The effect of Family Inertia on the Value Creation Process in Family Firms: New Insights from a Simulation Study[1]

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The present research can be viewed as a contribution to the literature on the simulation of first-order models of theory testing and on the simulation of second-order models of theory building. It sets out through computer simulations in system dynamics the positive dynamic interconnections studied by Koiranen and Chirico (2006) between knowledge, capabilities, dynamic capabilities, entrepreneurial performance and trans-generational value in family business. Interesting results and new insights emerge when analyzing family inertia in the model (as a function of paternalism) that influences the creation of capabilities and dynamic capabilities negatively, though with some exceptions. We conclude that although a paternalistic behaviour can be positive in guiding and training offspring at the beginning of the activity, it may become less crucial if it persists over time preventing change even when it is needed. Family firms should be able to understand the long-term effects and results of actual events, decisions and behaviours, and, at the same time, prevent their negative consequences.

Keywords: Simulation modelling, family business, family inertia, paternalism, value creation.

1 INTRODUCTION

While much has been written about trans-generational value creation in family business (see for example Habbershon and Pistrui, 2002), the process through which the value is created has not been extensively studied. The field is currently lacking a systematic framework that allows the answering of questions, such as why some family firms consistently show adaptive traits within dynamic environments, even over relatively long periods of time, while others fail to do so. Or how can the capabilities to adapt be

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described within successfully working family firms. Or, in a similar vein, how do some family firms renew their competences and change their culture to respond to shifts in their target business environments (see Salvato, 2006: 69).
A first attempt to answer those questions was made by a family-business research team (see Koiranen and Chirico, 2006) who jointly created in 2004-2006 a research partnership called the FITS Project. The acronym FITS referred to the participating countries: Finland (University of Jyvaskyla), Italy (Bocconi University) and Switzerland (University of Lugano, USI). They built up a model (the FITS model, see Koiranen and Chirico, 2006: 47), based on an extended review of the literature and a pilot study on six family firms from Finland, Italy and Switzerland. The aim was to investigate the complex dynamic process through which dynamic capabilities are generated by knowledge and generate entrepreneurial performance, allowing a family firm to compete in situations of rapid change and create value over time to be partially reinvested for the creation of new knowledge (e.g. training courses). For the sake of this argument, dynamic capabilities were seen as a double concept: basic and advanced dynamic capabilities. In addition, family inertia was considered to be a factor preventing the creation of dynamic capabilities (Teece et al., 1997; Eisenhardt et al., 2000; Hall et al., 2001; Larsen and Lomi, 2002; Habbershon and Pistrui, 2002; Zahra and George, 2002; Sharma, 2005; Koiranen and Chirico, 2006).

The objective of that study was to fill the gap in understanding the process that leads to trans-generational value creation in family business through the lens of knowledge, dynamic capabilities and family culture.

In this paper the theory testing and building of the FITS model is supported by computer simulation in *system dynamics* which is especially relevant for studying the way complex systems (set of processes with causality and timing) behave (Larsen and Lomi, 1999, 2002; Davis et al., 2007, forthcoming). Indeed, system dynamics is a powerful method through which to build a shared understanding and gain useful *insights* into situations of dynamic complexity created by interdependencies, feedbacks, time delays and nonlinearities (Sterman, 1992; Van Ackere et al., 1993; Sterman, 2000). The simulation analysis will allow us to verify the internal validity and robustness of the model presented and make virtual experiments in order to yield new insights for theory building (Forrester and Senge, 1980; Davids et al., 2007, forthcoming). We are particularly focused on understanding the effect of the family-business culture on the value creation process in family business. Interesting results will emerge from analyzing family inertia (as a function of paternalism) in the basic model which influences the creation of capabilities and dynamic capabilities negatively though with some exceptions. We will explore the effect that a paternalistic behavior may have in guiding and training offspring at the beginning of the activity, and what happens if paternalism persists over time preventing change even when it is needed.

The present research can be viewed as a contribution to the literature on the simulation of first-order models of theory testing and on the simulation of second-order models of theory building. As pointed out by Larsen and Lomi (2002), first-order models are directed to test a theory, while second-order models are representations, based on a rebuilding or integration of a series of existing theories, aimed at building a new theory (see also Wittenberg et al., 1992).
Our general goal is to shed light on the opportunity to use the system dynamics' methodology as a tool for theory testing and theory building.

The paper will be organized as follows. After a review of the literature related to the determinants of family firm's performance, the feedback loops model which leads to value creation across generations in family business is presented. This is followed by the details of the experimental design in system dynamics of our study and the advantages of using SD-based simulations for theory building. Then, the model structure, from feedback loops to dynamic models, is analyzed and its results and new insights are reported and discussed. In this section, we examine four different scenarios describing the evolution of paternalism over three generations (90 years), and their consequent effects on the model as a whole. The paper concludes with a summary of the main insights, limitations and suggestions for further research.

2 A FEEDBACK LOOPS REPRESENTATION OF THE VALUE CREATION PROCESS IN FAMILY FIRMS

2.1 The knowledge reinforcing loop

The knowledge-based theory of the firm identifies knowledge as the most fundamental asset of the firm, which all other resources depend on (Grant, 1996b; Spender, 1996). It is a significant source of competitive advantage, which enables an organisation to be innovative and remain competitive in the market (Polany, 1958, 1967; Nonaka, 1991; Nonaka and Takeuchi, 1995; Grant, 1996a; Smith, 2001).

In this respect, Cabrera-Suarez et al. (2001) underline the importance of knowledge as a source of competitive advantage in family business; and Bjuggren et al. (2001) posit that there is a form of family idiosyncratic knowledge (and loyalty) that makes intergenerational succession within the family more profitable than other types of succession through acquisition and sharing of knowledge.
Knowledge in family business can be defined as pure knowledge and skill which family and non-family members working in the family firm have gained and developed through education and experience (Chirico, 2006b: 16).

In order to investigate how family firms can maintain and sustain new and innovative forms of competitive advantage through knowledge and generate value over time in rapidly changing environments, we need to introduce the concept of dynamic capabilities.
Habbershon and Pistrui, (2002) posit that the family ownership group has to develop entrepreneurial change capabilities in order to shed or redeploy resources which erode in value and become obsolete quickly in changing markets. The combination process of resources is the core concept behind the dynamic capability view of economic development (Teece et al., 1997) which allows a firm to gain and sustain entrepreneurial performance, i.e., a new and innovative form of competitive advantage given by entrepreneurial innovation and strategic adaptation to the market (Teece et al., 1997; Eisenhardt and Martin, 2000; Habbershon and Pistrui, 2002; Zahra and George, 2002; Zollo and Winter, 2002; Koiranen and Chirico, 2006). Indeed, dynamic capabilities facilitate processes directed to (Teece et al., 1997: 516) "integrate, build, and reconfigure internal and external competences to address rapidly changing environments". They are "routines through which managers alter their resource base - acquire and shed resources, integrate them together, and recombine them" (Eisenhardt and Martin, 2000: 1107)[2].

[2] The term 'dynamic' refers to the capacity of renewing the organisation to better suit the changing environment; while 'capabilities' refers to the ability to build and combine internal and external resources so as to achieve congruity with a changing environment (Teece, Pisano and Shuen, 1997).

Dynamic capabilities are here described as processes embedded in firms designed to acquire, exchange and transform (integrate and recombine) internal and external resources in new and distinctive ways and, at times, shed them to build and sustain entrepreneurial performance in environments of rapid change. (Teece et al., 1997; Eisenhardt and Martin, 2000; Zahra and George, 2002; Koiranen and Chirico, 2006). Absorptive capacity is itself a dynamic capability (Zahra and George, 2002).

Resources are conceived as knowledge and capabilities (see Hart and Banbury, 1994; Habbershon and Williams, 1999). When dynamic capabilities refer to processes designed to acquire, exchange, transform and shed *knowledge*, they are called 'basic dynamic capabilities' (BDC); if dynamic capabilities apply to processes aiming at acquiring, exchanging, transforming and shedding *capabilities*, they are named 'advanced dynamic capabilities' (ADC) (see figure 5).

Dynamic capabilities result from mechanisms of knowledge sharing, collective learning, experience accumulation and transfer (Eisenhardt and Martin, 2000; Zollo and Winter, 2002; Zhara and George, 2002). Most of the advantages of family firms refer to those family and organisational processes which may be facilitated in family firms, compared to non-family firms due to the high level of emotional involvement of family members and the socially intense interactions between family members (see Tagiuri and Davis, 1996; Habbershon and Williams, 1999; Salvato and Melin, 2003; Koiranen and Chirico, 2006b; Salvato, 2006). This allows them, firstly, to exchange knowledge more efficiently and with greater privacy compared to non-family businesses; secondly, to develop *idiosyncratic knowledge* (see Coleman, 1988; Bjuggren et al., 2001; Koiranen and Chirico, 2006) and *specific dynamic capabilities for resource-recombination* which remains within the family and the business across generations (see Kusunoki et al., 1998; Deeds et al., 1999; Eisenhardt and Martin, 2000; Salvato 2006; Salvato, Pernicone and Chirico, 2006).

Absorptive capacity (see Cohen and Levinthal, 1990) is viewed as a **basic dynamic capability** described by Zahra and George (2002: 186,188) as a set of organisational routines and processes, through which firms acquire and assimilate external knowledge (PAC: potential absorptive capacity) and transform and exploit the knowledge that has been absorbed (RAC: realized absorptive capacity)[3].
Moreover, Cohen and Levinthal (1990) underline that organisations need prior related knowledge, which is knowledge available within the firm, to assimilate and use new external knowledge. Some psychologists suggest that prior knowledge increases learning because the storage of knowledge is developed by 'associative learning', i.e., a principle based on the assumption that ideas and experience reinforce one another and can be linked with pre-existing concepts to enhance the learning process (Bower and Hilgard, 1981).

Therefore, organizations rely on their existing knowledge to 'acquire, assimilate' and 'transform, exploit' knowledge (BDC); and, in turn, create new knowledge within the

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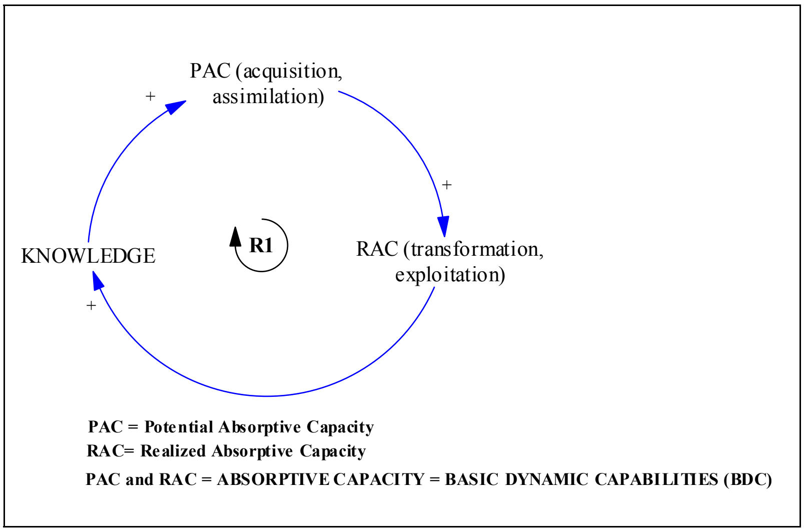
[3] Acquisition capability means "the ability to identify and acquire externally generated knowledge"; assimilation capability refers to "the ability to analyze, process, interpret and understand knowledge acquired from external sources"; transformation capability indicates the ability to "develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge"; and exploitation capability refers to "the ability to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations" (Zahra and George, 2002: 189,190).

firm (Cohen and Levinthal, 1990; Bower and Hilgard, 1981; Lane and Lubatkin, 1998; Zahra and George, 2002), as shown in figure 1 with the reinforcing loop 1 (R1) [4].

Figure 1: The Knowledge reinforcing loop (R1)*



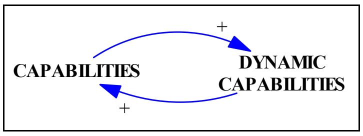
(*) The "+" means that the two variables move in the same direction, all other things being equal. More details in appendix D.

2.2 Knowledge, capabilities and dynamic capabilities as tripled reinforcing loops to value creation

Researchers (see for instance, Collis, 1994; Winter, 2003) underline the positive correlation between capabilities and dynamic capabilities (Erik Larsen, 2006. Personal Communication). The definition of capabilities can be applied from the broader concept of organizational routines which allow any firm to produce significant outputs of a particular type (Winter, 2000).

Indeed, in Collis (1994) and Winter (2003)'s view, capabilities can be valuable but their rate of innovation must be continually updated through higher order capabilities. Collis (1994) explicitly refers to dynamic capabilities as higher-level organisational routines which govern the rate of change of ordinary capabilities. Winter (2003: 991, 992) confirms that ordinary or 'zero-level' capabilities enable a firm to 'make a living' in the short term and dynamic capabilities allow a firm to extend, modify or create ordinary capabilities (see figure 2).

Figure 2: The capability reinforcing loop

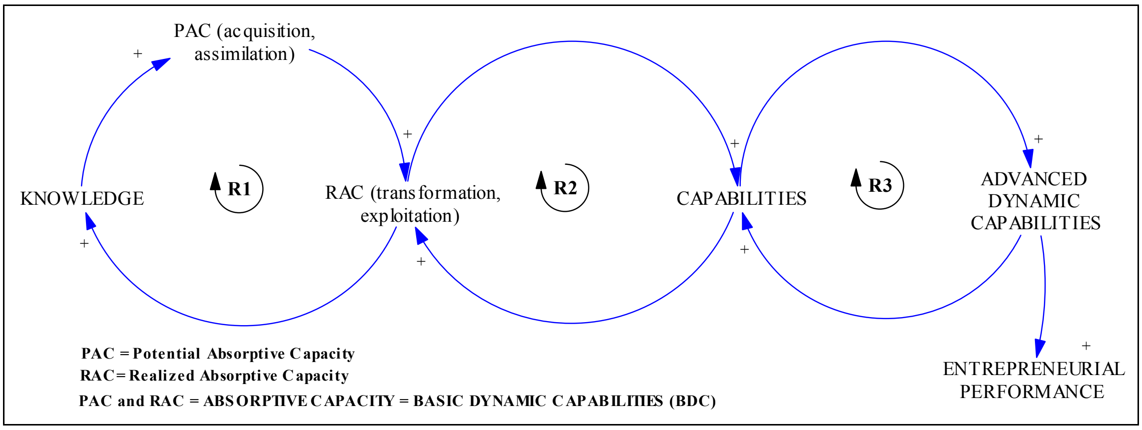


In this respect, Zahra and George (2002) propose a definition of absorptive capacity (BDC) as creating and deploying knowledge which, in turn, generates new organisational capabilities, for instance in distribution and production.

