Modelling a Startup Energy Service Company (ESCO) Using System Dynamics

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Abstract

This paper describes the development of a system dynamics model for exploring and learning about the dynamics of a startup energy service company (ESCO) which business is based on energy performance contracting (EPC). The simulation of that model provides a helpful basis for analysing and explaining the development of key variables, and for accelerating learning on the managerial processes that are critical for the success of the venture. The simulation of the modelled firm produces an overall negative market value added mainly due to long sales cycles, indicating a low probability of success. The model is sensitive to changes in the word-of-mouth contact rate parameter which suggests that effective management or policy interventions should consider initiatives that accelerate word-of-mouth among EPC adopters and prospects. Also, the model simulations point out that a policy to subsidize the interest rate on debt would provide an effective support to this business venture.

Key words: Energy Performance Contracting, Startup Modelling, Business Simulation, System Dynamics

1. Introduction

Energy performance contracting (EPC) projects focus at the deployment of comprehensive solutions for improving energy efficiency. EPC is a contractual arrangement between the beneficiary and the provider, an energy service company firm (ESCO). This type of contract would help to overcome financial constraints to energy efficiency investments by paying off initial costs through the future energy cost savings resulting from reduced energy consumption. However, despite of government policies supporting EPC, the EPC market in Portugal is underdeveloped, far from its promised potential. There are a few firms that have engaged in EPC ventures and many of those firms have reported several difficulties and consequently have abandoned and closed their business operations. At the business level, an important question remains – what policies, business strategies and managerial processes might promote the success of EPC business ventures and ultimately foster the diffusion of EPC adoption in the Portuguese market?

This paper presents an exploratory study about the dynamics of launching an ESCO venture by means of system dynamics modelling and simulation. This research focuses on how to develop a successful EPC business in the Portugal. The key question is to understand the critical factors involved in a startup ESCO and the dynamic interactions among those factors that will drive the economic success of that venture. To explore and gather insights on this question, a system dynamics model representing an ESCO venture in the Portuguese EPC market was created. The simulation of that model provides a helpful basis for analysing and explaining the development of key variables, and for accelerating learning on the managerial processes that are critical for the success of the venture.

The first stage of this research aimed at identifying and analysing the key factors and critical cause-effect relations that drive the adoption of EPC and value creation by the ESCO firm. With this purpose, a qualitative content analysis on relevant documents was performed and a set of interviews was conducted to gather insights and discuss the experience of energy efficiency experts, national authorities, energy services companies (ESCOs) professionals and energy end-users regarding the development of an EPC business in the Portuguese market. That data was analysed to capture the critical variables and their interrelation to build a representation of the system structure as stock and flow diagrams. Then, the quantitative simulation model is obtained by defining the equations, assumptions, and initial values.

This paper has the following structure. Section 2 starts with a review of European and Portuguese energy policies that shape the context of the EPC market, defines the concept of EPC and gives an overview of the current status of the EPC industry in Portugal. Section 3 presents the objectives and methodology of the present research. Section 4 presents and interprets the data gathered about the main factors affecting the developing of a ESCO venture in the Portuguese market. Section 5 describes the development of the system dynamics model. Section 6 discusses the results of model simulation. Section 7 presents the main conclusions of the present research.

2. Closing the Efficiency Gap through Energy Performance Contracting

The Portuguese policy context

Under the Kyoto protocol, the European Union has agreed to reduce greenhouse gas (GHG) emissions. In 2006, the European Commission published the Action Plan on Energy Efficiency which aims to realize a 20% energy efficiency improvement by 2020 (EC 2006a). This objective was reinforced in 2007 when the European Commission defined its energy package for the twenty-first century. The package included a 20% emissions reduction target for greenhouse gases by 2020, among others, to be achieved by improving energy efficiency by 20% (EC 2007). Realizing this potential requires the introduction of effective energy efficiency policies on the European and the national level. According to many energy efficiency advocates and policy makers, most of this energy savings potential can be effectively realized through performance contracting of energy efficiency measures. The main mechanism to achieve this objective will be to improve the functioning of a commercially viable and competitive market for EPC.

In 20 May 2008, the Portuguese Government published the National Energy Efficiency Action Plan (RCM 80/2008). The objectives were to cut 10% in final energy consumption by 2015 and create and promote Energy Services Companies (ESCO’s) and energy performance contracting (EPC). The Portuguese National Energy Strategy (ENE 2020

RCM 29/2010) promotes energy efficiency aiming for a 20 % reduction in final energy consumption by 2020. That strategic plan reinforces that the development of the ESCOs and EPC market will be a priority, as this will create an energy efficiency industry with long term relevance (Fernandes, 2010; Zorrinho, 2010).

The Nature of Energy Performance Contracting

The Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-use Efficiency and Energy Services (Energy Services Directive), recently repealed and replaced by Directive 2012/27/EU (Energy Efficiency Directive), established the following terminology (Marino et al, 2010):

• "energy performance contracting" (EPC): a contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement;

• "energy service company" (ESCO): a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria;

Under an energy performance contracting, the ESCO defines and implements a project to deliver energy efficiency, or a renewable energy project, and uses the stream of income from the cost savings, or the renewable energy produced, to repay the costs of the project, including the costs of the investment (Bartoldi et al, 2006).

In a typical energy efficiency project supported by an energy performance contract, the ESCO may: perform energy audits, project design and engineering, install new energy conversion, distribution and/or control equipment at the client site; finance this investment, or assist in obtaining finance for the client; operation and control of some equipment, monitoring and verification of performance in terms of energy efficiency; assume decision rights over a significant proportion of the useful energy streams and final energy services within the host site; assume decision rights over a significant proportion of the organisational activities required to provide those streams and services; assume property rights over some of the assets involved in the energy efficiency project; guarantee a particular level of savings in energy consumption or energy costs; take on the majority of the risks related to the performance of the energy efficiency project, including equipment performance risk, and credit risk.

The Economics of EPC

From an economic point of view, the primary objective of energy performance contracting is to minimise the total cost of supplying energy services, given by the sum of production costs and transaction costs (Sorrel, 2007). Energy performance contracting is supposed to allow the client to minimise the total cost for the services that energy provides.

Production costs include the financing costs of energy efficiency project, the operation and maintenance costs, and the purchase cost of energy commodities. Transaction costs include the staff, consulting and legal costs associated with searching for a supplier, negotiating and writing the contract, monitoring contract performance, enforcing compliance, negotiating changes to the contract when unforeseen circumstances arise and resolving disputes (Sorrel, 2007). Production and transaction costs will be incurred by the client for the case of in-house provision of energy efficiency project as well as for the case of EPC. In the case of the latter, production and transaction costs will also be incurred by the ESCO.

