour of the system is culturally feasible and systemically desirable by the people involved in the problem situation). The validation process here is made to the problematic context diagram as well as to the problematic system dynamics model (nouns, verbs, adverbs and causal relationships).

In the second iteration of SSDM (World 3), a comparison is made between Stage 7 (solving-oriented system dynamics model(s) *versus* stage 2 (rich picture) after stages 6 and 7 are done.

4.6. Stage 6: Determine culturally feasible and systemically desirable changes

From the work done in the previous stage (first iteration), a list of culturally feasible and desirable 'solving' changes can be obtained, leading this to see the way they can be implemented in the real-world in order to 'improve', the problem situation. The changes could be a new 'noun' (level), a new verb in gerund (flux) or adverb (auxiliary variable) (ie a SD's variable) or one or some causal relationships that need to be aggregated to the problematic system dynamics model, or, on the contrary, the elimination of a noun, a verb or an adverb (ie a SD's variable) or one or some causal relationships which allows to change the behaviour from a problematic to what we call a 'solution-based' model. This can be tested using the sensitivity analysis of the 'solving-oriented' system dynamics model(s).

In Tubos S.A., it was noticed that several changes can be made at the problematic context diagram and at the causal diagram which can lead to 'improve' the problem situation.

4.7. Stage 7: Building system dynamics models of the solving situation

Figures 5 and 6 show the 'solving' context diagram and the 'solving' causal diagram with several culturally feasible and