[4] *Reinforcing Loop* (**R**) is a structure which feeds on itself to produce growth or decline. In other words, R tends to reinforce or amplify whatever is happening in the system (Sterman, 2000). More details in Appendix D.

Hence, firms also rely on knowledge acquired from external sources to facilitate the development of their own capabilities, which consist of multilayered knowledge (Lane and Lubatkin, 1998, Kusunoki et al., 1998). Likewise, Grant (1996a) and Kusunoki et al., (1998) believe that the essence of organisational capabilities is the integration of specialised knowledge created and accumulated by individuals within the firm.
For this reason, basic dynamic capabilities, particularly the realised absorptive capacity, allow a firm to generate new capabilities. The acquisition, exchange, integration, recombination and shedding of such capabilities (with the knowledge accumulated) produce new dynamic capabilities named **advanced dynamic capabilities** (e.g. the product development process) which are real enablers of entrepreneurial performance in dynamic markets. In turn, ADC enhance the ability of the firm to change and modify its own capabilities. Therefore, new capabilities are shaped, such as: capabilities of developing strategies to manage change; shedding or redeploying unproductive resources; and gaining or manipulating knowledge (RAC) as depicted in figure 3 with the reinforcing loops 2 and 3 "R2 and R3" (see Collis, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Zhara and George, 2002; Habbershon and Pistrui, 2002; Winter, 2003).
The process described above can be clarified by an example. The ability to continually innovate product characteristics is a dynamic capability known as product development. It stems from the knowledge of the firm and its capacity of acquiring, assimilating, transforming and exploiting internal and external knowledge (i.e. basic dynamic capabilities). Indeed, BDC create new capabilities (e.g., how to make products). In rapidly changing environments, when the specific firm's products go, for instance, out of fashion, such capabilities (with the knowledge accumulated) enable the firm to develop processes designed to exchange, integrate, recombine and, at times shed, its capabilities (i.e. ADC, in the case in point the *'product development process'*). In turn, ADC allow the firm to create new capabilities in product making and in manipulating or shedding existing knowledge (RAC). Finally, entrepreneurial performance (entrepreneurial innovation and strategic adaptation) generated by dynamic capabilities will lead to the creation of trans-generational value in family business.

Figure 3: Knowledge, capabilities and dynamic capabilities as tripled reinforcing loops (R1, R2, R3)

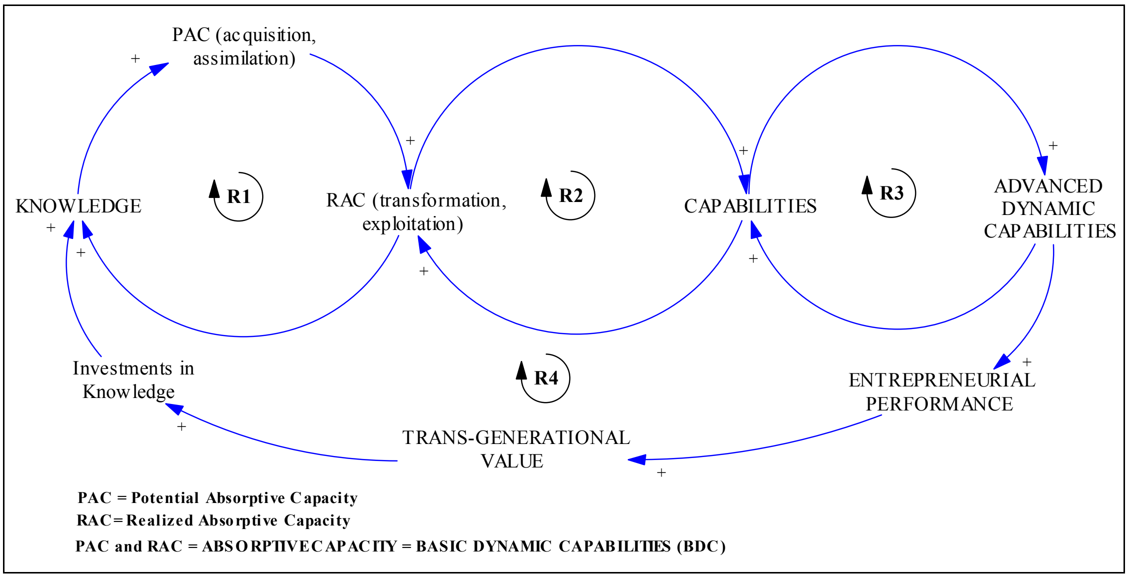


The creation of value (TGV) in family business is accumulated through continuous creation of business wealth. It has been measured by Koiranen and Chirico (2006) through the analysis of the balance sheet of the family firms studied. It is a kind of value creation process generated by human capital (Sherer, 1995; Pennings et al., 1998; Hitt et al., 2001) and dynamic capabilities (Teece et. al., 1997; Zahra and George, 2002) through innovation, strategic flexibility/adaptation (Zahra and George, 2002), strategic renewal (Floyd and Lane, 2000) and strategic opportunities (Lei et al., 1996). As a matter of fact, the intermediate variable of the process is represented by entrepreneurial performance, as shown below:

Knowledge → (Dynamic) Capabilities → *Entrepreneurial Performance* → Trans-generational Value
←
(Innovation, strategic flexibility/ adaptation, renewal and opportunities)

The feedback structure in figure 4 outlines the dynamic process from knowledge to TGV. It also underlines (R4) the positive effect that TGV may have on the creation of new knowledge through investments designed to acquire new knowledge and/or implement the existing one (e.g. training, executive courses, employing/using external non-family members such as consultants and so on. See Lansberg and Astrachan, 1994; Nonaka and Takeuchi, 1995; Kaye, 1999).

Figure 4: The feedback structure from knowledge to value creation (R4)



2.3 The family inertia problem

Although dynamic capabilities "exhibit common features (best practice) that are associated with effective processes across firms" (Eisenhardt and Martin, 2000: 1108), they are unique and idiosyncratic processes that emerge from the path-dependent history of each firm (Teece et al., 1997; Eisenhardt and Martin, 2000). Hence, the history and culture of the family firm can deeply influence the development of its dynamic capabilities.

How rapidly (or slowly) the process depicted in figure 4 converts knowledge into value creation strongly depends on the family-business culture.

Family firms are often inflexible, resistant to change and based on path-dependent traditions and culture hostile to new proactive entrepreneurial strategies (Dyer, 1994; Gersick et al., 1997; Aronoff and Ward, 1997; Habbershon and Pistrui, 2002).
Alvesson (1993: 2,3) defines 'culture' as a shared and learned world of experiences, meanings, values and understandings which inform people and which are expressed, reproduced and communicated in partly symbolic form.
The family-business culture is the result of the combination of different patterns (see Dyer, 1986; Zahra et al., 2004). For the purpose of the study conducted by Koiranen and

Chirico (2006), the focus was on two specific family-business cultural aspects, paternalism and entrepreneurial drive.

Paternalism is the practice of caring for others in a manner that is overly intrusive such as a father to a child[5]. It means that the owner protects the family-business members while denying them any responsibility and the freedom to express their ideas and make autonomous choices and changes. Decisions are often taken in the realm of family values rather than in the realm of the business. The ideology of paternalism is protective and dominating in a fatherly way with a strong attitude to preserve family firm's traditions and not to make changes (Fotion, 1979; Johannisson et al., 2000; Johannisson, 2002; Koiranen, 2004: 301, 305). Somehow, the organisation reflects its founder (Davis and Harveston, 1999). Some researchers refer to 'generational shadow' as the enduring effect of previous business patterns on the subsequent evolution of the family firm (see Davis and Harveston, 1999).

Koiranen (2004: 304, 305) also emphasises the concept of *entrepreneurialism* (or *entrepreneurial drive*) as the attitude to keep the business changing through initiative and innovation. In addition, Koiranen (2006) has recently pointed out that entrepreneurial drive in family business is the mindset, united effort, energy and initiative characterised by entrepreneurialism (Johannisson, 2002). The typical constituents of entrepreneurialism are sensitivity in opportunity recognition, proactiveness in opportunity seizing, industriousness (or hard-work), risk and growth (often associated), innovativeness and the pursuit of value creation (Miller, 1983; Bygrave and Minniti, 2000).
Likewise, Habbershon and Pistrui (2002) believe that an entrepreneurial behaviour based on flexibility, innovativeness, proactiveness and risk-taking is needed to achieve superior performance for a family business. In this way, the firm enhances its capabilities of developing strategies to manage change; shedding or redeploying unproductive resources (Habbershon and Pistrui, 2002); and gaining new knowledge (Gavetti and Levinthal, 2000), as shown in figure 5.

Paternalism, as opposed to entrepreneurial drive, may easily lead to inertia. Sharma et al., (2005) also analyse the relation between the family-business culture and the varying levels of inertia in family business.

Inertia is defined by Larsen and Lomi (2002) as the tendency of organisations to resist change even when it is needed to match the requirements of a changing environment. Indeed, the two authors point out that inertia negatively effects the creation of new capabilities and, consequently, the creation of dynamic capabilities. In particular, Larsen and Lomi (2002) posit that when performance fails to meet expectations, "pressure for change" (leading to "variation" and "creation of new capabilities") is needed in order to achieve the "expected performance". Obviously, inertia negatively influences "pressure for change" and, as a consequence, the "creation of new capabilities".

Family Inertia is here described as the tendency of family firms to resist change even when it is needed to match the requirements of a changing environment. It is a function of paternalism and entrepreneurial drive in family business where paternalism and entrepreneurial drive influence family inertia positively and negatively, respectively, as shown in figure 5 (Adapted from Chirico, 2006b: 45).

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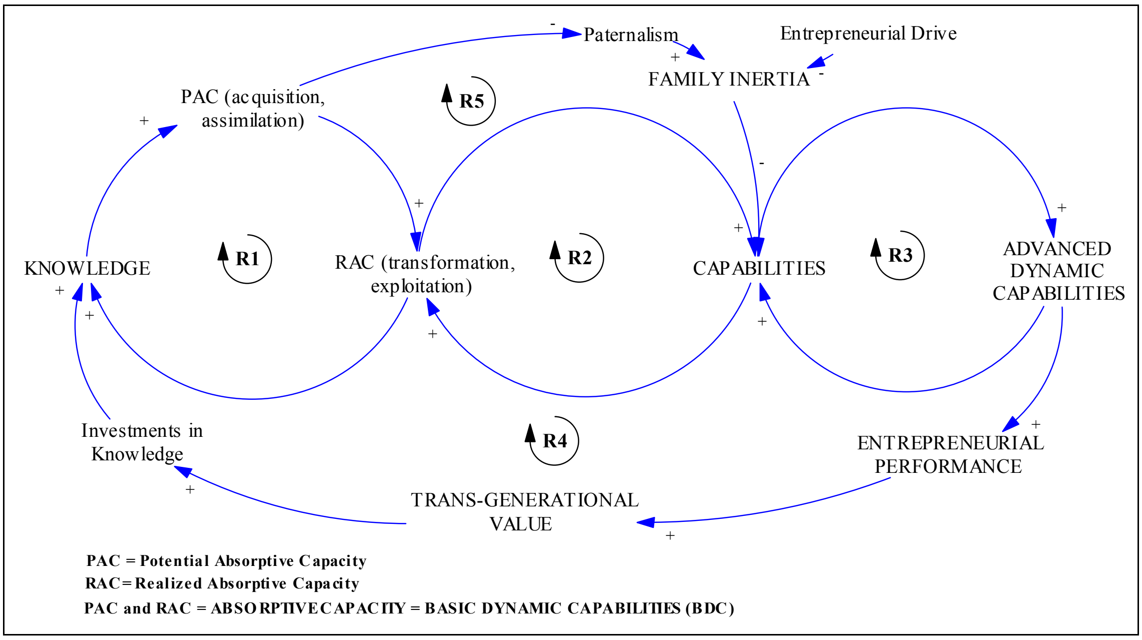
[5] "Paternalism comes from the Latin *pater*, meaning to act like a father" (Koiranen, 2004: 301).

In other words, the family firm should be able to create an 'open' and 'explicit' family-business culture, in which firm members are encouraged to express their ideas, make autonomous choices and changes so as to foster and support double-loop learning especially in changing markets. Culture should facilitate entrepreneurial change (entrepreneurial drive) rather than tend to preserve the traditional way of doing business (paternalism) (see Hall et al., 2001; Habbershon and Pistrui, 2002; Koiranen, 2004).

Finally, the FITS model (Koiranen and Chirico, 2006: 47) does not consider that learning is the antidote to inertia because it allows a firm to acquire and develop knowledge in order to enhance its capabilities for innovation. As a consequence, family inertia is negatively affected by the firm's capability to acquire and assimilate external knowledge, i.e. by the potential absorptive capacity (see Cohen and Levinthal, 1990; Robertson and Langlois, 1994; Zhara and George, 2002). In particular, external learning reduces the phenomenon of paternalism both within the family and the business. It opens up new horizons and new ways of doing business as depicted in figure 5 with the reinforcing loop 5 "R5" (see Cohen and Levinthal, 1990; Richmond, 1998; DeSouza et al., 1999; Zahra and George, 2002; Koiranen, 2004).