The conditions for a viable energy performance contract are that (Sorrel 2007):
- the contract payments are less than the total savings achieved by the client;
- the contract revenues are greater than the total costs incurred by the ESCO;
- the total saving in production costs achieved through the contract must be greater than the total increase in transaction costs:

As it is expected EPC to reduce overall production costs but increase overall transaction costs, the saving in production costs is the key to a successful energy performance contract. EPC viability requires that the savings in production costs are sufficiently large to offset the transaction cost of contracting. Thus a client will engage in EPC if it can reduce its estimated and anticipated total cost at the time of making the decision (Buckley and Chapman, 1997).

EPC may achieve savings relative to in-house provision of energy efficiency project through the combination of scale advantages, competitive bidding, and performance incentives of outside providers (ESCOs):
- Economies of scale: Many organisations lack the scale to manage energy projects efficiently. As ESCOs specialise in energy management and contract with multiple clients, they achieve considerable scale economies (Sorrel, 2007; Globerman and Vining, 1996).
- Market incentives: If the energy efficiency project is managed in-house, the relevant staff will not be affected by the incentives of market competition. Competitive bidding will provide an incentive to ESCOs to maximize energy savings (Sorrel, 2007; Globerman and Vining, 1996).
- Performance incentives: EPC provides an effective incentive to ESCOs to maintain and improve performance over time. Although such incentives could potentially be provided by an internal management mechanism (Irrek et al., 2005), the effectiveness will depend upon the management ability to implement and maintain over time that incentive scheme.

Financing of EPC projects

Finance for an energy efficiency project through EPC refers to the source of capital for investment in new energy conversion and control equipment. In general three broad financing options for financing EPC project can be distinguished: energy user/ client financing, ESCO financing, and third party financing which may involve a single purpose entity (Thumann, 2009).

This study focuses mainly on ESCO financing as this concept is assumed a good introductory model in EPC developing markets because clients assume no financial risk (CTI, 2003; Dreessen, 2003). The ESCO financing model refers to financing with internal funds of the ESCO and may involve own capital or equipment lease. Under an EPC agreement contract the energy savings are split in accordance with a pre-arranged percentage. This percentage depends on the cost of the project, the length of the contract and the risks taken by the ESCO and the consumer. In this arrangement, the ESCO takes on the majority of the risks related to the performance of the efficiency project provision and credit risk as well.

Benefits of Energy Performance Contracting

The primary objective of EPC is to minimise the total cost of supplying energy services. Thus, EPC allows the client to achieve lower energy costs and may guarantee particular levels of service provision, such as lighting levels, room temperatures, humidity and ‘comfort’ at reduced cost.
In a conventional ‘turnkey’ energy efficiency project, the contractor is responsible for design, specification, construction and commissioning, and is paid on project completion. The contractor has neither the incentive nor the means to optimise the performance of the energy efficiency project subsequent to its delivery. In contrast, an energy performance contract establishes a link between contract payments and project performance and schedules these payments at intervals over a long-term period. This provides the contractor (ESCO) with a long-term incentive to optimize and maintain the performance of the energy efficiency project (Sorrel, 2007).

This approach involves the transfer of technical risks from the client to the ESCO based on performance guarantees given by the ESCO. In EPC payment is based on performance; a measure of performance is the level of energy savings.

ESCOs may have greater access to information, skilled labour and managerial expertise in the relevant areas and may leverage these benefits by having individual staff serve a number of clients. Such staff should be able to develop and apply specialist skills that would not be feasible within the client organisations and to rapidly disseminate learning benefits between different clients. (Sorrel, 2007)

EPC industry in Portugal – Present status

The present status of the Portuguese EPC industry was recently described by Marino et al (2010). The markets for energy services and efficient technologies have been developing since 2008, mainly supported by the energy efficiency programs of the government. Some of those programs allocated important funds for the support of ESCO activities. Other program requires industries to perform energy audits and to present and implement energy efficiency project containing specific measures to reduce energy consumption. At present, the public procurement of new energy projects is assumed as the main driver for the growth in the EPC market in Portugal. Recently, the Portuguese government has established new procurement rules (DL 29-2011) in order to facilitate long term EPC agreements between ESCOs and public administration. With these programs and governmental commitments to support EPC, a strong boost in this sector was expected.

Despite of those policies supporting EPC projects, the Portuguese EPC market has been growing at a slow rate. Approximately 10 firms declare that they are ESCOs. Most of these companies are small. There are not many cases reported of EPC based projects. Some companies declare that they are using EPC, though other types of non-performance based contracts are much more frequent (Marino et al, 2010). Only a few firms are engaged in EPC ventures and a great part of those firms reported several difficulties and consequently abandoned and closed their EPC business operations. Thus, it is important to understand the dynamics of that business venture in order to help policy makers and managers to define effective policies, strategies, and managerial processes that will promote the success of EPC business ventures and ultimately foster the diffusion of EPC adoption in the Portuguese market.

3. Research Objectives and Methodology

Problem statement

EPC projects focus at the deployment of comprehensive solutions for improving energy efficiency. This type of contract would help to overcome financial constraints to energy efficiency investments by paying off initial costs through the future energy cost savings resulting from reduced energy consumption. However, as the present analysis points out, despite of government policies supporting EPC, the EPC market in Portugal is underdeveloped, far from its promised potential. Additionally, some firms that had engaged in EPC ventures, decided recently to abandon and close their business operations. An important question remains – what policies, business strategies and managerial processes might promote the success of EPC business ventures and ultimately foster the diffusion of EPC adoption in the Portuguese market?

Research objective

This research focuses on how to successfully develop new ventures of EPC business. The key question is to understand the critical factors involved in the EPC business processes, and the dynamic interactions among those factors that will drive the value creation in the long term. The main purpose of this research is to recommend political and managerial actions that foster reinforcing processes towards a sustained development of ESCO ventures and the diffusion of EPC as an effective service for improving energy efficiency.

Some specific questions are:
- What are the essential factors that determine the long term value creation of EPC business?
- How do these factors interact dynamically with each other?
- What are possible policies and managerial actions to foster the success of new EPC business ventures?

Methodology

To explore and gather insights on those questions, a system dynamics model was developed, that represents the market, the human resources, the capital employed, and cash flow for a new ESCO firm. The simulation of that model provides a helpful basis for analysing and explaining the development of key variables, and accelerating learning on the managerial, organisational and political processes that foster the success of EPC business ventures.