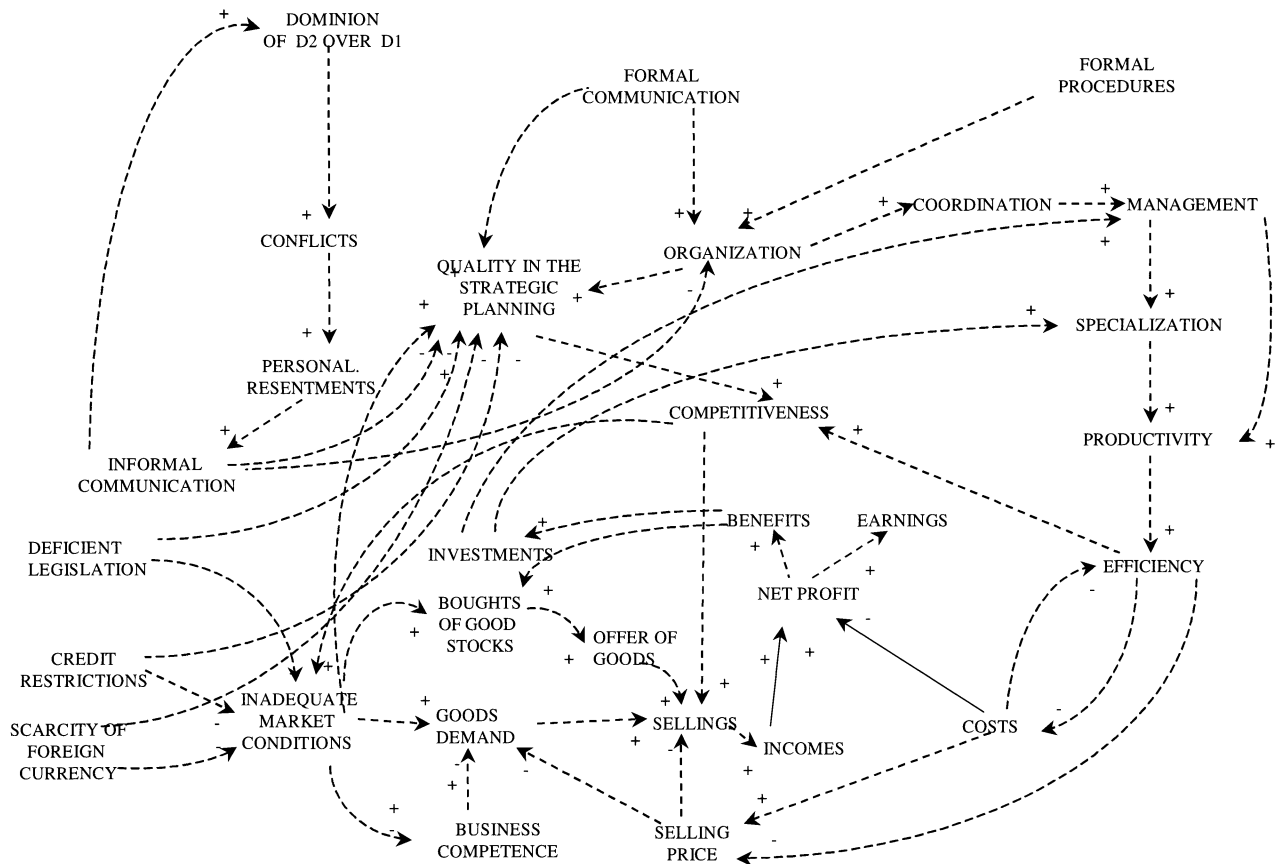


Figure 4 SSDM's stage 4: problem-oriented causal diagram based on the problem-oriented context diagram based on a problem-oriented root definition (Figure 3) (after Montbrun and Porras, 1998 and Rodríguez-Ulloa, 1999).

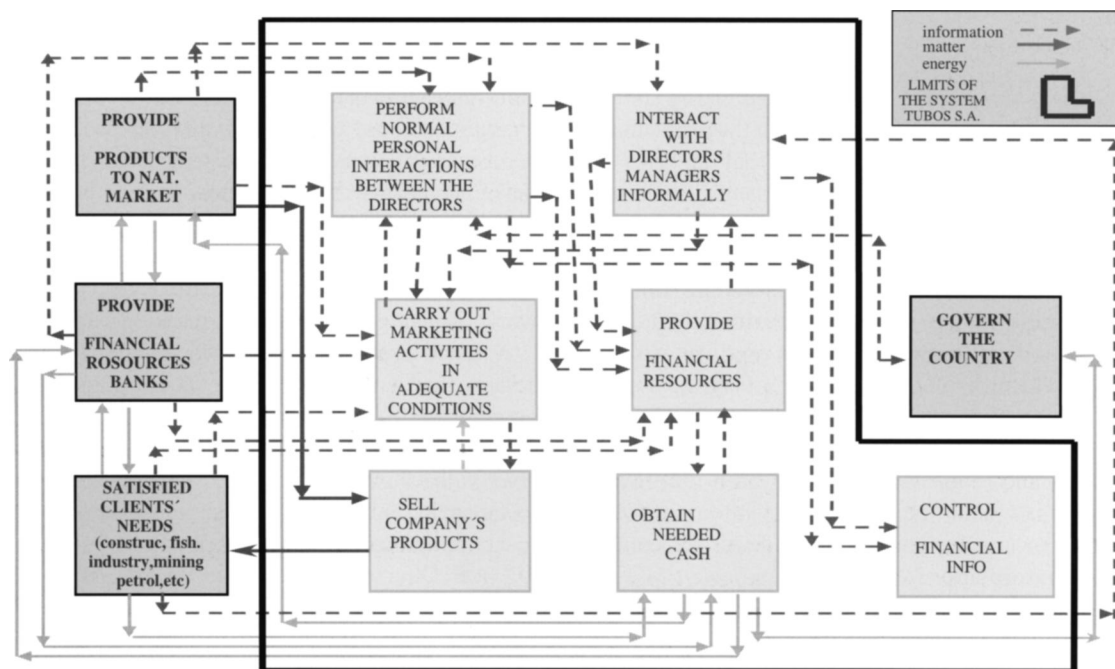


Figure 5 SSDM's stage 7: solution-based context diagram of the problem situation that comes from a 'solution-based' root definition (after Montbrun and Porras, 1998 and Rodríguez-Ulloa, 1999).