Figure 5: The effect of family inertia on the value creation process (R5) *



Source: Adapted from Koiranen and Chirico (2006: 47)

(*) The "+" means that the two variables move in the same direction, all other things being equal.
The "-" means that the two variables move in opposite directions, all other things being.
More details in appendix D.

3 EXPERIMENTAL DESIGN

3.1 Virtual experiments

We rely on simulation models, also described as virtual experiments (Carley, 2001; Lomi et al., 2005) in system dynamics, not as an alternative to empirical research but as a way of exploring, testing and building a new theory based on the findings, thoughts and the dynamic implications of the complex dynamic feedback structure of figure 5 (see Hanneman et al., 1995; Senge and Stermann, 1992; Larsen and Lomi, 1999; Bothner and White, 2001).

We believe that conducting theoretical and/or empirical research and, then, formalising and testing them through a series of virtual experiments can be useful to confirm or bring about radical changes in basic assumptions. Propositions and hypothesis can be interlinked and new insights may emerge to build a new theory (Morecroft and Sterman, 1992; Senge and Sterman, 1992; Oreskes et. al, 1994; Sterman, 2000; Lomi and Larsen, 1999, 2001; Davids et al., 2007, forthcoming).

Simulation is the appropriate method for analyzing our model because of its evolutionary dynamics. For instance, it is a powerful tool to explore and understand the future effects and results of actual events and decisions taking into account temporal delays. The existence of delays and feedback loops in figure 5 makes virtual experiments once more useful to represent the interdependent relations among variables studied over generations in family business.

The opportunity to make explicit assumptions enables us to study the evolution of some variables and their effects on the model as a whole. For instance, the phenomenon of paternalism in family business has never been studied dynamically in order to figure out its evolution across generations and look for new insights.

Hanneman et al., (1995: 3) posit that "we do not really know what a theory is saying about the world until we have experimented with it as a dynamic model" and Bothner and White (2001: 206) point out that "simulation models are always formulated as mechanisms for simplifying the moving parts of a social process down to it core features…and yield surprising *insights* for further exploration".

Although some researchers believe that virtual experiments do not yield reliable results because they are not accurate and realistic[6] (see Chattoe, 1998; Fine and Elsbach, 2000), the use of simulation approaches for theory development is becoming popular in the literature (Larsen and lomi, 2002; Adner, 2002; Repenning, 2002; Rivkin & Siggelkow, 2003; Zott, 2003; Lomi et al., 2005). Particularly, there are many scientific articles which shed light on some important issues related to knowledge and organizational learning (e.g., Levinthal and March, 1981; Lant and Mezias, 1990; Mezias and Eisner, 1997; Sastry, 1997).

Virtual experiments allow researchers to make assumptions explicit, control/varying variables, consider multiple chronological and historical paths over an extended period of time (in contrast, empirical studies rely on the observation of one historical path). They yield new insights into complex relationships which are not easily observable through traditional methods of analysis, sometimes because of data limitations (Mezias and Eisner, 1997).

In particular, Larsen and Lomi (1999: 407,412,413) foster researchers to use the system dynamics methodology for theory building because it provides the opportunity to formalize propositions within a more articulated theoretical framework, consider temporal delays, test their dynamic consistency, explore new ways in which the propositions can be related, and test (and develop) the theory not as a series of individual propositions but as a system of interdependent causal factors. This is exactly what it is needed to develop our theories in family business made of a series of interconnected implicit propositions conditioned by time delays, and study the long-term implications of the system which lack of empirical data. Data limitations is another important factor (see Zott, 2003; Davis et al., 2007, forthcoming) that support the use of virtual experiments in our research. We also recognize that the traditional statistical methods used in empirical research are not completely suitable to analyze our model. Indeed, statistical methods do not enable researchers to study the constructs of interest

[6] Simulation models are simplified representations of the world with some (and not all) the features of the world (Lave and March, 1975)

dynamically. Researchers are forced to examine the effects of some variables to others instantly with a clear distinction between dependent and independent variables and without considering time delays (Larsen and Lomi, 1999). In addition, statistical methods do not allow values' adjustments once the data are collected. In contrast, as explained above, virtual experiments, in particular ***system dynamics***, allow experimentation across a broad variety of conditions by merely varying the computer codes (Larsen and Lomi, 1999; 2002; Lomi et al., 2005; Davis et al, 2007, forthcoming).

3.2 System dynamics

System dynamics is an approach to modelling the dynamics of complex feedback systems through formal computer simulations and gain useful insights into situation of dynamic complexity created by interdependencies, feedbacks, time delays and nonlinearities (Sterman, 1992; Van Ackere et al., 1993; Sterman, 2000). Feedback is a core concept in system dynamics. It refers to the situation of X affecting Y and Y, in turn, affecting X through a chain of causes and effects. Causal loop diagrams are used to represent the feedbacks of a system, that is, the way a system is connected by positive (*self-reinforcing*) and negative (*self-balancing or self-correcting*) feedback loops (Forrester, 1961, 1968; Sterman, 2000). More details in Appendix D.

Feedback loops (Figures 1-5) are useful to capture and communicate mental models but they have many limitations. For instance, they do not take into consideration the stocks and flows of the system (Sterman, 2000).

System dynamics is based on the *Principle of Accumulation*. It states that all dynamic behaviours in the world occur when *flows* accumulate in *stocks* (figure 6). Stocks and flows are the basic building blocks of a system dynamics model which allow us to analyse the feedback loops of the system[7] (Forrester, 1961, 1968; Morecroft, 1982, 1983; Morecroft and Sterman, 1992; Sterman, 2000; Mollona, 2000; Lomi and Larsen, 2001).

A *stock* is an entity which is accumulated over time by inflows and depleted by outflows. It accumulates past events characterising the state of the system. A Stock typically has a certain value at each moment of time (e.g. knowledge). Mathematically, a stock (S) can be seen as an integration (accumulation) of the difference between inflow and outflow (F) in the long term:

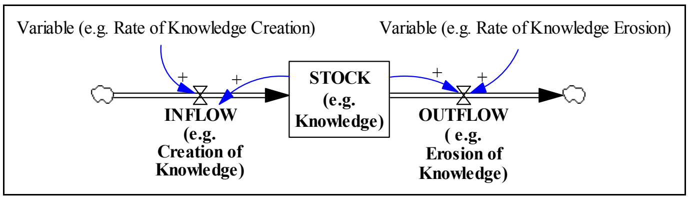
$$S_t = \int_{t0}^{t} \left[Inflow(t) - Outflow(t) \right] dt + S(t_0)$$

A *flow* changes a stock over time by inflows (e.g. creation of knowledge) and outflows (e.g. erosion of knowledge). It is typically measured over a certain interval of time. Mathematically, a flow (F) can be seen as the derivative of the stock (S) with respect to the time (t) that is its net rate of change:

$$F = inflow - outflow; \; F = \frac{dS}{dt}$$

[7] A series of constant and auxiliary variables are also needed to simulate the model of the system.

Figure 6: Stocks and Flows[8]



Stocks are the source of delays. A *delay* is the amount of time by which an event is retarded. It is the time between the instant at which a given event occurs and the instant at which a related aspect of that event occurs (e.g. time between the creation and absorption of knowledge). Delays are responsible for generating effects which are very often nonlinear and counter-intuitive in the real world (Sterman, 2000).
The system dynamics methodology follows three steps: taking into consideration a *system* which exists and operates in time and space; *model* the system (a model is a simplified representation of a system at some particular point in time or space intended to promote understanding of the real system); and *simulate* the model (a simulation is the iteration of a model in such a way that it operates on time or space to compress it, thus enabling one to perceive the interactions that would not otherwise be apparent because of their separation in time or space).

3.3 Numerical values, graphic functions and assumptions

To run the model and make the simulations, it was necessary to assign numerical values to all parameters, initial values to stocks and proper shapes to graphic functions according to the literature and case studies analysed by Koiranen and Chirico (2006). Assumptions were also needed when the theory did not provide enough information for the simulation.
Because the model presented is a model of a theory (second-order model) based on few case studies (Koiranen and Chirico, 2006), we could not rely on statistical data. In spite of that, numerical values were not chosen randomly but were always calibrated to be consistent across the model (Larsen and Lomi, 1999, 2002; Lomi et al., 2005). Whenever possible, numerical values were based on empirical research in order to test the robustness of our model to assumptions' changes and to calibrate the parameters used (see Forrester and Senge, 1980; Barlas, 1996). For instance, the graphic function used for modelling the 'evolution of the rate of knowledge creation through investments in knowledge' and the consequent effect of 'investments in knowledge on knowledge creation' is based on the empirical research carried out by Argote (1999).
Sterman (1992: 10) points out that "the skilled modeller uses all available information sources to specify the relationships in the model (numerical data, interviews, direct observation and other techniques)".
To make simulations simpler, graphic functions were built through linear relations. This kind of representation through "graphic converters" (graphic functions), which specify the functional relationship between two variables, allowed us to easily test specific aspects of our dynamic model and analyse possible implications derived by variations (adjustments) in the graphic function(s) (Larsen and Lomi, 1999, 2002; Lomi et al., 2005).

[8] Sterman (2000:192) explains that "- Stocks are represented by rectangles; - Inflows by a pipe pointing into (adding to) the stock; - Outflows by a pipe pointing out (subtracting from) the stock; - Valves (at the center of flows) control the flows; - Clouds (at the extremities) represent the sources and sinks for the flows (boundaries)".

More details are presented in Appendices A, B and C. The set of numerical values given to parameters, initial variables and graphic converters' shapes are one of the possible values that assure dimensional consistency criteria. We performed a huge amount of experiments and calibrations in order to explore completely the model behaviours (Forrester and Senge, 1980). Through these it became possible to realize that by changing numerical values in our model only has scaling implications and does not significantly alter the results of the virtual experiments.
We have also performed some extreme-conditions tests in order to evaluate the validity of our model under extreme conditions (see Forrester and Senge, 1980; Barlas, 1996). For instance, setting to zero all the stocks of the basic model and considering the level of knowledge equal to 0 over time, virtual experiments show what would happen in a similar condition in real life, i.e., the business cannot be started. Instead, if we assume that knowledge and absorptive capacity are equal to zero over time, the experiments suggest the expected failure of the business during the first generation after an initial period of activity, similar to the honeymoon effect described by Fichman and Levinthal (1991). Indeed, Fichman and Levinthal, (1991) point out that the initial endowments including beliefs, trust, goodwill, financial resources, or psychological commitment shield the firm at the beginning of the activity from the risks of failure (but problems comes after this period if knowledge is not built). Instead, if we consider that a percentage of knowledge is accumulated over time, this enables the firm to start-up the business and creates value over generations (more details available from authors). During the simulations, we have always kept in mind that experiments do not predict the future but just provide consistent stories about the future (Morecroft and Sterman 1994: 17-18).

We use Vensim PLE for Windows, Version 5.4d for the computer simulation. The settings of the software are reported in Appendix E.

4 MODEL STRUCTURE

4.1 From Feedback loops to dynamic models

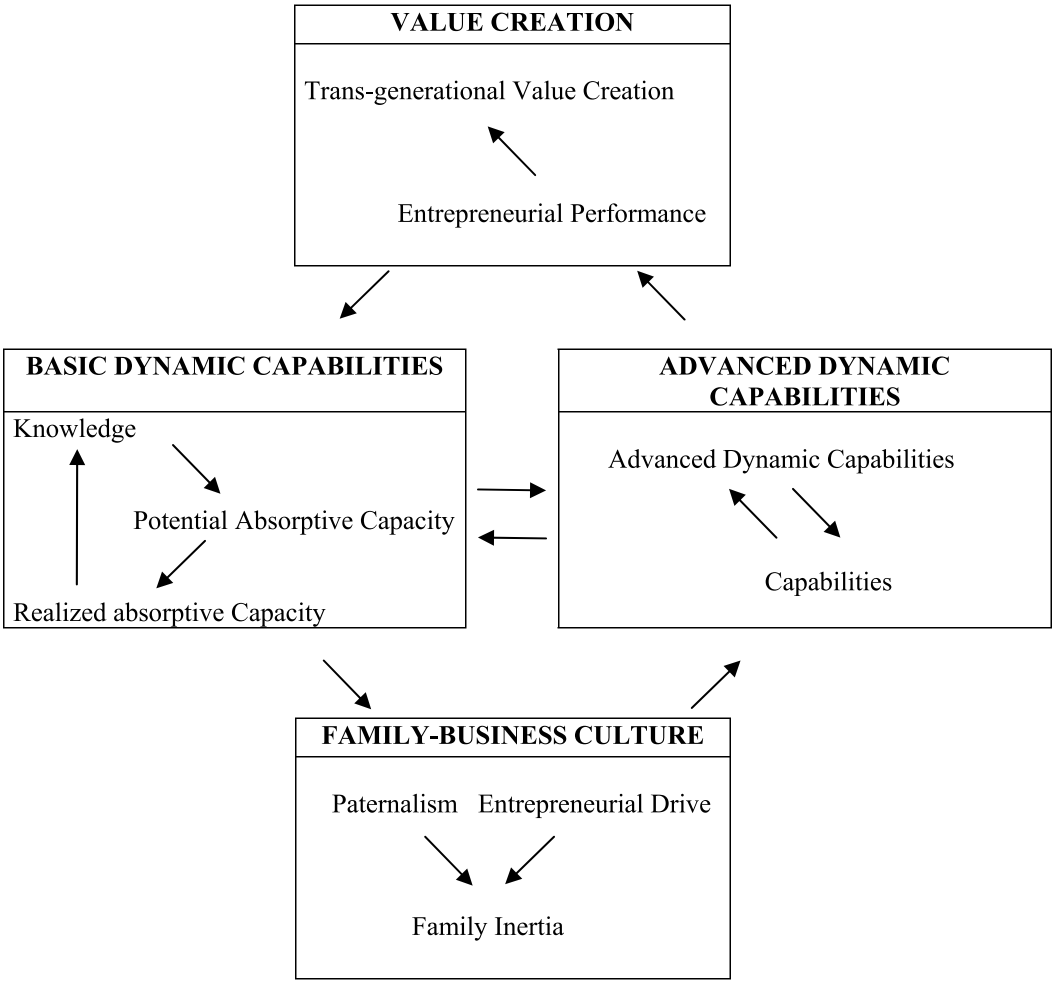
The feedback loops representation in figure 5 for value creation in family firms shows the reciprocal relations between key variables to success in family business with five reinforcing loops (**R**).
The first feedback loop (R1) specifies the relation between knowledge and basic dynamic capabilities (PAC and RAC). The second one (R2) identifies the relation between RAC and capabilities. The third feedback loop (R3) shows the relation between capabilities and advanced dynamic capabilities. The fourth one (R4) indicates the entire complex dynamic process from knowledge to trans-generational value creation, and back to knowledge through investments in knowledge. The fifth feedback loop (R5) underlines the negative effect of family inertia on the creation of new (dynamic) capabilities and the negative effect of PAC on the phenomenon of paternalism in family firms.