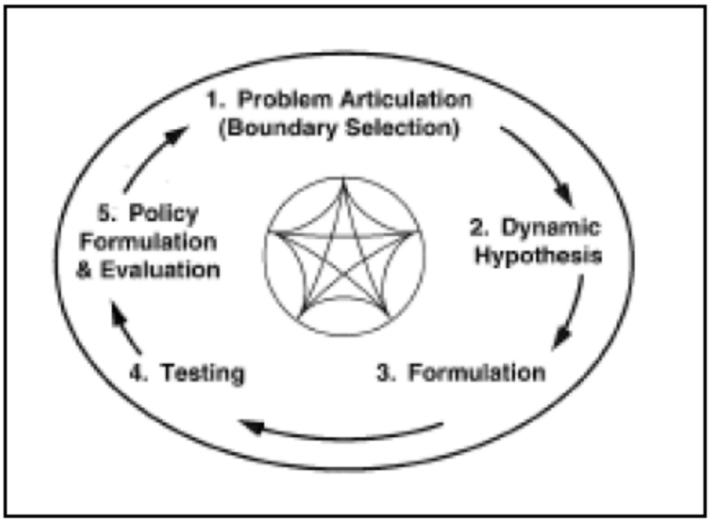

Figure 1: The iterative process of model development (Sterman, 2000)

The structure, parameters, and assumptions built into the model are supported by the literature reviewed and by the interviews, the case studies, and the personal experience of the author working with ESCO ventures. The methodological approach for capturing the critical variables and their interrelation considers the following data and methods:

- The current research builds on a review of existing literature on factors and barriers facing the EPC business (Bartoldi et al, 2006; Goldman et al, 2005; Marino et al, 2010; OECD and IEA, 2007; Seefeldt, 2003; Soroye, 2010; Steinberger, 2009; Vine, 2005);
- The author conducted informal semi-structured interviews. The purpose of this survey was to discuss the experience of energy efficiency experts, national authorities, EPC professionals, academia, and financial institutions regarding the development of an EPC business venture;
- Qualitative content analysis of documents and texts about this subject was also applied, seeking to identify perceived factors, barriers and cause-effect relations that might explain and drive the market and business development. The texts surveyed include political, legal and regulatory documents, written interviews with government members, papers issued by national and regional energy agencies, communications presented in conferences and workshops on energy efficiency and EPC.

The system dynamics model was developed according to the standard modelling process (Sterman, 2000) as presented in figure 1, which involved the following steps.

- Problem definition and articulation.

- Formulation of influence and causal loop diagrams. Analysis of positive and negative feedback loops of the system. These diagrams show the critical variables and their inter-relations that are involved in the treatment of the research problem.
- Development of a theory about the dynamics characterizing the problem in terms of underlying feedback and stock and flow structures. The system structure of the research problem is represented as stock and flow diagrams.
- Formulation of the quantitative model by defining the variables, equations, constants, and initial parameter values.
- Testing of the simulation model.
- Simulation of the model and policies evaluation.

4. A start-up business based on Energy Performance Contracting

4.1 Factors effecting value of EPC

The data collected in the present study indicate the interaction of the main factors affecting the cost and value of implementing energy efficiency projects through EPC as shown in figure 2. This section describes those factors.

Value of future savings: The value of future savings achieved through EPC will depend upon the values of future energy savings and costs of EPC.
Trend of energy price: The rising trend of energy prices, including energy taxation, is understood as a favourable key market driver for EPC. The steady rise in energy prices and taxes has decreased the payback time of energy efficiency investments and increased the demand of energy efficiency investments and therefore EPC. On the other hand, falling and volatile energy prices are expected to have a negative impact on EPC.

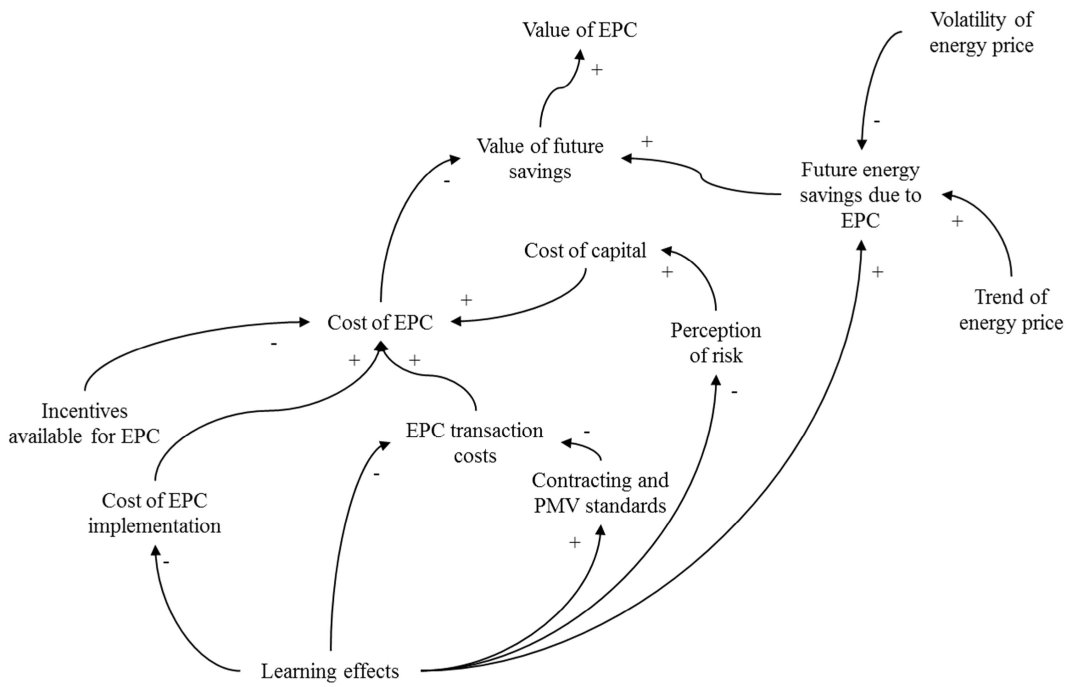

Figure 2 – Factors effecting value of EPC

Incentives available for EPC: It is assumed that subsidies and government programs supporting energy efficiency projects and EPC may be useful to foster the first moves of this industry. A common type of financial incentive policy is to subsidize the interest rate on debt. The result of this policy is to lower the financial cost of the ESCO, enabling higher profits without affecting the costs and attractiveness of EPC to the client firms.