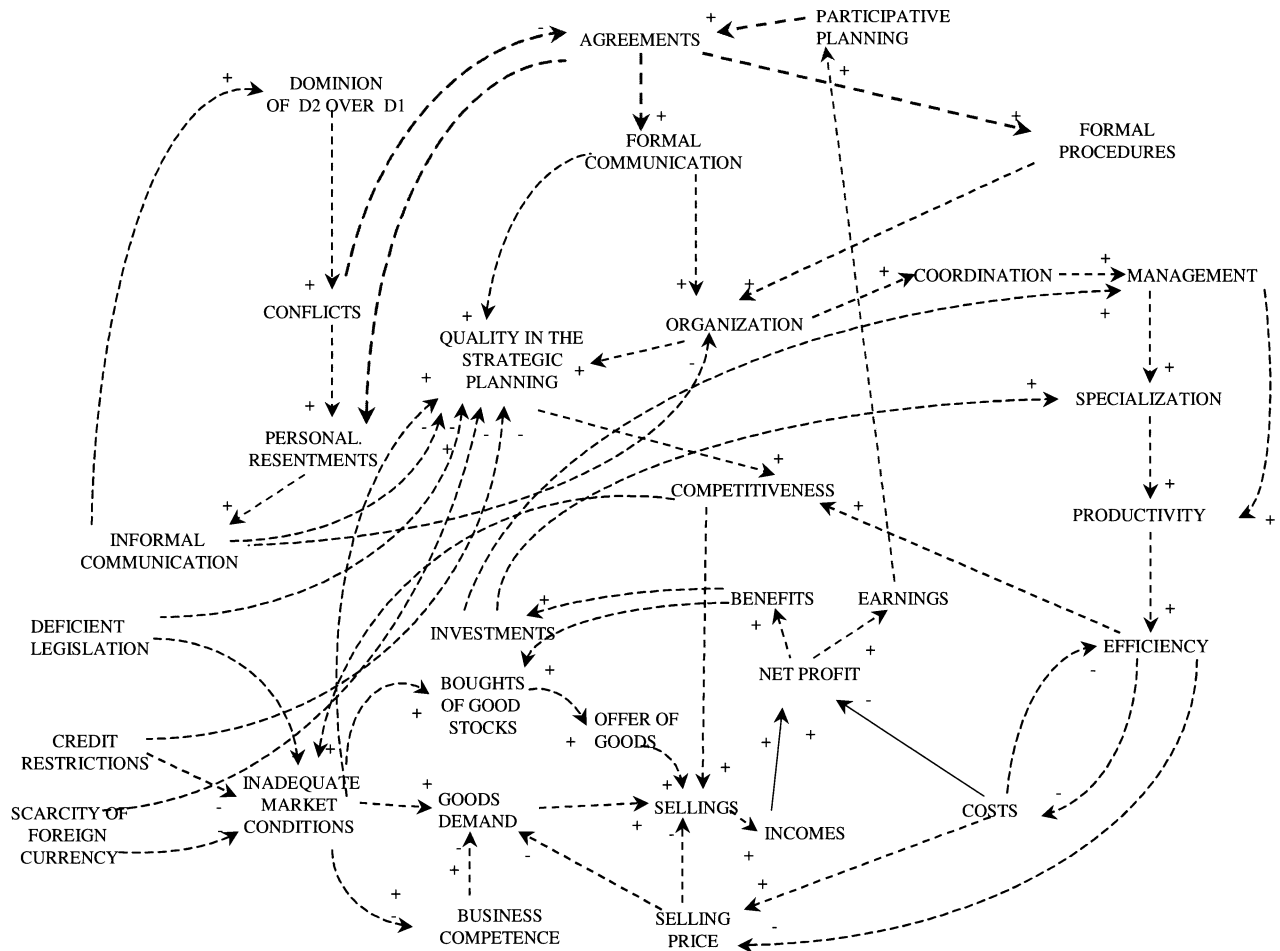


Figure 6 SSDM's stage 7: solution-based causal diagram of the problem situation based on the solution-based context diagram (Figure 5) (after Montbrun and Porras, 1998 and Rodriguez-Ulloa, 1999).

systemically desirable changes. For example, if the solving context diagram (Figure 5) is compared with the problematic one (Figure 3), then it can be detected that in order to change the overall behaviour of the system's structure, several changes have been proposed because of being culturally feasible and systemically desirables. Thus, the interactions between the directors are done in 'normal' conditions, consequently the marketing activities are done in adequate conditions, allowing to sell the products without disadvantages, which permits, as well, to satisfy the Tubos' clients. In the same manner, the financial resources can be provided in normal conditions (because the fluxes of communication and coordination have been improved) and then incomes can be obtained without difficult conditions. Similar conclusions can be made for the control of the financial information.