The model is composed of four interconnected macro-structures as shown in figure 7. According to the theory presented, the interaction between *basic and advanced dynamic capabilities* allow a firm to achieve entrepreneurial performance and *create value* in environments of rapid change, which in turn affect the basic dynamic capabilities structure positively. The process to convert dynamic capabilities into value creation is slowed down (or accelerated) by the effect of the *family-business culture* (paternalism vs. entrepreneurial drive) on advanced dynamic capabilities and, as a consequence, on the model as a whole. To make the model simpler, entrepreneurial drive will not be included in the simulation model and it will be assumed as a negative function of paternalism (see Koiranen, 2004; Chirico, 2006b).

After this general overview, it is now possible to represent the micro-structures of the model, trying to develop the same strategy used by Larsen and Lomi (2002: 279): "Our strategy is to keep notation as much as possible intuitive with the development of a minimal amount of formalism".

To understand all dynamic implications of the model, feedback loops will be translated into a system of equations (i.e. a system of inter-correlated propositions) rather than a series of different propositions. Variables will be represented as stocks/flows and measured in dimensionless units (see Sastry, 1997; Larsen and Lomi, 1999).

Figure 7: Macro-structures of the model



The micro-structures of the model present specific assumptions and delays, as follows:

4.2 Basic dynamic capabilities structure

Representing knowledge (K). As figure 8 illustrates, knowledge is represented as a stock which means that knowledge can be accumulated (or depleted) over time. It integrates the difference between increase (new knowledge "NK") and decrease (erosion of knowledge "EK") in knowledge.

$$Kt = \int_{t0}^{t} \left[NK(s) - EK(s)\right] ds + K(t0)$$

While we assume that **erosion of knowlede (EK)** is affected by a natural annual rate of knowledge erosion "α" (*EKt* = *Kt* * α), **new knowledge (NK)** is positively affected by an amount of possible overall knowledge which may be generated (OKG) on the basis of several parameters as pointed out by Chirico, 2006a (e.g., academic courses and practical training courses, working outside the family firm, employing/using talented non-family members and so on). We assume that a unit of knowledge may be generated per year (OKG) which depends on the effect of absorptive capacity (EAC) and the effect of investments in knowledge (EIK) on the creation of new knowledge (Erik Larsen, personal Communication, 2006; see Cohen and Levinthal, 1990; Lansberg and Astrachan, 1994; Nonaka and Takeuchi, 1995; Kaye, 1999; Zahra and George, 2002).

*NKt = OKG * (EACt + EIKt)*

To represent EAC, is specified a linear functional relation (graphic function as described in Appendix A.*a*) between knowledge acquisition through realised absorptive capacity (KA) and realised absorptive capacity (RAC) in which:

Min(KA) if RACt=0 *(there is no RAC but the firm is still able to acquire some knowledge from outside "Min(KA)")*

KA = …

Max(KA) if RACt=1 *(RAC is very high and consequently KA is very high, as well)*

EACt= KA (time)

where KA is a function that specifies the effect of absorptive capacity on the increase in new knowledge over time.

EIK is equal to investments in knowledge (IK) multiplied by the evolution of the rate of knowledge creation through investments in knowledge over time (ERKC).

*EIKt = IKt * ERKCt*

To represent ERKC, is specified a linear functional relation (graphic function as described in Appendix A.*b*) between rate of knowledge creation through investments in knowledge (RKC) and time, in which RKC decreases as time passes according to Argote's view (1999). RKC also declines because values, beliefs, traditions and commitment in family business tend to decrease as time passes, particularly after the second generation as pointed out by Astrachan et al., (2002).

Max(RKC) when time=0 years (RKC is very high at the beginning of the first generation)

RKC = …

Min(RKC) when time=90 years (RKC is very low at the end of the third generation)

ERKCt = RKC (time)

where RKC is a function that specifies the evolution of the rate of knowledge creation through investments in knowledge over time.

Representing outside industry knowledge to discover (INKD). Outside industry knowledge to discover is the total outside industry knowledge which has not been discovered yet. It is formulated as a stock that integrates the corresponding net flow, i.e. the difference between increase (outside industry inventions "INI") and decrease (outside new industry knowledge "NINK") in outside industry knowledge to discover.

$$INKDt = \int_{t0}^{t} [INI(s) - NINK(s)]ds + INKD(t0)$$

Outside industry inventions (INI) refer to outside fundamental base inventions which are as of yet, not well explained. They still have to be discovered in order to be exploited. INI are modelled through a random function which generates inventions randomly because they cannot be predicted.

INIt = IF THEN ELSE (RANDOM UNIFORM (0, 1, 99632)>0.98,4,0)

Outside new industry knowledge (NINK) is the outside industry knowledge which has been invented, explained and can be exploited. It is affected by a fixed annual discovery rate (β).

$NINKt = INKDt / \beta$

Representing outside industry knowledge (INK). Outside industry knowledge is the total industry knowledge which exists outside the family firm. It is represented as a stock that accumulates over time from outside new industry knowledge (NINK).

$$INKt = \int_{t0}^{t} [NINK(s)]ds + INK(t0)$$

Therefore, as plotted in figure 8, NINK is the outflow of INKD and the inflow of INK (Erik Larsen, 2006. Personal Communication).

Representing potential absorptive capacity (PAC). PAC is a complex construct, presented in the theory as the firm's capacity to acquire and assimilate external knowledge (Zahra and George, 2002). We model it as a stock that integrates the change in PAC (Ch PAC) as depicted in figure 8.

$$PACt = \int_{t0}^{t} [ChPAC(s)]ds + PAC(t0)$$

According to the literature (Bower and Hilgard, 1981; Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Zahra and George, 2002), **Change in PAC (Ch PAC)** depends on the relative knowledge (RK) of the family firm, that is, the percentage of the outside industry knowledge (INK) possessed by the family firm. RK is equal to the knowledge of the family firm (K) divided by the total industry knowledge outside the family firm (INK).

$RKt = Kt / INKt$

PAC is calculated with a first order exponential smoothing of the observed value of RK (information delay from RK to PAC, i.e. the amount of time needed to convert RK into PAC), whose formulation is similar to an adaptive expectations mechanism (Forrester, 1961; Larsen and Lomi, 1999; Sterman, 2000; Mollona, 2000; Lomi, Larsen and Freeman, 2005).

Forrester (1961: 407,408) posits that "smoothing is a process of taking a series of past information values and attempting to form and estimate of the present value of the underlying significant content of the data. In particular, the exponential smoothing gives the greatest weight to the most recent value and attaches progressively less significance to older information".
In this respect, Sterman (2000) explains exponential smoothing with the concept of adaptive expectations. Sterman (2000: 428,429) argues that "adaptive expectations mean the perceived or expected value (belief) gradually adjusts to the actual value of the variable. The expected value changes when it is in error, that is, when the actual value differs from the expected value of the variable. The state of the system adjusts (with an adjustment time, i.e. delay) in response to the gap between expected value and actual value".

According to Forrester (1961) and Sterman (2000), change in PAC is given by:

Ch PACt = (RKt – PACt)/ Delay PAC

where PAC is the expected value (or average); RK is the actual value; delay PAC is the information delay (time to average).
In other words, this process assumes that the gap between RK (actual value) and PAC (expected value) closes only gradually causing delays.

Representing realised absorptive capacity (RAC). RAC is the second complex construct of absorptive capacity, defined as the firm's capacity to transform and exploit the knowledge that has been absorbed (Zahra and George, 2002). We formulate it as a stock that integrates the change in RAC (Ch RAC) as shown in figure 8.

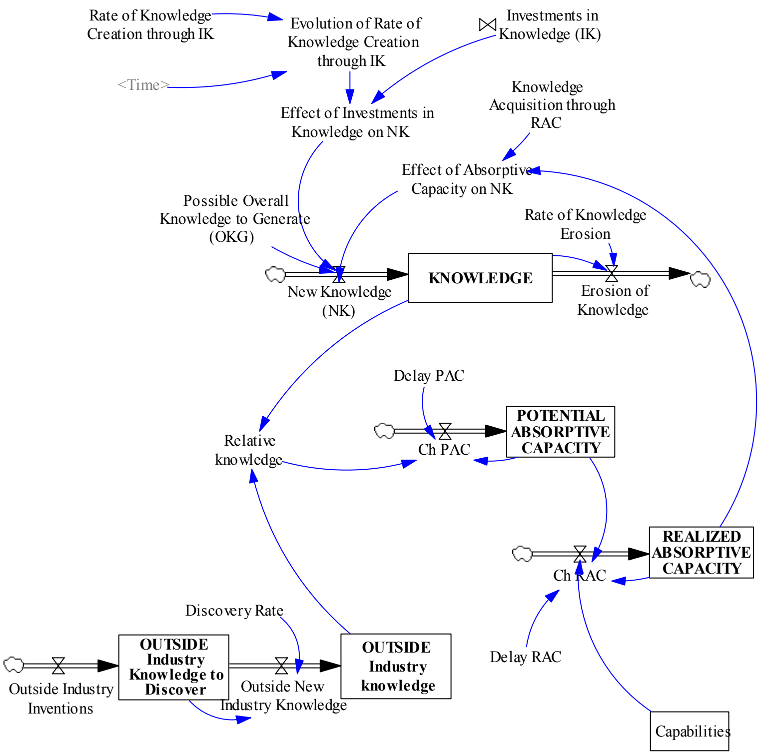
$$RACt = \int_{t0}^{t} [ChRAC(s)]ds + RAC(t0)$$

Based on the literature, **Change in RAC (Ch PAC)** depends on the PAC and the capabilities of the firm (see Collis, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Zhara and George, 2002; Habbershon and Pistrui, 2002; Winter, 2003). As before, RAC is calculated with a first order exponential smoothing (information delay from PAC to RAC) of the observed value of PAC, as follows:

*Ch RACt = [(PACt – PACt)/ Delay RAC]*Ct*

where RAC is the expected value; PAC is the actual value; delay RAC is the information delay.

Figure 8: Graphic details of the basic dynamic capabilities structure



4.3 Advanced dynamic capabilities structure

Representing capabilities (C). As plotted in figure 9, capabilities accumulate over time from realized absorptive capacity (RAC) and advanced dynamic capabilities (ADC), but are also lost during the business life (Collis, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Zhara and George, 2002; Habbershon and Pistrui, 2002; Winter, 2003). This can be formulated as a stock that can both increase or decrease depending on the dynamics of the two related flows (new capabilities "NC" and erosion of capabilities "EC").

$$Ct = \int_{t0}^{t} [NC(s) - EC(s)]ds + C(t0)$$

While we assume that **erosion of capabilities (EC)** depends on an annual rate of capabilities erosion "γ" (*ECt = Ct * γ*), **new capabilities (NC)** are positively influenced by RAC (Grant, 1996a; Lane and Lubatkin, 1998, Kusunoki et al., 1998; Zahra and George, 2002) and ADC (Collis, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Zhara and George, 2002; Habbershon and Pistrui, 2002; Winter, 2003), but they are also negatively affected by family inertia (FI) as argued by Larsen and Lomi (2002) and Chirico (2006b). C is calculated with a first order exponential smoothing (information delay from RAC to C) of the observed value of RAC, as follows:

*NCt = {[(RACt – Ct)/Delay C] * ADCt}/FIt*

where C is the expected value; RAC is the actual value; delay C is the information delay.

Representing advanced dynamic capabilities (ADC). Advanced dynamic capabilities are modelled (see figure 9) as a stock that integrates the difference between increase (new ADC "NADC") and decrease (erosion of ADC "EADC") in advanced dynamic capabilities.

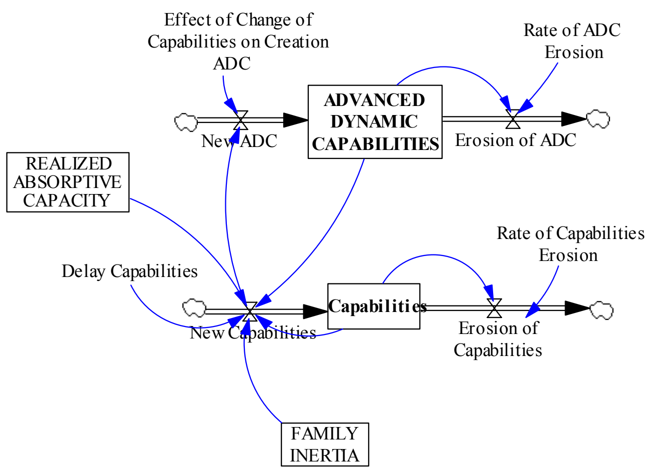
$$ADCt = \int_{t0}^{t} \left[NADC(s) - EADC(s)\right] ds + ADC(t0)$$

New ADC (NADC) are positively affected by new capabilities (Collis, 1994, Winter, 2004) which depend on 'the effect of change of capabilities on the creation of new ADC'(δ) but they are also **eroded (EADC)** over time at a rate of ADC erosion (ε).