EPC transaction costs: Standardization of performance contracting and verification determine the transaction costs which in turn influence the total cost and feasibility of EPC. For small projects, EPC may offer large percentage energy savings, but the absolute savings are likely to be outweighed by the associated transaction costs. The high level of detailed information required for performance contracting and verification is considered costly and time consuming, especially for projects of smaller scale. To reduce those costs to a reasonable level it is assumed that standards to support efficiently those tasks must be developed and applied. Moreover, it is expected that standardized contracts and measurement and verification procedures will help energy users and the financial community better understand EPC.

Perception of risk and cost of capital: Estimation of energy savings potential and performance verification involve volatility data which is an important source of risk. This perceived risk forces lenders to increase the cost of borrowing, which in turn erodes the intrinsic cost-effectiveness of EPC projects and lowers the overall level of available financial resources.

Learning effects and EPC capabilities: Learning effects in increasing EPC capabilities are often mentioned as important drivers for decreasing EPC cost elements and increasing the certainty of the estimated future savings.

4.2 Factors that affect the adoption of EPC

In order to build the simulation model, the main factors that affect the adoption of EPC were identified. These include (figure 3) regulatory factors, such as subsidies programs; economic factors such as, economic value of EPC; behavioural factors, such as the aversion to outsource energy management, the awareness of technical risk, the familiarity with EPC contracting and procedures for performance measurement and verification, and ESCO reputation; and the effects of communication and word-of-mouth.

Financial incentives and program deadlines played a powerful role in making EPC attractive for many clients. Beyond providing a financial source, subsidy programs presented firm deadlines, which fostered a sense of urgency for action which drives EPC adoption.

Awareness and perception of EPC benefits: Low awareness and scepticism towards the potential benefits of EPC was one of the most commonly reported barriers to the deployment of EPC projects. Most potential clients are ignorant of the concept or are reluctant to adopt EPC. The subjects surveyed revealed a common view about the importance of disseminating information on the benefits of implementing energy-efficiency projects through EPC, particularly in situations where there are limited financial or technical capabilities (e.g. in public buildings). The word-of-mouth and communication initiatives are perceived as determinant factors to influence the EPC awareness and attractiveness.

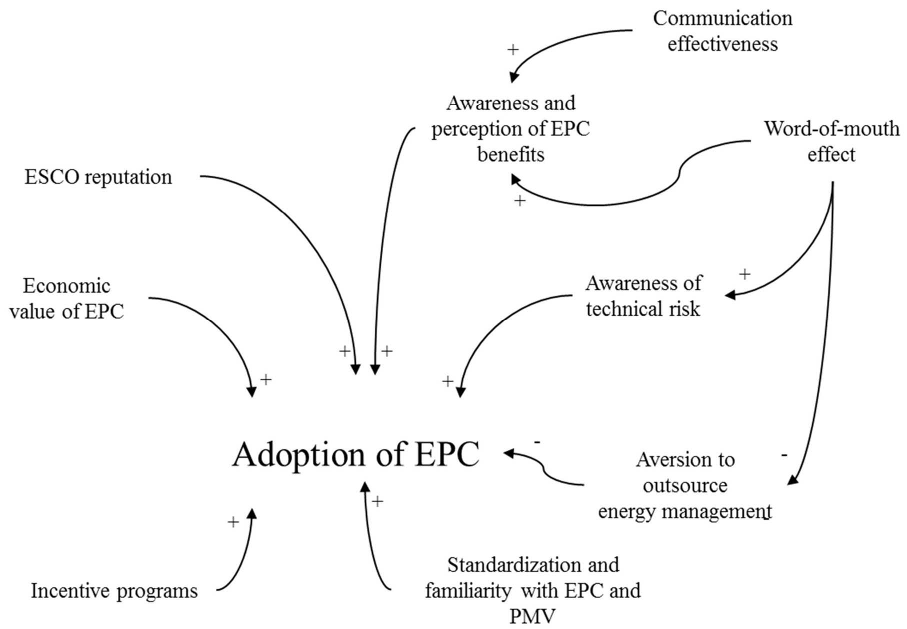

Figure 3 – Factors that affect the adoption of EPC

ESCO's reputation: The ESCO's track record can influence the EPC adoption. A positive reputation helps to achieve the mutual trust between the ESCO and their clients, leading to increased comfort with EPC. Many advocated an accreditation system for ESCOs to provide a qualified and reliable EPC project.

Standardization of EPC and performance, measurement and verification (PMV): The lack of standardization in energy performance contracting and performance measurement and verification (PMV) of project savings is perceived as an important source for mistrust in the EPC model both from clients and from financing institutions. Standardizing these processes will help end-users and the financial community better understand EPC. Transaction costs may be lowered by standardized contracting and PMV.

Aversion to outsource energy management: One factor reported that influences negatively the adoption of EPC is the aversion to outsource energy management, especially where in-house technical expertise exists.

Awareness of technical risk: One of the main EPC benefits is the transfer of technical risk from the client to the ESCO. New and more efficient energy technologies involve some technical and operational risks which may jeopardize future savings and the viability of the project. Clients have defined and implemented in house energy projects helped by energy consultants and suppliers of end-user energy technologies. When evaluating the EPC alternative, managers have difficulties in understanding their economics and benefits and they perceive it as uncertain and costly. The perception of technical risk will detract from the attractiveness of in house projects and will favour the EPC alternative.

4.3 The Dynamics of an EPC business venture

The analysis of the data surveyed suggests some positive feedbacks that could support the development of an EPC business (ESCO) venture if they were understood and considered by managers. Figure 4 depicts many of those loops.