The 'solution-based' causal diagram (Figure 6) can be compared with the problematic causal diagram (Figure 4), observing that several 'solving' changes have been encountered to probably be culturally feasible and systemically desirables. It can be argued that these changes are 'probably'

culturally feasible and systemically desirable 'solving' changes, because only the simulation process through the computer will show that effectively, the proposed changes make significant modifications in the behaviour of the system's structure towards the achievements of 'improvements' of the overall performance of Tubos S.A. For doing this, quantitative specific indicators are considered in this work, applying what is called quantitative SD.

A careful examination of both figures (Figures 3 and 5) reveals that if the problematic causal diagram is modified, adding the variables 'participative planning' and 'agreements', then the overall behaviour of the system starts to change because the variable 'agreements' decreases the 'personal resentments' variable, which improves the 'informal communication' by decreasing the dominion of Director D2 over Director D1, which in turn, leads to a decrease in the conflicts between them. If conflicting relationships between them decrease, then more agreements will be achieved in diverse issues, improving the formal communication and procedures. As the formal communication is improved, the quality of the strategic planning process is

improved also increasing Tubos S.A.’s competitiveness, which allows more sales and so on. The models elaborated at this stage must be compared with the rich picture, in order to validate its cultural feasibility and desirable systemicity.

4.8. Stage 8: Solving-oriented root definitions of the problem situation

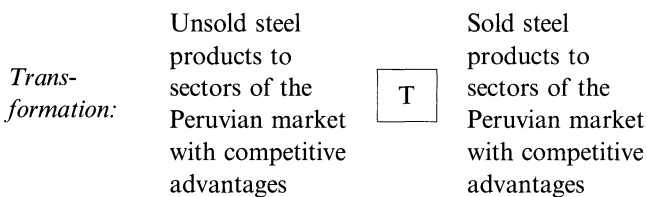
At this stage, those root definitions which being culturally desirables and systemically feasible are elaborated to express the transformation processes that ‘improves’, ‘finish’, ‘solve’ or ‘alleviates’ the problem situation encountered in the problematic analysis so taking into account the problematic root definition (Stage 3) then the corresponding ‘Solution-based’ (ie ‘solution-based’) root definition will be:

‘A human activity system owned by a private company, which sells steel products to the construction, mining, petrol, fishing and industry sectors of the internal Peruvian market, with competitive advantages in order to satisfy its clients’ needs. To get the adequate competitiveness, this process is done under the implementation of a formal management and culture at different hierarchical levels of the company, aiming to have good human relations, good communication, adequate organization, high quality strategic planning processes and performance for the enterprise as a whole, as measured in marketing and financial results and achievements along time. This HAS is being done under diverse external constraints, as a result of the unclear environmental situation existing in the country, like credit restrictions, scarcity of foreign currency and deficient legislation’

CATWOE analysis:

Clients: Directors, managers, workers, clients, providers of Tubos S.A., the Peruvian state.

Actors: Directors, managers, workers



Owners: Director D1 (Martinelli) and D2 (Ampuero), managers (Mr Zapata and Mr Merino)

Environment: Credit restrictions, scarcity of foreign currency, deficient legislation

4.9. Stage 9: Implement culturally feasible and systemically desirable changes in the real world

Once the adjustments have been done among stages 8, 2 and 7 as well as among stages 5, 6 and 7, then the culturally

feasible and systemically desirable changes selected are ready to be implemented in the real world. At this stage, it has been seen, according to our experience using SSM, that the process of implementing changes can also be the arena where several situations could happen, which may be could not be considered for any reasons in all the previous stages (the real world is very different from the ideal one), then some last time adjustments could be needed to implement in the selected changes, in the real world.