NADCt= NCt * δ
EADCt = ADCt * ε

The positive correlation between dynamic capabilities and capabilities (Collis, 1994, Winter, 2004) is evident in the model structure (see figure 9): NC influence the creation of NADC and the stock ADC influences the creation of NC.

Figure 9: Graphic details of the advanced dynamic capabilities structure



4.4 Value creation structure

Representing entrepreneurial performance (EP). Entrepreneurial performance, as a stock, may increase or decrease over time as depicted in figure 10. It integrates the related net flow, i.e. the difference between increase (creation of EP "CEP") and decrease (erosion of EP "EEP") in entrepreneurial performance.

$$EPt = \int_{t0}^{t} \left[CEP(s) - EEP(s)\right] ds + EP(t0)$$

While it is assumed that **erosion of EP (EEP)** is influenced by an annual rate of EP erosion (η), **creation of EP (CEP)** is affected by ADC (Teece, Pisano and Shuen, 1997; Eisenhardt and Martin, 2000; Habbershon and Pistrui, 2002; Salvato and Melin, 2003; Salvato, 2006; Chirico, 2006b, 2007) at an annual rate of entrepreneurial performance creation (ζ). A delay between the creation of ADC and the creation of EP (delay EP) is taken into consideration in the virtual experiment.

*CEPt = (ADC * ζ)/Delay EP*

$EEPt = EPt * \eta$

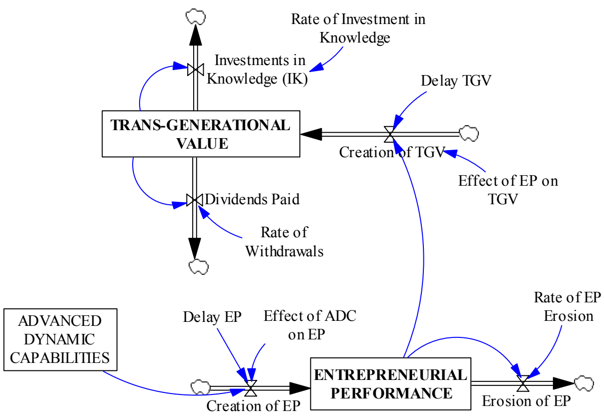
Representing trans-generational value (TGV). Trans-generational value is accumulated over time from entrepreneurial performance (EP) and depleted from dividends paid to family-business members (DP) and investments in knowledge (IK). TGV is modelled in figure 10 as a stock that integrates the difference between increase (creation of TGV "CTGV") and decrease (dividends paid "DP" and investments in knowledge "IK") in trans-generational value.

$$TGVt = \int_{t0}^{t} [CTGV(s) - DP(s) - IK(s)]ds + TGV(t0)$$

Creation of TGV (CTGV) is positively affected by EP (Lei et al., 1996; Floyd and Lane, 2000; Zahra and George, 2002) at an annual rate of TGV creation (θ). A delay between the creation of EP and the creation of TGV (delay TGV) is taken into consideration in the virtual experiment. **Dividends paid (DP)** and **investments in knowledge (IK)** are influenced by a rate of withdrawals (ι) and a rate of investments in Knowledge (κ), respectively.

$CTGVt = (EPt * \theta)/Delay\ TGV$
$DPt = TGVt * \iota$
$IKt = TGVt * \kappa$

Figure 10: Graphic details of the value creation structure



4.5 Family-business culture structure

Representing family inertia (FI). As plotted in figure 11, family inertia is formulated as a stock that integrates the change in family inertia (Ch FI).

$$FIt = \int_{t0}^{t} [ChFI(s)]ds + FI(t0)$$

According to Chirico, 2006b, Ch FI depends on the family-business culture, in particular on the effect of paternalism on family inertia (EPFI). This is mediated by the firm's capacity to acquire and assimilate external knowledge "PAC" (Cohen and Levinthal, 1990; Robertson and Langlois, 1994; Richmond, 1998; DeSouza et al., 1999; Koiranen, 2004). FI is calculated with a first order exponential smoothing (information delay from EPFI to FI) of the observed value of EPFI, as follows:

*Ch FIt = [(EPFIt – FIt)/Delay FIt)]*PAC*

where FI is the expected value; EPFI is the actual value; delay FI is the information delay.
To represent EPFI, it is specified a functional relation (graphic functions, as described in Appendix B) between paternalism (P) and time, considering four scenarios. The first scenario does not consider paternalism in the simulation, whereas the other three scenarios take into account three different evolutions of paternalism over three generations:

- **Scenario 1**: Basic case without paternalism.

- **Scenario 2**: Paternalism decreases over time (Appendix B.*a*).

$EPFIt_2 = P_2(time)$

where P_2 is a function that specifies the effect of paternalism on family inertia over time in scenario 2 (P decreases ➔ FI decreases).

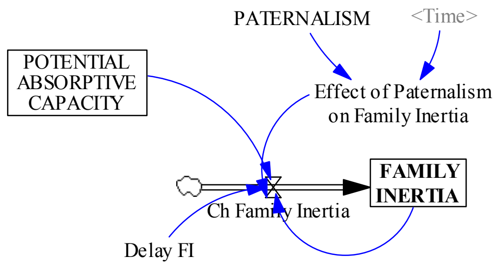
- **Scenario 3**: Paternalism increases over time (Appendix B.*b*).

$EPFIt_3 = P_3(time)$

where P_3 is a function that specifies the effect of paternalism on family inertia over time in scenario 3 (P increases ➔ FI increases).

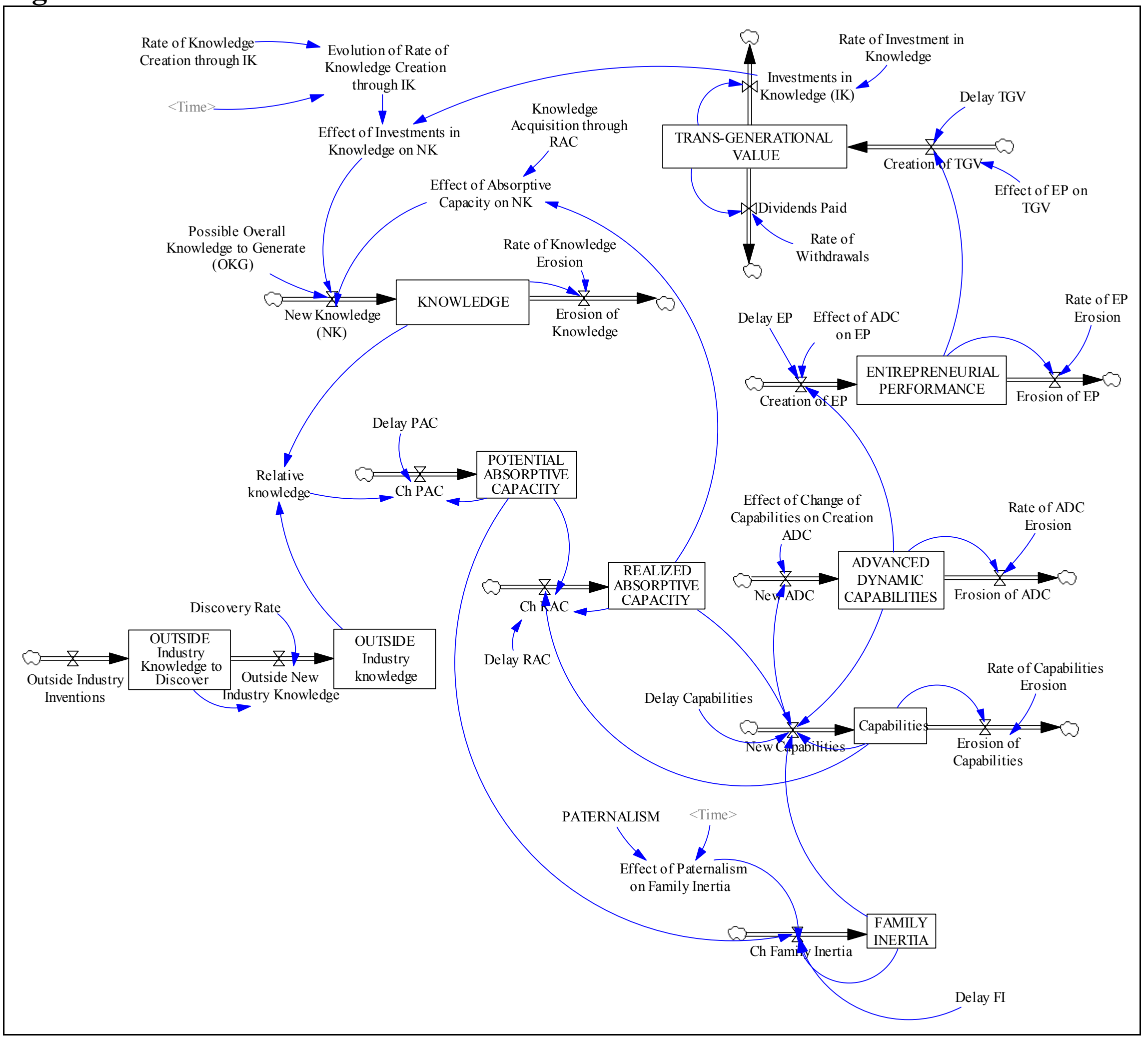
- **Scenario 4**: Paternalism fluctuates over time (Appendix B.*c*,*d*,*e*). Details in the next paragraph.

Figure 11: Graphic details of the family-business culture structure



The entire model, composed of the four micro-structures examined above, is depicted in figure 12. The model will be simulated and its behaviour analysed below.

Figure 12: The entire model



Erik Larsen, 2006. Personal Communication

5 RESULTS AND NEW INSIGHTS

We have considered four different scenarios describing the evolution of paternalism over three generations in family business and the consequent effects on the model as a whole. Figures, which will be presented from now on, can be interpreted in a relative sense because variables are measured in dimensionless units (see Sastry, 1997; Larsen and Lomi, 1999).

Figure 17 illustrates the simulation results of the model over three generations (90 years; each generation lasts 30 years) of a generic family firm with regards to scenario 1, scenario 2 and scenario 3.
The simulation results support the FITS model (Koiranen and Chirico, 2006: 47) of value creation in family business which denotes that is predicted the behaviour of the original theories (see Forrester and Senge, 1980) though with some exceptions when the family-business culture structure is introduced in the basic case model of scenario 1.
How rapidly (or slowly) the process depicted in figure 5 converts knowledge into value creation strongly depends on the family-business culture, in particular the effect of family inertia on the creation of (dynamic) capabilities.

Scenario 1: *Basic case without paternalism*. As it was expected from the original theories, if knowledge (K) increases over three generations, basic dynamic capabilities (BDC: PAC and RAC), capabilities (C), advanced dynamic capabilities (ADC), entrepreneurial performance (EP) and trans-generational value (TGV) also increase through dynamic reinforcing loops (figure 17).
In particular, capabilities and dynamic capabilities (PAC, RAC and ADC) increase at a slower rate in the third generation, i.e. about from the 60th to 90th year(see also scenario 2 and 3). This can be clearly explained through the family-business literature which stresses the fact that generally values, beliefs, traditions, commitment and psychological ownership[9] of family members over the family firm tend to decrease after the second generation so as to negatively influencing the creation of capabilities within the business (see e.g. Astrachan et al., 2002).

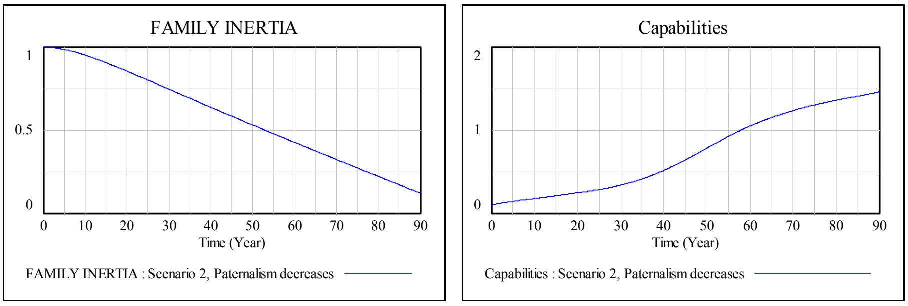
Interesting results emerge when family inertia (as a function of paternalism) is included in the model.

Scenario 2, scenario 3 (figure 17) and Appendix B show the simulation results concerning the effect of paternalism on family inertia (EPFI) and the consequent effects on the entire model.

Scenario 2: *Paternalism decreases over time.* As paternalism decreases, family inertia decreases, as well. Consequently, the creation of capabilities increases (see figure 13) and a positive effect drives all the variables of the model (figure 17, Appendix B.*a*).
Results are similar to the first simulation (scenario 1) but values become higher due to the decrease in family inertia and diverge during the second and third generation.
For instance, the maximum value of knowledge at the end of the third generation is equal to 36.93 in scenario 1 and it is equal to 39.37 in scenario 2. The maximum value of trans-generational value at the end of the third generation is equal to 2.07 in scenario 1 and it is equal to 2.66 in scenario 2 (figure 17).

[9] *Psychological ownership* is the psychologically experienced-phenomenon where owners, managers and employees develop possessive feelings that the family firm is “mine” or “ours”. For instance, strength of identifying oneself with the family business, sense of belonging to the family business, strong feeling of responsibility towards the family business and so on (Koiranen, 2006: adopted from Pierce et al., 2003).