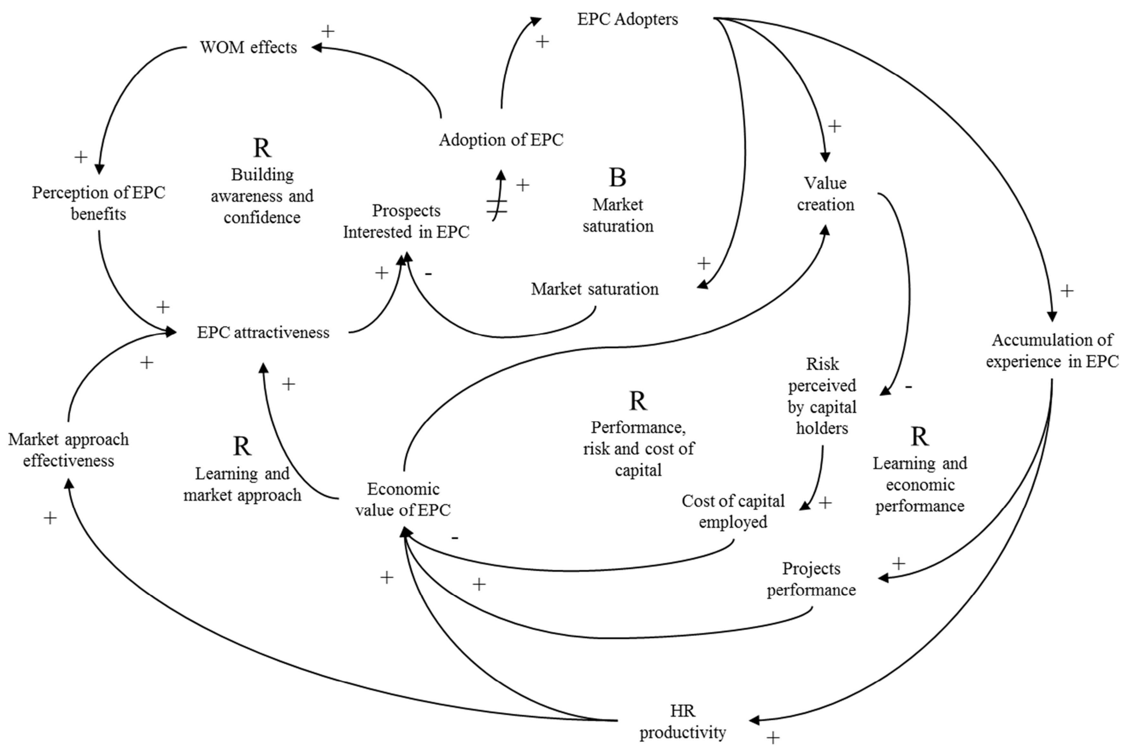

Figure 4 – Causal loop diagram representing the development of an ESCO venture

Building awareness and confidence: The benefits of EPC offered by the ESCO must be known and understood in order to improve its attractiveness. The power of word-of-mouth marketing among clients would help meeting that objective. The poor attractiveness of EPC can be explained by the unusual business practice. As EPC is first introduced by the ESCO, there is an intrinsic resistance to the unknown that is mitigated as more EPC from the ESCO is adopted and positive word of mouth concerning its benefits spreads. Once the adoption of EPC streams, the ESCO firm and prospects become more familiar with EPC and performance measurement and verification. This process of building familiarity would increase the attractiveness of EPC. Also, the mutual trust between the ESCOs and the clients would be achieved, leading to increased comfort with EPC. However the word of mouth loop only works if there are enough firms (EPC adopters) to spread the experience with EPC. If there are not enough new adopters it may further discourage other firms from adopting EPC.

Market saturation: Market saturation induces a negative loop that limits the growth of EPC adopters. The more the EPC adopters on the system, the less the potential projects and the lower the expected new profits from EPC.

Learning and increasing of ESCO capabilities: One of the most important positive loops is supposed to be the virtuous learning-accumulation of experience loop. This learning process will create and enhance the capabilities of the ESCO for selling, defining, and implementing EPC projects. As the ESCO employees are engaged in EPC projects they gain further experience, most project processes become less costly and they improve their technical, financial, management and marketing abilities in order to develop the market. The lower cost of EPC increases its attractiveness and encourages further adoption.

Performance, risk and cost of capital: As the ESCO improves its capabilities and increases the value creation through EPC business, the capital holders will start seeing the EPC business as a lower risky business and a promising market niche and will gradually require a less interest rate.

5. Model Development

System Dynamics has a valuable track record for studies in the energy sector. The pertinence and legitimacy of using SD in such strategic studies stems from the ability of capturing structural mechanisms and feedback loops, which cause either success or failure. This section presents a description of ESCO venture simulation model. The purpose of this simulation model is to help managers to better identify and understand the factors that determine the success of a new ESCO firm which business is based on energy performance contracting. The model was designed in order to support managers to explore the underlying dynamics of this business process and to help the definition of strategies that would increase the probability of success and ultimately of a wider adoption of energy performance contracting. The model includes feedback relationships that represent the previously discussed dynamics. The structure, parameters, and assumptions built into the model are supported by the literature reviewed, and by the interviews, the case studies, and the personal experience of the author working with ESCO ventures.

The simulation model is divided into five sectors that will then be described in more detail: Market (market and prospect chain), HR (Human Resources), HR Assignment (this sector deals with the assignment of HRs to business activities), EVA, and Finance.

Market sector

The market consists of public or private commercial buildings with potential for an energy efficiency project and may benefit from adopting EPC. The geographical focus of the model will be Portugal. The EPC market is modelled as a series of stocks representing prospective clients at various stages in the adoption cycle. Clients move among various stages and it is important to understand how clients move between them. This client choice pipeline is based on (Warren, 2008, pp 345-356) and the Bass diffusion model (Bass, 1969) which was extended in order to more closely represent the process of market development. Figure 5 shows the stock-flow diagram of this model sector. Based on interviews and previous studies, the stock of potential EPC adopters was disaggregated into “Potential”, “Interested”, “Audits in Progress”, “Projects in Progress” and “EPC Adopters”.

The stock “Potential” consists of public or private organisations that own buildings with potential for implementing an efficiency project with EPC considering the current technical and economic conditions. This stock includes those prospects whose decision makers are not aware or are not interested in EPC, as they have not yet decided to adopt it. These are potential customers that have been selected by the ESCO to apply marketing and sales efforts to inform or persuade them to adopt the EPC. The stock Potential is replenished as economic, legal and technical conditions evolve and drive the increasing of the number of buildings with economic potential for implementing an efficiency project with EPC.