In the case of Tubos S.A., by reflecting and observing the ‘solution-based’ causal diagram (Figure 6) several changes have to be implemented, hopefully, in the real world:

- Introduce participative planning
- Introduce ways and techniques of agreement between the parts in conflict
- Establish links between the following variables (See Figure 6):

- (1) Earnings to Participative Planning (+)
- (2) Participative Planning to Agreements (+)
- (3) Agreements to Personal Resentments (–)
- (4) Conflicts to Agreements (–)
- (5) Agreements to Formal Communication (+)

As in SSM, these changes can be ordered according to priority criteria (logic criterion, importance and urgency). Then a plan can be elaborated at stage 6, which can be implemented at stage 9.

4.10. Stage 10: Learning points

Here the learning points from the sensitivity analysis of the problematic and solving system dynamics models computer simulation (Stages 4 and 7 in SSDM) can bring some insights to learn about the ‘pathological’ and the ‘healthy’ behaviour of the system being studied. For example, the concentration of power made by director D1 brought many and diverse kind of problems to Tubos S.A. and only the cultural acceptance of participative planning by the directors, allowed to improve the communication between D1 and D2 and from this, to reshape the strategic behaviour of Tubos S.A.

On the other hand, the implementation process Stage 9, can also bring about some insights from the experience of implementing what is proposed at stage 6, for learning purposes. The way how to do participative planning for example, or how to improve the communication between the directors, can have special issues to treat that only can be seen at this stage. Both learning experiences, one theoretical and the other from the real world will help very much in the adjustments and learning process of the analysts for tackling future problematic situations using SSDM in the same problematic situation (ie Tubos S.A.) or in a new one.

Finally, it must be mentioned that the system dynamics models have not been presented in this paper for brevity, but

the technology which encompasses the SD approach can be used in full, as part of the use of SSDM.

5. Conclusions

- Soft Systems Dynamics Methodology (SSDM), a type of multiparadigm and multimethodology practice that have been used extensively in LA has been revisited and its steps briefly outlined. A framework containing the ontological, epistemological and methodological premises underpinning SSDM and its constituents, SSM and SD has been advanced.
- The methodology described includes ten stages and two systemic loops which forces the practitioner to visit SSDM's 'three worlds': (i) real world (SSDM's World 1); (ii) problem situation-oriented systems thinking world (SSDM's World 2); and (iii) solving situation-oriented systems thinking world (SSDM's World 3). By travelling through its two loops, the methodology becomes a useful framework and arena for debating both the 'whats' and 'hows' concerning a particular 'problematical situation' in a dialectical way: in the first loop one face of the coin (the problematic view of the problematical situation) is seen; and in the second loop, the other face of the same coin (the 'solution-based' view of the mentioned problematical situation) is seen.
- An important distinction as regards SSM is the way how root definitions are built and used: SSDM adheres to a dialectical approach; root definitions here are built in two different ways: When we are in the first loop (SSDM's World 2) then root definitions described the problematic transformation process which is culturally feasible and systemically desirable in that situation. When we are at the second loop (SSDM's World 3), then root definitions describe what we call the 'solution-based' transformation process which should be culturally feasible and systemically desirable, to be implemented in the real world. This fashion of building and using root definitions differs significantly in the way that SSM constructs and uses root definitions.
- We have argued, conceptually and illustrated with a case study, that SSDM synthesizes the diverse philosophical frameworks, paradigms and intellectual tools from SD and SSM, which working together allow it to be a powerful intellectual framework for the analysis and design of social systems.
- Essentially, SSDM draws and combines the following stages from SSM and SD:
 - From SSM, the phenomenological way of describing real-world complexity (Stages 1 and 2) are taken. To these two first stages, several new mental tools and concepts have been added and using in structuring messy problems and soft situations, in order to build suitable rich pictures, all of this coming from the

experience of using SSM in Peru and other Latin American countries in the last 15 years.