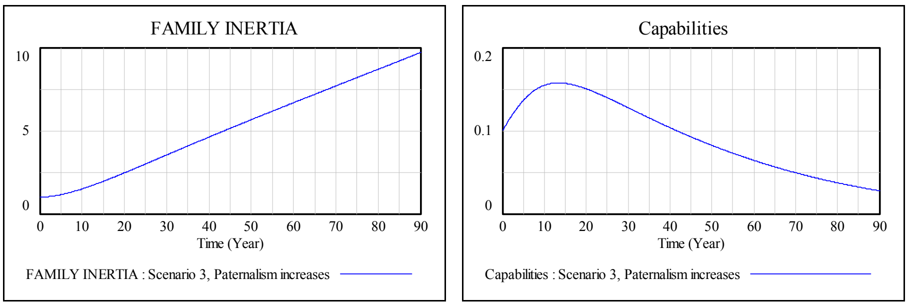
Figure 13: Effect of family inertia on capabilities in scenario 2



Scenario 3: *Paternalism increases over time.* As paternalism increases, family inertia increases, as well. Consequently, the creation of capabilities decreases (see figure 14) and negatively influences the variables of the model (figure 17, Appendix B.*b*).
The negative effect can be clearly observed for C, ADC, EP and TGV; whereas, K, PAC and RAC increase but their values become lower compared to the simulations made before and completely diverge during the third generation when usually problems arise in family business (see Astrachan et al., 2002).
Results are consistent with the literature that stresses how critical the third generation is to family firms and how issues may be amplified during this generation (see Aronoff and Ward, 2001, Astrachan et al., 2002; Colombo, Koiranen and Chirico, 2006).
For example, the maximum value of knowledge at the end of the third generation is equal to 36.93 in scenario 1; it is equal to 39.37 in scenario 2; and it is equal to 25.69 in scenario 3 (figure 17).

A new *insight* emerges from the simulation of scenario 3. In fact, unexpectedly the creation of capabilities is not negatively influenced by the increase in family inertia at the beginning of the activity for about 10 years (see figure 14). Consequently, a positive effect drives advanced dynamic capabilities for the same period and the effect is even bigger for entrepreneurial performance and trans-generational value which keep on increasing during the first generation (see figure 17).

Figure 14: Effect of family inertia on capabilities in scenario 3



This behaviour / phenomenon can be explained going back to the definition of family inertia and the meaning of paternalism:

Family inertia is defined as the tendency of family firms to resist change even when it is needed to match the requirements of a changing environment. It is a function of paternalism which affects family inertia negatively. The ideology of paternalism is *protective and dominating in a fatherly way with a strong attitude of wanting to preserve a family firm's traditions and not to make changes.*

But at the beginning of the activity a paternalistic behaviour may be seen to some extent as being positive as it guides and trains the new generation. Problems (caused by FI) arise if such paternalistic behaviour persists over time especially when the two generations work actively together as shown in figure 17 (from the 10th year). To explain better such an effect, we refer to the article of Giddings (2003). He posits that the founder of a family firm often wants to run things his way. He is a paternalistic person but this is good at the beginning of the family firm when a mentor/leader is needed. Indeed, offspring must be guided and trained. But as time passes, a dominating and autocratic climate might predominate and make working conditions difficult for offspring, to express their ideas, to make autonomous choices and to make changes in the business for the good of the business (Giddings, 2003; Koiranen 2003; Chirico, 2006b). In other words, the paternalistic behaviour which was essential at the beginning of the activity may become less crucial if it persists over time preventing change even when it is needed. As a consequence, the effect of paternalism on family inertia becomes higher after an initial period and negatively influences the creation of capabilities and dynamic capabilities (Larsen and Lomi, 2002; Collis, 1994; Sharma et al., 2005; Chirico, 2006b). This produces a negative effect on all the other variables of the model (figure 17).

From the results gathered from scenario 3, we can consider new scenarios where paternalism fluctuates over time (scenarios $4_{.1}$, $4_{.2}$, $4_{.3}$).

Scenario 4: *Paternalism fluctuates over time.* Paternalism does not affect much family inertia not just at the start-up of the firm but at the beginning of each generation for a certain period (τ). Then, this effect rises up to a peak and falls down again with the following generation. Indeed, the effect of paternalism on family inertia declines as a kind of resetting clock at the beginning of each generation in which the behaviour described above recurs every generation. The beginning of the new generation and the complete end of the previous one (which might represent a dramatic change in the business), can be thought of as "resetting the clock" similarly to the resetting clock used by Amburgey et al., (1993) in describing the dynamics of organisational change and failure.

As before, to represent the effect of paternalism on family inertia (EPFI), it is specified a functional relation (graphic function, as described in Appendix B.*c*) between paternalism (P) and time. It is assumed that τ is equal to 10 years (Scenario $4_{.1}$):

(τ) = 10 years

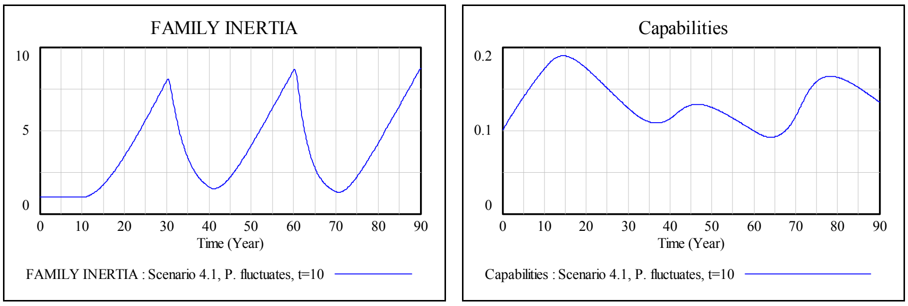
$EPFI_{4.1} = P_{4.1}\ (time)$

where $P_{4.1}$ is a function that specifies the effect of paternalism on family inertia over time in scenario $4_{.1}$ with τ= 10 (P fluctuates ➔ FI fluctuates).

The virtual experiments depicted in figure 18 and Appendix B.*c* show that, as expected when paternalism does not have much affect on family inertia at the beginning of each generation for about 10 years, C (see figure 15), ADC, EP and TGV keep on increasing.

After that when the effect of paternalism on family inertia starts rising up to a peak while the two generations work actively together, C (see figure 15), ADC, EP and TGV are negatively influenced.

Figure 15: Effect of family inertia on capabilities in scenario $4_{.1}$



The increase in entrepreneurial performance and trans-generational value is very high during the first generation for about 25-30 years and then stabilises in the second and third generation, even though capabilities and advanced dynamic capabilities go up and down because of the effect of family inertia (figure 18).

Results become more significant with the assumption that paternalism does not affect much family inertia at the beginning of each generation for a longer period (i.e. τ =15 in scenario $4_{.2}$ and τ = 20 in scenario $4_{.3}$; see figure 18 and Appendix B.*d*,*e*):

<u>(τ) = 15 years</u>

$EPFI_{4.2} = P_{4.2}\ (time)$

where $P_{4.2}$ is a function that specifies the effect of paternalism on family inertia over time in scenario $4_{.2}$ with τ = 15 (P fluctuates ➔ FI fluctuates).

and

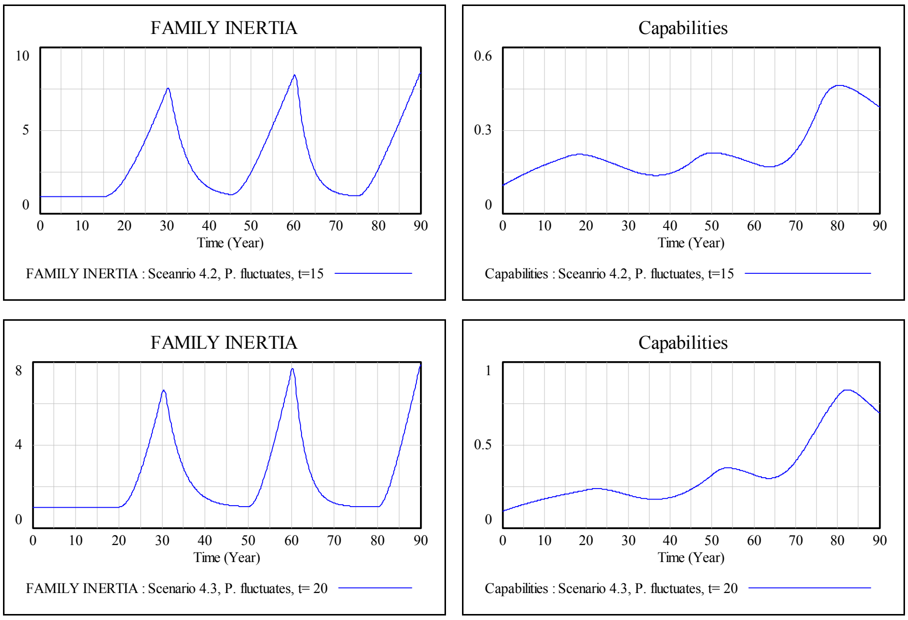
<u>(τ) = 20 years</u>

$EPFI_{4.3} = P_{4.3}\ (time)$

where $P_{4.3}$ is a function that specifies the effect of paternalism on family inertia over time in scenario $4_{.3}$ with τ = 20 (P fluctuates ➔ FI fluctuates).

As plotted in figure 18 when paternalism does not affect much family inertia at the beginning of each generation for a longer period, the family firm is able to better react to the period in which the effect of paternalism on family inertia increases. Indeed, in contrast with scenario $4_{.1}$, in scenario $4_{.2}$ and $4_{.3}$, C (see figure 16), ADC, EP and TGV increase over time, though with some fluctuations.
For instance, the level of capabilities increase over time in scenario $4_{.2}$ when τ is equal to 15, compared to scenario $4_{.1}$ when τ is equal to 10. It increases even more in scenario $4_{.3}$ when τ is equal to 20 (figure 15 and 16).

Figure 16: Effect of family inertia on capabilities in scenario 4.2 and 4.3



K, PAC and RAC keep on increasing following the same path during the first and the second generation in scenario 4.1, 4.2 and 4.3 and diverge during the third generation when generally family-business issues are amplified, as mentioned earlier (see Aronoff and Ward, 2001, Astrachan et al., 2002; Colombo, Koiranen and Chirico, 2006). For instance, at the end of the third generation the maximum value of knowledge is equal to 28.18 in scenario 4.1; it is equal to 31 in scenario 4.2; and it is equal to 32.96 in scenario 4.3 (figure 18).

In other words, the longer is the period in which paternalism at the beginning of each generation does not effect much family inertia (τ), the higher and faster is the increase of all the variables represented in the model (see figure 18). This is because the family firm is able to better react to the period in which the effect of paternalism on family inertia increases**.** For example, at the end of the third generation the maximum value of TGV is 0.33 when "τ" is equal to 10 (scenario 4.1); it is 0.71 when "τ" is equal to 15 (scenario 4.2); and it is 1.18 when "τ" is equal to 20 (scenario 4.3).