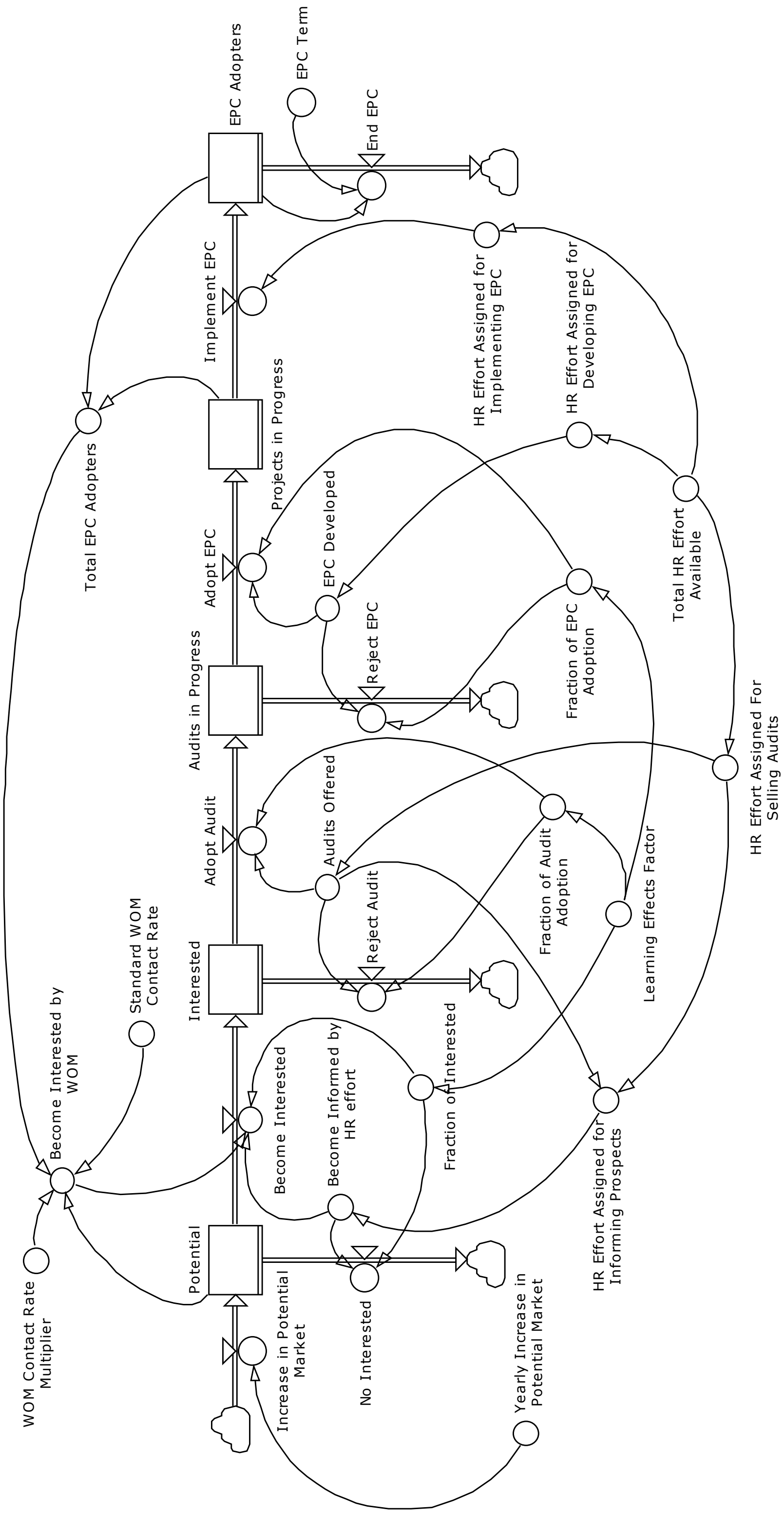

Figure 5 – Stock-flow diagram of the Market sector

“Interested” represents the organisations with commercial buildings capable (legal, economically and technically) of adopting EPC that are aware and interested in applying EPC in partnership with the ESCO. These prospects have been selected by the ESCO to apply special sales effort to convince the decision makers of these organisations to learn more about EPC to be able to adopt it by purchasing the energy audit as they have been qualified to be more likely to adopt EPC in partnership with the ESCO. Once potential clients have become aware of EPC and form a favourable perception of the EPC, they flow (Become Interested rate) from Potential to Interested. This flow is dependent on marketing and sales effort and word of mouth. The effect of word of mouth is modelled according to Sterman (2000, p333) and Morecroft (2007, pp166-174). As more organisations decide to adopt EPC with the ESCO, persons from those organisations will come in contact with persons from other organisations and spread word about their EPC benefits. It is assumed that many decision makers will not adopt EPC without hearing about its benefits at other similar organisations. From this point forward, it is assumed that the word of mouth effect is no longer relevant.

“Audits in Progress” are organisations that have closed an initial EPC agreement for performing an energy audit. Potential clients flow from Interested to Audits in Progress (Audit Adoption Rate) as they are engaged in an energy audit agreement in order to design an energy efficiency project. The Adopt Audit rate is dependent on sales effort and some components of EPC attractiveness which are influenced by experience and learning effects. It is assumed that marketing and word of mouth are no longer determinant factors at this stage.

“EPC Adopters” are organisations that have contracted energy performance and implemented the associated energy efficiency project. Once the energy audit has performed, the ESCO presents the client an EPC offer. The clients flow (Adopt rate) from “Audit in Progress” to “EPC Adopters” as they sign an EPC agreement and the ESCO installs and puts into operation the energy efficiency project. The adoption rate depends on ESCO sales and engineering effort, and some components of EPC attractiveness which are influenced by experience and learning effects. At this stage, it is also assumed that word of mouth is not relevant.

There is also a stock of “Lost Prospects” (figure 6) which are prospects that lost interest in adopting the EPC or decided not to adopt.

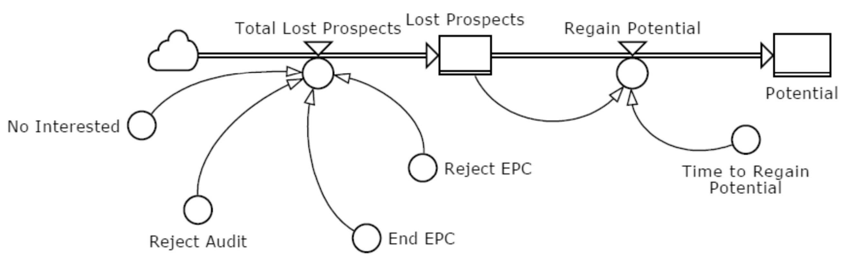

Figure 6 – Stock-flow diagram of lost prospects

HR sector

The Human Resources sector of the model (see figure 7) is based on the structure of labor and hiring of Sterman (2000, p758). The stocks in this model sector are HR (human resources) and HR Experience.