- From SD it takes the functionalistic and causal rationality, that being treated in a positivistic way in the 'austere SD' (Lane, 1999, 2001a, b), here causal rationality is used under a phenomenological umbrella, coming from the influence of SSM over SD. Thus, from each problematic 'solution-based' root definition, a causal diagram can be generated, but in this case, this causal diagram is based on a particular world-view (ie Weltanschauung), clearly defined and identified in the root definition which it is based on which define the context diagram and the subsequent qualitative and quantitative system dynamics model.
- SSDM overcomes the limitations of SSM by bringing SD and the support of *ad-hoc* computer software to simulate in the laboratory diverse social behaviours, making it possible to probe if the suggested 'culturally feasible' and 'systemically desirable' changes are really as we think they can be or they are just a chimera because they will not work in the real-world as it was expected. The contribution of phenomenological SD models (ie SD models coming from diverse Weltanschauungen) can be of crucial importance to see the possibilities of the changes the analysts can propose to be implemented in the real world, before wasting time and other resources.
- Although the Tubos S.A. application study has been a good arena where to show the use of SSDM, it must be stressed that what is has been shown in the present paper is just one of the '*n*' possible visions of the analysis. SSDM can be seen as a learning process from both, the problematic situation which is being analysed; because if we do iterate in an attempt to gain more understanding of it, as well as proposing 'solutions' for it, from diverse Weltanschauungen, we will gain more insight into the situation, adding richness to the systemic intervention.
- SSDM, has been in use and tested for some time now mainly in LA settings. The authors continue working for further adjustments to it and do not claim that the methodology is free of possible improvements, thus comments and criticisms from SSM, SD and, especially, from management sciences multi-methodological practitioners are welcome.

References

- Andersen DF and Richardson GP (1997). Scripts for group model-building. *System Dynamics Rev* 13(2): 107–129.
- Brocklesby J and Cummings S (1995). Combining hard, soft, and critical methodologies in systems research: the cultural constraints. *Syst Res* 12(3): 239–245.
- Brocklesby J (1997). Becoming multimethodology literate: an assessment of the cognitive difficulties of working across paradigms. In: Mingers JC and Gill A (eds). *Multimethodology*. John Wiley and Sons, Chichester.