Figure 17: Virtual experiments in Scenario 1, 2 and 3

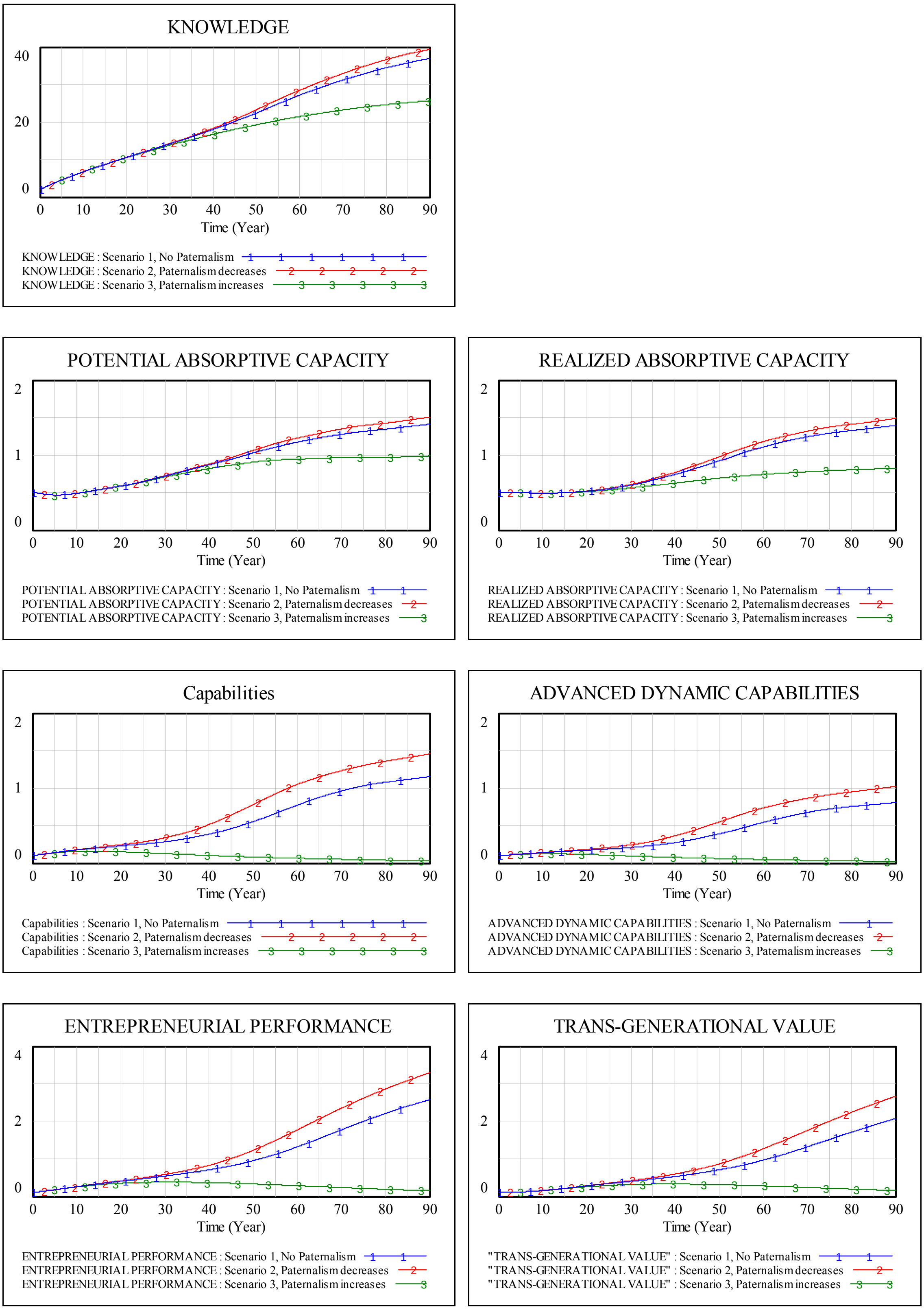
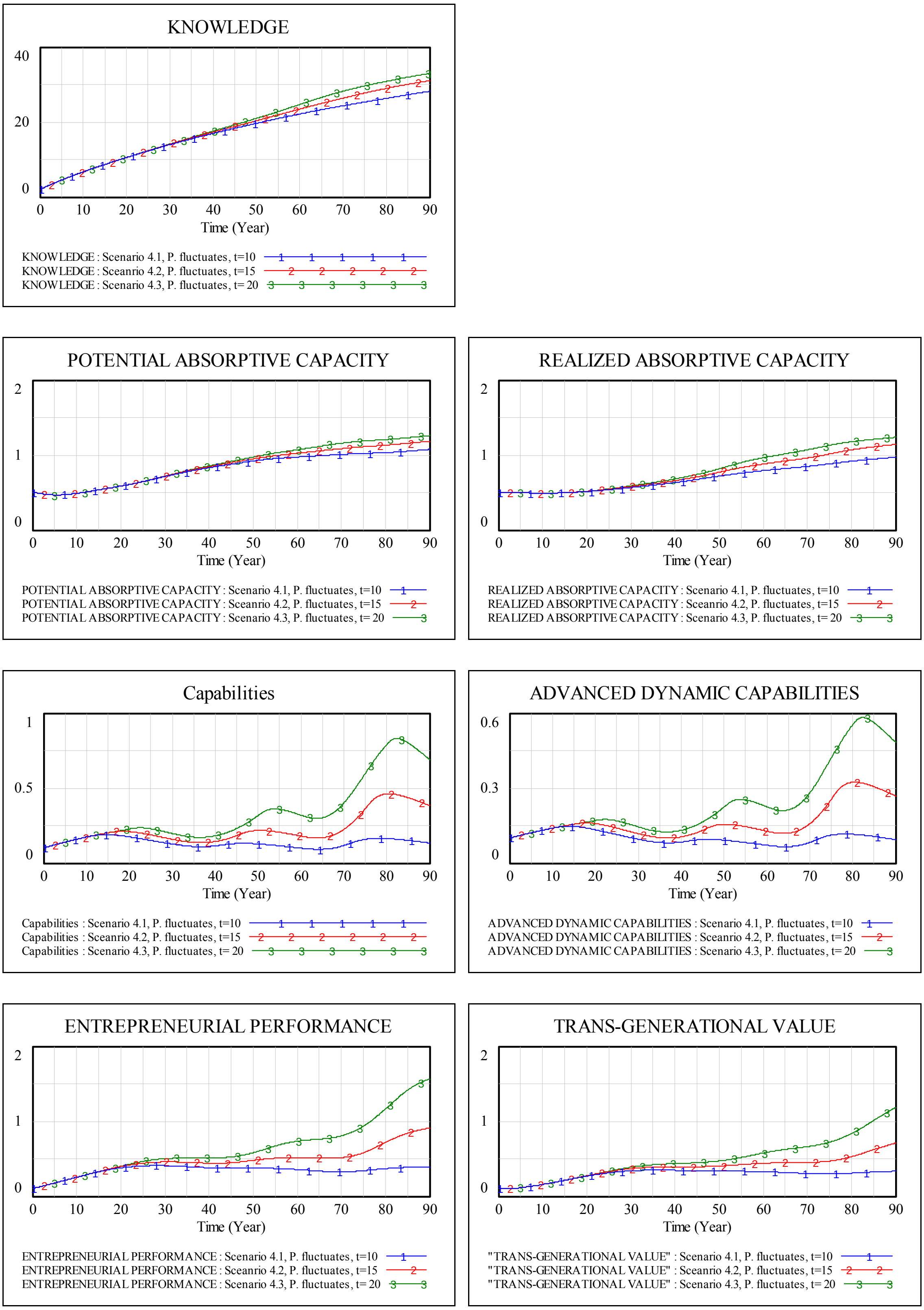


Figure 18: Virtual experiments in scenario $4_{.1}$, $4_{.2}$ and $4_{.3}$



DISCUSSION AND CONCLUSIONS

Bothner and White (2001) posit that simulation models are useful when in reducing the real world complexity, they almost inviolate the established facts and yield surprising insights for further exploration.

By virtual experiments, it was possible to explore further the dynamic feedback loops of figure 5 and test its internal consistency (simulation results consistent with the original set of interconnected existing theories), exploring the simulation with different construct values, varying assumptions and representing variables as dynamic accumulation processes (see Larsen et al, 1999; Gavetti and Levinthal, 2000; Rivkin, 2001; Larsen et al, 2002; Zott, 2003; Lomi et al., 2005).

A simulation model (figure 12) was built using the system dynamics methodology and interesting results and new insights emerged as reported in this research. The dynamic model allowed us to test different sets of assumptions at the same time.

The simulation results support the FITS model of value creation in family business (Koiranen and Chirico, 2006: 47). How rapidly (or slowly) the process examined converts knowledge into value creation strongly depends on the family-business culture. In particular, it depends on the negative effect of family inertia on the creation of (dynamic) capabilities, though with some exceptions. The mis-match found between the theory and the simulation results regarding the initial effect of family inertia on the model as a whole forced us to look at the literature more in detail (see Giddings, 2003) and gave us the opportunity to develop new theoretical insights for theory development through virtual experiments (see for example, Sastry, 1997; Davis et al, 2007, forthcoming).
In fact, a paternalistic behaviour which leads to family inertia can be positive in guiding and training offspring at the beginning of the activity even though becomes less crucial if it persists over time preventing change even when it is needed.

Simulations gave evidence of the positive dynamic relations between knowledge, basic dynamic capabilities, capabilities, advanced dynamic capabilities, entrepreneurial performance and trans-generational value (*Scenario 1, 2, 3* and *4*); the positive relation between paternalism and family inertia (*Scenario 2*, *3* and *4*); and the negative relation between family inertia and capabilities though with some exceptions (*Scenario 2, 3* and *4*).

In particular:

- *Scenario 2*: if paternalism decreases, family inertia decreases, as well. Consequently, the creation of capabilities increases and a positive effect drives all the variables of the model (figure 17, Appendix B.*a*).
- *Scenario 3*: If paternalism increases, family inertia increases, as well. Consequently, the creation of capabilities decreases and a negative effect drives all the variables of the model (figure 17, Appendix B.*b*). ***However, the creation of capabilities is not negatively influenced by the increase in family inertia at the beginning of the activity with positive effects on the model.***
- *Scenario 4*: Paternalism fluctuates over time. Paternalism does not affect much family inertia at the start-up and at the beginning of each generation for a certain period (τ). Then, it rises up to a peak but falls down again with the following generation. Problems (caused by family inertia) arise after "τ" years from the

beginning of each generation when the effect of paternalism on family inertia increases. The longer is "τ", the better the family firm is able to react to the period in which the effect of paternalism on family inertia increases (figure 18, Appendix B.*c,d,e*).

Results become more evident and visible during the third generation when usually problems arise in family business. Indeed, according to the literature, the most critical period faced by family firms is the third generation, and the effects of past events, decisions and behaviours may be amplified during this generation (see Aronoff and Ward, 2001, Astrachan et al., 2002; Bridge et al., 2003; Colombo, Koiranen and Chirico, 2006). Family firms should be able to understand the long-term effects and results of actual events, decisions and behaviours, and, at the same time, prevent their negative consequences. System dynamics may be a useful tool to achieve such a result.
John Sterman[10] explains in one of his business courses for managers, planners, and strategists (Sterman, 2006) that "in a world of growing complexity, many of the most vexing problems facing managers arise from the unanticipated side-effects of their own past actions. In response, organizations struggle to speed learning and adopt a more systemic approach. The challenge is to move past slogans about accelerating learning and 'thinking systemically' to practical tools that help managers understand complexity, design better operating policies, and guide effective change. System dynamics is a powerful framework for identifying, designing, and implementing high-leverage interventions for sustained success in complex systems".

The study conducted encourages family-business researchers to make use of the powerful methodology of system dynamics. Interesting results and insights may emerge and help researchers to better understand the complexity of dynamism in a family business context and assist family firms to better manage their activity within the family and the business.

A first limitation of our research is related to the fact we have examined a 'model of a theory' (which is a new model) and in so doing we have simplified even more the existing theories on which our simulation model is based (see Wittenberg, 1992; Larsen et al., 1999; 2002).
In addition, although some researchers argue that creating a "good" theory is the central point in theory development, giving less attention to external validation (Weick, 1989; Van Maanen, 1995), we recognize another limitation of our study which refers to problems related to model validation, i.e., the match between simulation results and empirical evidence. But as we have mentioned, we built up a second-order model that is a model of a model based on the literature and six family-business case studies developed by Koiranen and Chirico (2006). This enabled us to make a precise validation of our model but within the very narrow context of that research (see Davids et al, 2007, forthcoming).
Larsen and Lomi are used to validating their simulation results (see for instance Larsen and Lomi, 1999; 2002) with a "link-by-link approach" that is by controlling the match of every single relation and symbolic representation in the simulation model with the original existing theories (Barlas and Carpenter, 1990; Sterman and Wittenberg, 1999). We have followed the same path. For instance, the graphic function used for modelling the 'evolution of the rate of knowledge creation through investments in knowledge' and the consequent 'effect of investments in knowledge on knowledge creation' is based on

[10] Professor of Management at the Sloan School of Management, Massachusetts Institute of Technology and Director of MIT's System Dynamics Group.

the empirical research carried out by Argote (1999); and the correlation between knowledge and absorptive capacity is based on the studies of Cohen and Levinthal, (1990) Bower and Hilgard, (1981), Lane and Lubatkin, (1998) and Zahra and George, (2002).
The validity of simulation models presents the same problems of any other kind of empirical model (Masuch, 1995). Lomi and Larsen (2001: 11) posit that “computational and simulation models of organizations differ from other kinds of models like empirical models, only in terms of the constraints that define the specific language being used”. In this respect, Oreskes et al., (1994) and Sterman (2000) agree that specific validation and verification of numerical and simulation models are impossible but this is not limited to computer models but to any theory and research which relies on simplifications of the real world and assumptions.

In addition, the literature lacks empirical studies which show the real trend/degree of paternalism in family business over time. The use of graphic converters (graphic functions) helped us to solve this problem (Larsen et al., 1999, 2002; Lomi et al., 2005).

This research can be viewed as a contribution to the literature on the simulation of first-order models of theory-testing, and, partially, on the simulation of second-order models of theory building. More work and virtual experiments are needed before generalising and building a new theory based on the results and insights of this study. In the future, more accurate scenarios about the phenomenon of paternalism in family business could be formalised after empirical research, and some components of the model could be disaggregated to focus on particular issues related to family business. It would be also interesting to study non-family firms to compare if, definitively, the model proposed is exclusive of family firms or not. This is the future direction of our research.

Further research could be also directed to test the model empirically on a large representative sample. Data may be elaborated using a structural equation modelling (SEM) approach which seems to be the most appropriate to our research based on dynamic feedback loops. Indeed, SEM allows to consider multiple regressions simultaneously to permit the analysis of direct, indirect, and spurious relationships; estimate models with latent variables and use the confirmatory factor analysis to reduce measurement error by having multiple indicators per latent variable; test models with multiple dependents; estimate the loadings of each observed variable in the context of the full model rather than in isolation; accommodate measurement errors in both dependent and independent variables; accommodate reciprocal causation, simultaneity, and interdependence; and account for correlations among error terms (Fornell et al., 1990; Hoyle et al., 1995; Olsson et al., 2000).

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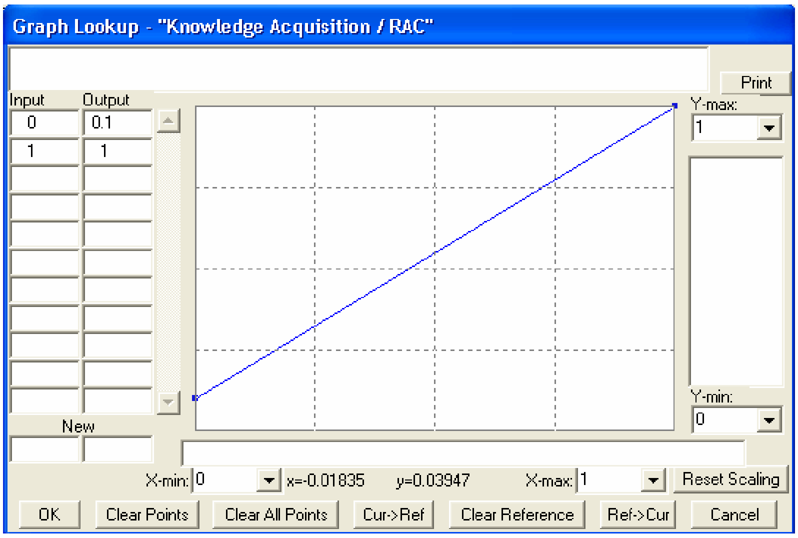
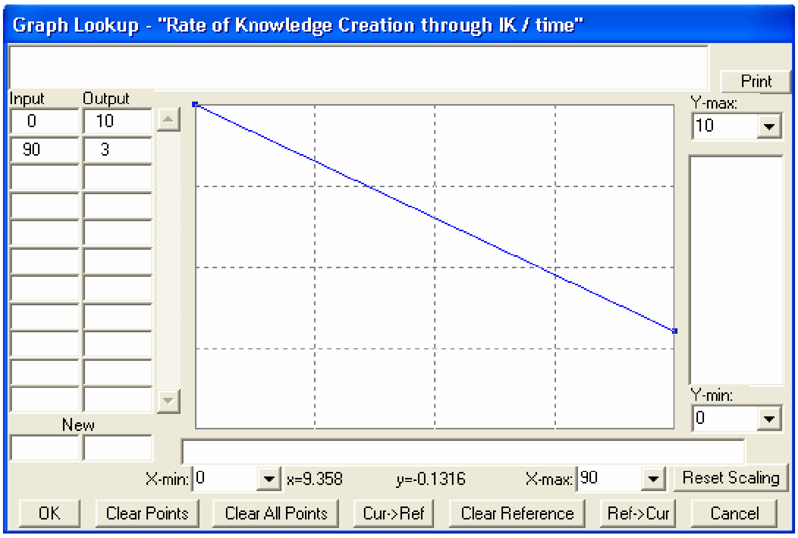
Appendix A

a- Relation between KA (Y-axis) and RAC (X-axis)