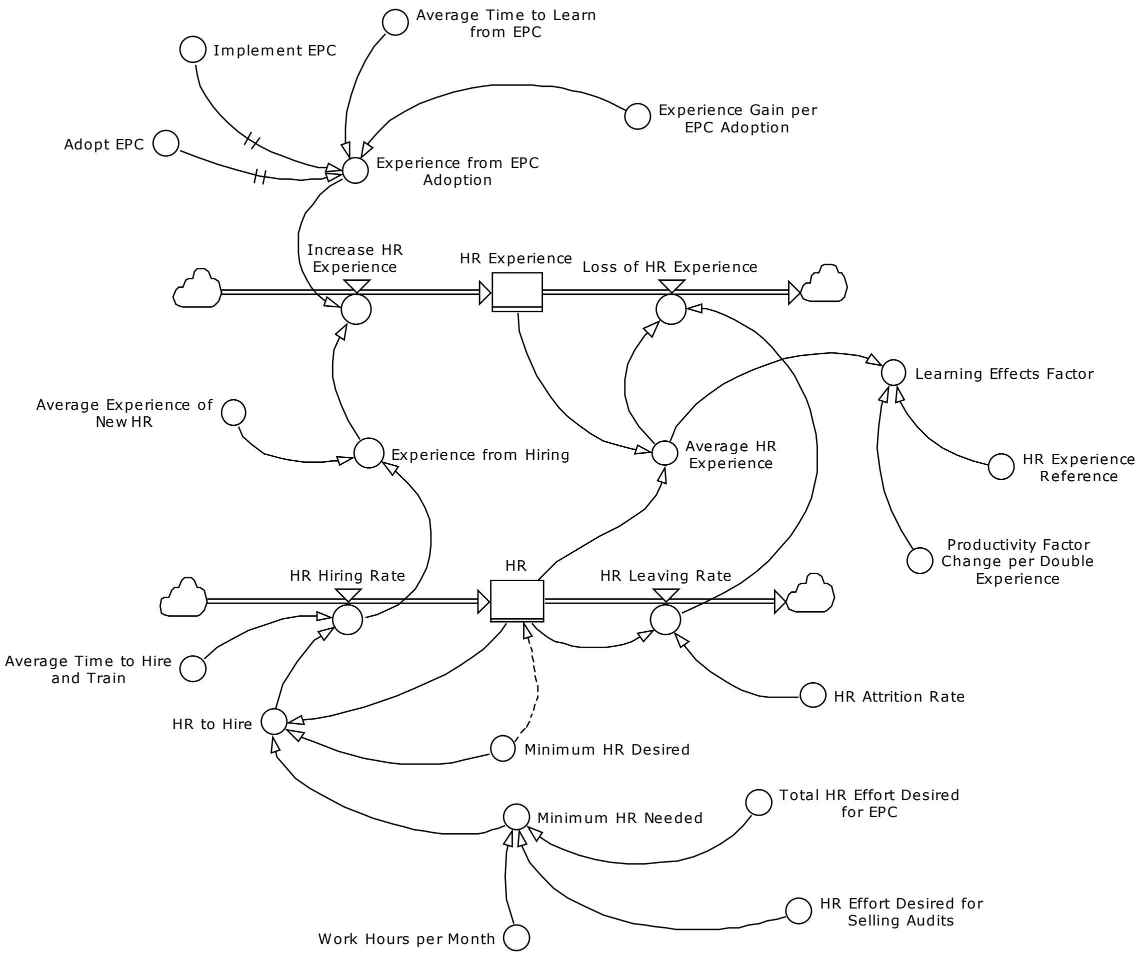

Figure 7 - Stock-flow diagram of the HR sector

The stock “HR” represents the number of relevant employees (project managers) in the ESCO firm. The model accounts for the main type of employees: project managers. Project managers are employees with marketing, sales, and technical skills. They are employees with sales and marketing responsibilities, or EPC development responsibilities including project engineering and management. The “HR Hiring Rate” is the flow into the stock of employees (HR), and it is diminished by the “HR Leaving Rate”. The “HR to Hire” is determined by “Minimum HR Needed” which is influenced by the total effort desired for performing the business operations.