- Checkland PB (1981). *Systems Thinking, Systems Practice*. John Wiley and Sons: Chichester.
- Checkland P and Scholes J (1990). *Soft Systems Methodology in Action*. John Wiley and Sons: Chichester.
- Flood R and Jackson M (1991). *Creative Problem Solving: Total Systems Intervention*. John Wiley and Sons: Chichester.
- Jackson MC (1992). *Systems Methodology for the Management Sciences*. Plenum Press: New York.
- Jackson MC (1997). Pluralism is systems thinking and practice. In: Mingers JC and Gill A (eds). *Multimethodology*. John Wiley and Sons, Chichester.
- Jackson MC (1999). Towards coherent pluralism in management science. *J Opl Res Soc* **50**: 12–22.
- Jackson MC (2000). *Systems Approaches to Management*. Kluwer Academic/Plenum Press Publishers: New York.
- Jackson MC (2003). *System Thinking: Creative Holism for Managers*. John Wiley and Sons: Chichester.
- Lane D (1999). Social theory and system dynamics practice. *Eur J Opns Res* **113**: 501–527.
- Lane D (2000). Should systems dynamics be described as 'hard' or 'deterministic' systems approach? *Syst Res Behavioral Sci* **17**(1): 3–22.
- Lane D (2001a). Rerum Cognoscere Causas: Part I—How do the ideas of system dynamics relate to traditional social theories and the voluntarism/determinism debate? *Syst Dynamics Rev* **17**(2): 97–118.
- Lane D (2001b). Rerum Cognoscere Causas: Part II—Opportunities generated by the agency/structure debate and suggestions for clarifying the social theoretic position of system dynamics. *Syst Dynamics Rev* **17**(4): 293–309.
- Lane DC and Oliva R (1994). *The greater whole: towards a synthesis of the system dynamics and soft system methodology*. Working Papers Series, City University Business School, London.
- Mingers J (1997a). Multi-paradigm multimethodology. In: Mingers JC and Gill A (eds). *Multimethodology*. John Wiley and Sons, Chichester.
- Mingers J (1997b). Towards critical pluralism. In: Mingers JC and Gill A (eds). *Multimethodology*. John Wiley and Sons, Chichester.
- Mingers J (1999). A comparative characterisation of management sciences methodologies. *Systemist* **21**(2): 81–92.
- Mingers J and Brocklesby J (1996). Multimethodology: towards a framework for critical pluralism. *Systemist* **18**(3): 101–132.
- Montbrun A and Porras L (1998). *Informe de Trabajo Grupal*. International Workshop in Soft System Dynamics Methodology (SSDM), April 1998, Lima.
- Morecroft JD and Sterman JD (1994). *Modelling for Learning Organizations*. Productivity Press: Portland, OR.
- Munro I and Mingers J (2002). The use of multimethodology in practice—results of a survey of practitioners. *J Opl Res Soc* **53**(4): 369–378.
- Paucar-Caceres A (2002). Mapping the stages of the development of management sciences methodologies in the UK: from single solving methods to multimethodology. *UK Systems Society, 7th International Conference-Systems Theory & Practice in the Knowledge Age*, 7th July 2002, University of York; Plenum Publishers, New York, 2002.
- Richardson GP and Andersen DF (1995). Teamwork in group-model building. *Syst Dynamics Rev* **11**(2): 113–137.
- Rodriguez-Ulloa RA (1999). Soft system dynamics methodology-SSDM: a tool for social systems analysis and design. In: *Proceedings of the 43rd Annual Meeting of the International Processes Sciences Society-ISSS, Asilomar*.
- Rodriguez-Ulloa RA (2002). The soft system dynamics methodology (SSDM): the fusion of soft systems methodology (SSM) and system dynamics (SD). *Proceedings of the Third International Congress of Electromechanics and Systems Engineering, Instituto Politécnico Nacional—IPN, México D.F.*
- Rodriguez-Ulloa RA (2003). Soft systems methodology. In: *Virtual Encyclopedia of Life Support System (EOLSS)*, (www.eolss.net). UNESCO, Paris.
- Rodriguez-Ulloa R and Paucar-Caceres A (2004). Soft system dynamics methodology (SSDM): a combination of soft systems methodology (SSM) and system dynamics (SD). *Proceedings of the 22nd International Systems Dynamics Conference, July 25–29, 2004, Oxford, England*.
- Rodriguez-Ulloa and Paucar-Caceres (2005). Soft system dynamics methodology (SSDM): combining soft systems methodology and systems dynamics. *Systems Practice and Action Res* **18**(3): 303–334.
- Rouwette EAJA, Vinnex JAM and Van Mullekom TV (2002). Group model-building effectiveness: a review of assessment studies. *System Dynamics Rev* **18**(1): 5–45.
- Sterman JD (2000). *Business Dynamics: Systems Thinking and Modelling for a Complex World*. Mc Graw Hill: New York.
- Vennix JAM (1996). *Group Model Building: Facilitating Team Learning Using System Dynamics*. John Wiley and Sons: Chichester.
- Vennix JAM (1999). Group model-building: tackling messy problems. *System Dynamics Rev* **15**(4): 379–401.
- Vennix JAM, Akkermans HA and Rouwette EAJA (1996). Group model-building to facilitate organizational change: an exploratory study. *System Dynamics Rev* **12**(1): 39–58.
- Vennix JAM, Richardson GP and Andersen DF (1997a). Foreword: group model building, art and science. *System Dynamics Rev* **13**(2): 103–106.
- Vennix JAM, Richardson GP and Andersen DF (1997b). Group model-building: Adding more science to the craft. *System Dynamics Rev* **13**(2): 187–201.
- Warren K (2002). *Competitive Strategy Dynamics*. John Wiley and Sons: Chichester.

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