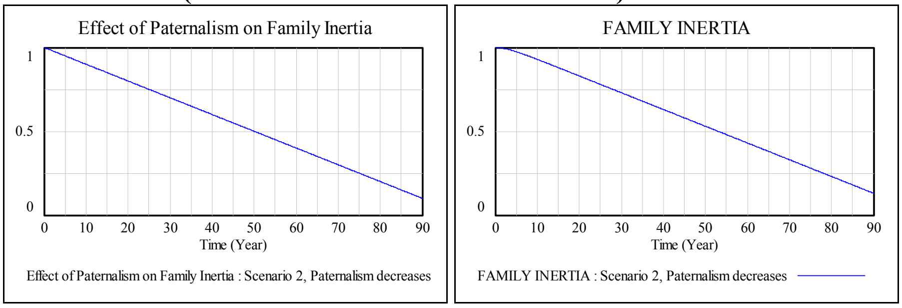
b- ERKC: relation between RKC (Y-axis) and time (X-axis)



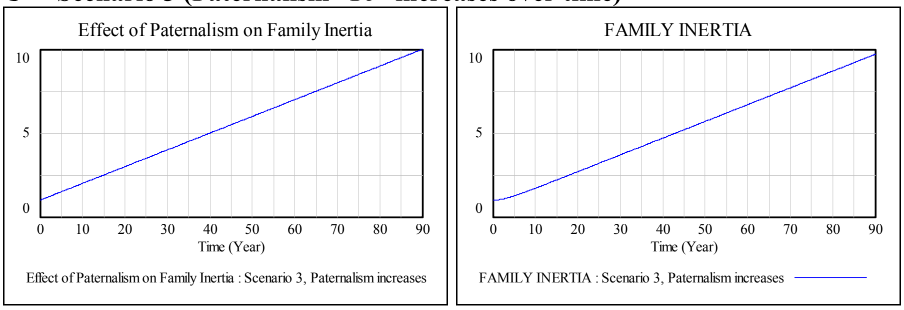
Appendix B

‘Effect of paternalism on family inertia’ and ‘family inertia’

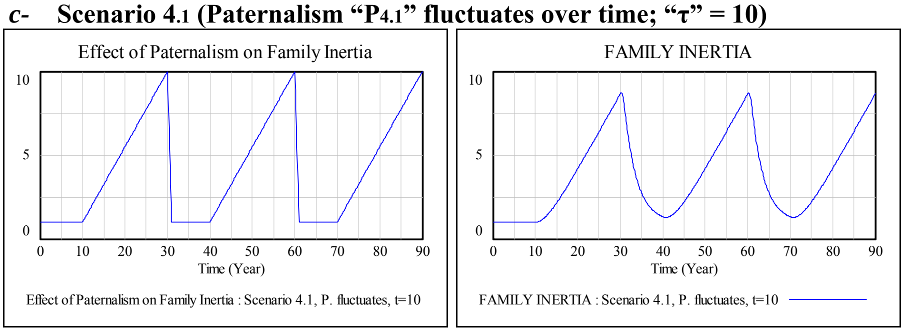
a- **Scenario 2 (Paternalism “P2” decreases over time)**



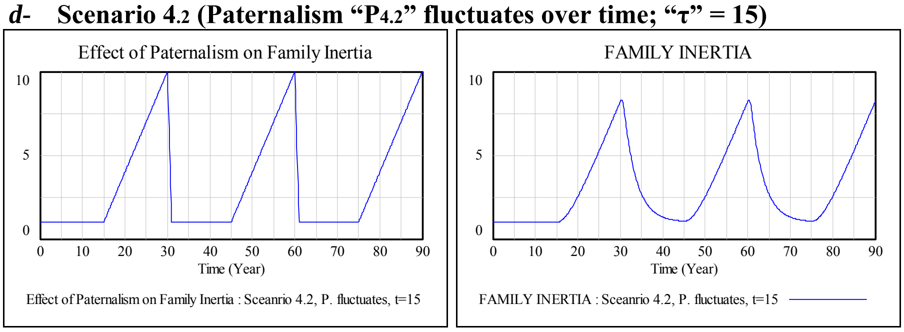
b- **Scenario 3 (Paternalism “P3” increases over time)**



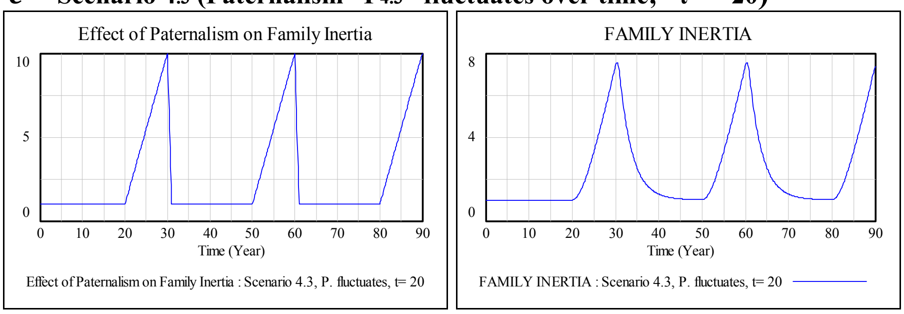
c- **Scenario 4.1 (Paternalism “P4.1” fluctuates over time; “τ” = 10)**



d- **Scenario 4.2 (Paternalism “P4.2” fluctuates over time; “τ” = 15)**



e- **Scenario 4.3 (Paternalism “P4.3” fluctuates over time; “τ” = 20)**



Min and Max of paternalism in scenario 2, 3 and 4

$P_2 =$ $Max(P_2)$ when time = 0 years (P_2 is at its maximum value at the beginning of the first generation)
…
$Min(P_2)$ when time = 90 years (P_2 is at its minimum value at end of the third generation)

$P_3 =$ $Min(P_3)$ when time = 0 years (P_3 is at its minimum value at end of the third generation)
…
$Max(P_3)$ when time = 90 years (P_3 is at its maximum value at the end of the third generation)

$P_{4.1} =$
$Min(P_{4.1})$ when $0<time<10$ years
…
$Max(P_{4.1})$ when time = 30 years

$Min(P_{4.1})$ when $31<time<40$ year
…
$Max(P_{4.1})$ when time = 60 years

$Min(P_{4.1})$ when $61<time< 70$ years
…
$Max(P_{4.1})$ when time = 90 years

$P_{4.2} =$
$Min(P_{4.2})$ when $0<time<15$ years
…
$Max(P_{4.2})$ when time = 30 years

$Min(P_{4.2})$ when $31<time<45$ year
…
$Max(P_{4.2})$ when time = 60 years

$Min(P_{4.2})$ when $61<time< 75$ years
…
$Max(P_{4.2})$ when time = 90 years

$P_{4.3} =$
$Min(P_{4.3})$ when $0<time<20$ years
…
$Max(P_{4.3})$ when time = 30 years

$Min(P_{4.3})$ when $31<time<50$ year
…
$Max(P_{4.3})$ when time = 60 years

$Min(P_{4.3})$ when $61<time< 80$ years
…
$Max(P_{4.3})$ when time = 90 years

Appendix C

Variables

Sector	Variable	Type	Value
K	K	Initial Value	2
K	OKG	Constant	1
K	Min(KA)	Constant	0.1
K	Max(KA)	Constant	1
K	Min(RKC)	Constant	3
K	Max(RKC)	Constant	10
K	α	Constant	0.03
INKD	INKD	Initial Value	12
IK	IK	Initial Value	4
INKD and IK	β	Constant	8
PAC	PAC	Initial Value	0.5
PAC	Delay PAC	Constant	3
RAC	RAC	Initial Value	0.5
RAC	Delay RAC	Constant	3
C	C	Initial Value	0.1
C	Delay C	Constant	3
C	γ	Constant	0.05
ADC	ADC	Initial Value	0.1
ADC	δ	Constant	0.7
ADC	ε	Constant	0.05
EP	EP	Initial Value	0.1
EP	ζ	Constant	0.6
EP	Delay EP	Constant	3
EP	η	Constant	0.05
TGV	TGV	Initial Value	0.1
TGV	θ	Constant	0.4
TGV	Delay TGV	Constant	3
TGV	ι	Constant	0.1
TGV	κ	Constant	0.05
FI	FI	Initial Value	1
FI	Delay FI	Constant	3
FI	Min(P_2)	Constant	0.1
FI	Max(P_2)	Constant	1
FI	Min(P_3, $P_{4.1}$, $P_{4.2}$, $P_{4.3}$)	Constant	1
FI	Max(P_3, $P_{4.1}$, $P_{4.2}$, $P_{4.3}$)	Constant	10
FI	τ	Constant	10; 15; 20

Appendix D

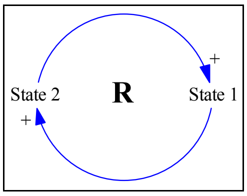
Positive and negative feedback loops

As reported by Gary and Larsen (2000), in a feedback loop diagram the arrow linking any two variables, x and y, indicates a causal relationship exists between x and y. The sign at the head of each arrow denotes the nature of the relationship as follows:

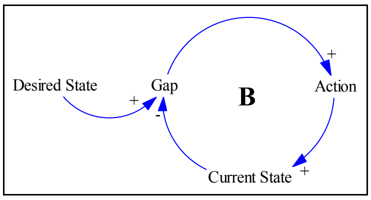
$$x \xrightarrow{+} y \Rightarrow \frac{\partial y}{\partial x} > 0 \quad \text{and} \quad x \xrightarrow{-} y \Rightarrow \frac{\partial y}{\partial x} < 0$$

An arrow from x to y with a positive sign signifies that the partial derivative of y with respect to x is positive; and an arrow with a negative sign indicates a negative partial derivative. Moreover, the polarity of each feedback loop is determined by tracing through the effects of each link, starting with any variable, until the loop is closed. If the net effect is to reinforce an initial change in the variable chosen as the starting point, the loop is positive and labelled with the letter R (*reinforcing loop).* If an initial change is counteracted, the loop is negative and labelled with the letter B (*balancing loop*):

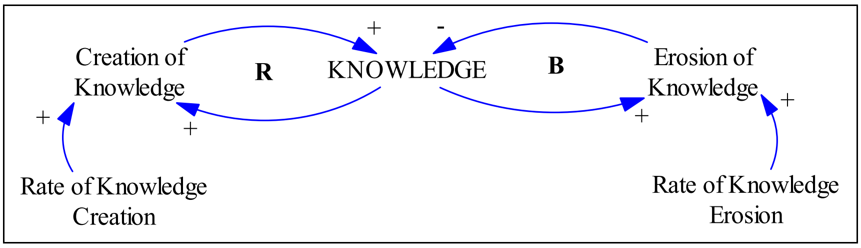
a. *Reinforcing Loop* (**R**) is a structure which feeds on itself to produce growth or decline: 'State 1' (the cause) increases or decreases 'State 2' (the effect) which, in turn, increases or decreases 'State 1', respectively. In other words, R tends to reinforce or amplify whatever is happening in the system. Of course, nothing grows forever. There must be some limits to growth which are created by negative feedbacks (Sterman, 2000):



b. *Balancing Loop* (**B**) counteracts and opposes change. It attempts to move some 'Current State' to a 'Desired State' (it is assumed that 'Current State' is lower than 'Desired State') through some 'Action': the 'Desired State' interacts with the 'Current State' to produce a 'Gap'. The larger the 'Gap', the stronger the influence to produce 'Action'. The 'Action' taken then moves the 'Current State' toward the 'Desired State' reducing the 'Gap' to zero:



An example will be helpful to clarify the above concepts. Figure 2 shows a simplified representation of the causal loop diagrams of knowledge in which the two feedback loops described above emerge (**R** and **B**):



'Knowledge' is positively influenced by the 'creation of knowledge' and negatively influenced by the 'erosion of knowledge'. 'Creation of knowledge' is given by 'knowledge' multiplied by the 'rate of knowledge creation', whereas 'erosion of knowledge' is given by 'knowledge' multiplied by the 'rate of knowledge erosion'.
Two balancing loops can be identified:

1. *Reinforcing loop* (**R**):
- Positive relation between 'creation of knowledge' and 'knowledge': the more knowledge is created, the more knowledge is accumulated;
- Positive relation between 'knowledge' and 'creation of knowledge': the more knowledge is accumulated, the more knowledge is created.
2. *Balancing loop* (**B**):
- Negative relation between 'erosion of knowledge' and 'knowledge': the more knowledge is eroded, the less knowledge is accumulated;
- Positive relation between 'knowledge' and 'erosion of knowledge': the more knowledge is accumulated, the more knowledge is eroded.

Balancing and reinforcing loops can be identified by counting the number of "-" and "+" in the feedback loop. A feedback loop is a balancing loop if the number of "-" is odd; it is a reinforcing loop if the number of "-" is even or zero.

Appendix E: Settings of the software Vensim PLE, 5.4d.

INITIAL TIME: 0;
FINAL TIME: 90 (the software Vensim makes the simulation over three generations of a generic family firm in which each generation lasts 30 years);
TIME STEP: 0.125 (results of simulation are saved every 1.5 months. This way, numerical integration errors are kept very small according to Larsen and Lomi, 2002);
UNITS FOR TIME: 1 year (the software Vensim simulates the model every year).