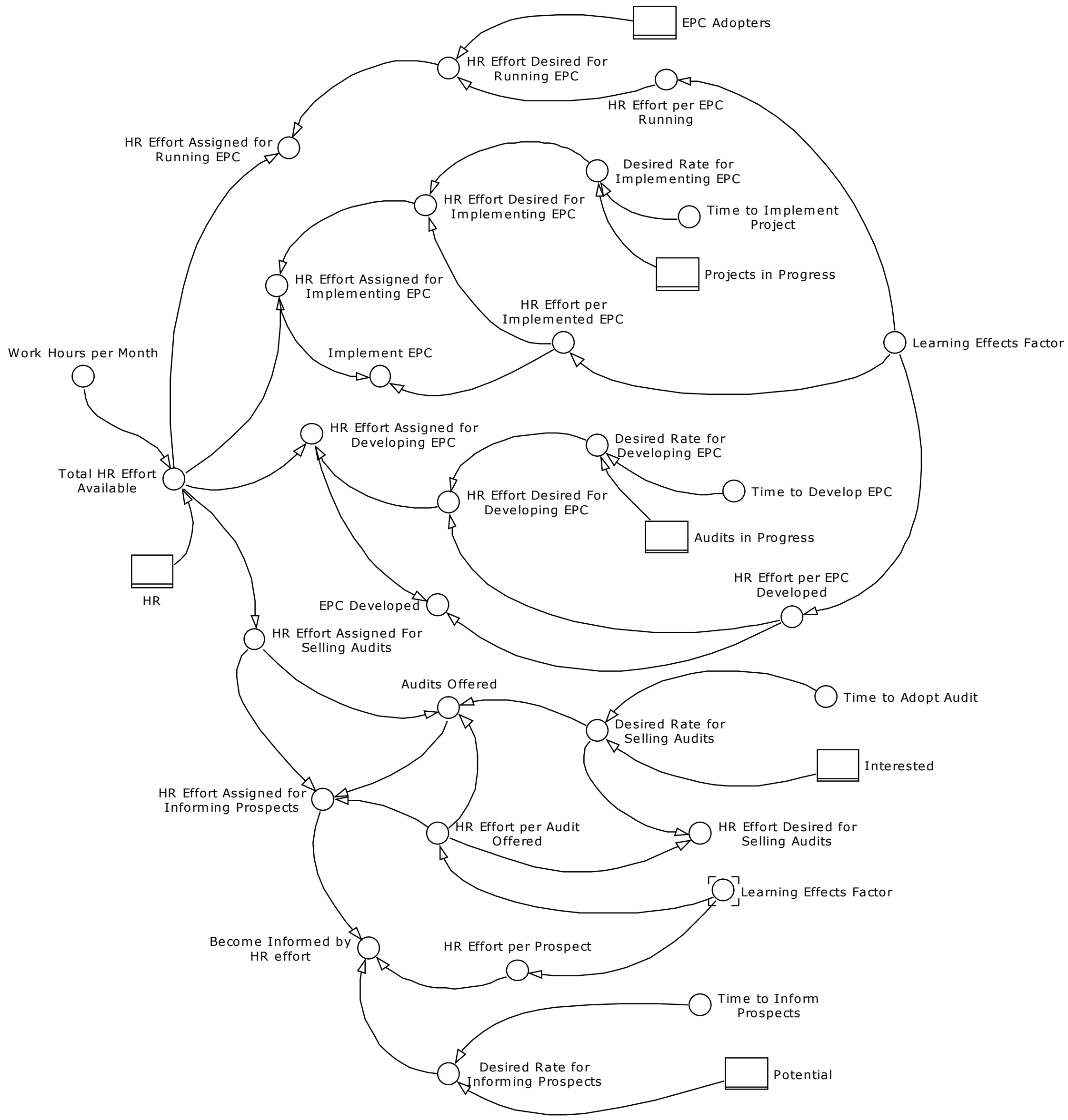

Figure 8 – Stock-flow diagram of the HR Assignment sector

The stock "HR Experience" represents the cumulative job experience (project management, engineering and sales) of ESCO firm employees in terms of number of person-hours. Particularly, HR Experience increases significantly for each adoption of EPC, assuming that the EPC development and implementation implies a valuable gain of experience. The human resources structure of the model takes into account the experience of the employees, based on the experience of a labor force coflow structure described in Sterman (2000, p505) and Warren (2008, pp258-261). The assumption is that employees learn and develop skills over time as they are exposed to the job challenges. The coflow measures the average and total effective experience of the employees. New employees bring a certain amount of experience with them, and departing employees take their experience with them. Experience increases with tenure in the job and declines as employees forget relevant knowledge.

The variable "Learning Effects Factor" represents the learning curve for productivity from experience. The equation used in this variable is based on formula 12-61 presented in section 12.2 of Sterman (2000, p507). The theoretical assumption is that productivity will rise by a given amount for every doubling of experience from an initial reference value. This is a very important variable as it influences the effectiveness and efficiency of human resources, and the revenues and costs regarding to the implementation and exploitation of energy efficiency projects.

HR Assignment sector

The stock-flow diagram of HR Assignment sector is presented in figure 8. The HR stock determines the "Total HR Effort Available" (the number of person-hours of work effort that are available per day). The HR effort assigned for each one of the business activities (informing about EPC, selling audits, developing EPC, implementing EPC, and running EPC) is determined by the work effort desired for each activity and constrained by the "Total HR Effort Available". The effort desired for performing each activity is determined by the stocks EPC Adopters, Projects in Progress, Audits in Progress, Interested, and Potential. The work effort is assigned according to the following priorities: firstly to perform the activities of developing, implementing, and running EPC, secondly to perform the activity of selling audits and finally to inform potential prospects about EPC.

The variables that represent the unitary work effort to perform the business activities are influenced by the variable "Learning Effects Factor" (learning curve for productivity from experience).

EVA (economic value added) sector

The EVA (economic value added) sector of the model describes how the ESCO firm creates value. The stock-low diagram of this sector is presented in figure 9 where some variables related to revenues, costs, capital and value creation are calculated from the status and flow of resources in the firm. The stock "Capital in Projects" represents the net capital employed in EPC projects. The inflow is determined by the rate of EPC implementation and the outflow represents the depreciation for the related assets. The variable EVA (economic value added) is the economic value added every time period and is defined as Net Operating Profit Less Amortizations and Taxes (NOPLAT) minus Capital Charge (Weighted Average Cost of Capital × Capital in Projects) (Young, 2000). The variable "MVA" (market value added) is the present value of futures EVAs and is estimated by summing the discounted economic value added (EVA). The revenues and the costs of the firm are determined by EPC Adopters, HR stocks, and Learning Effects Factor.

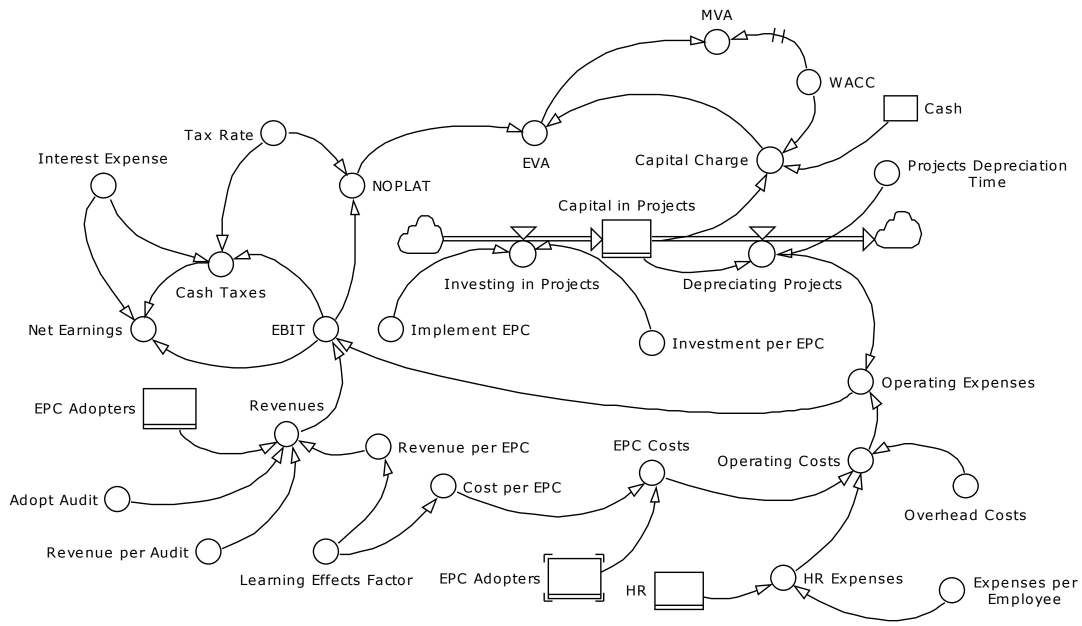

Figure 9 – Stock-flow diagram of the EVA sector

Finance sector

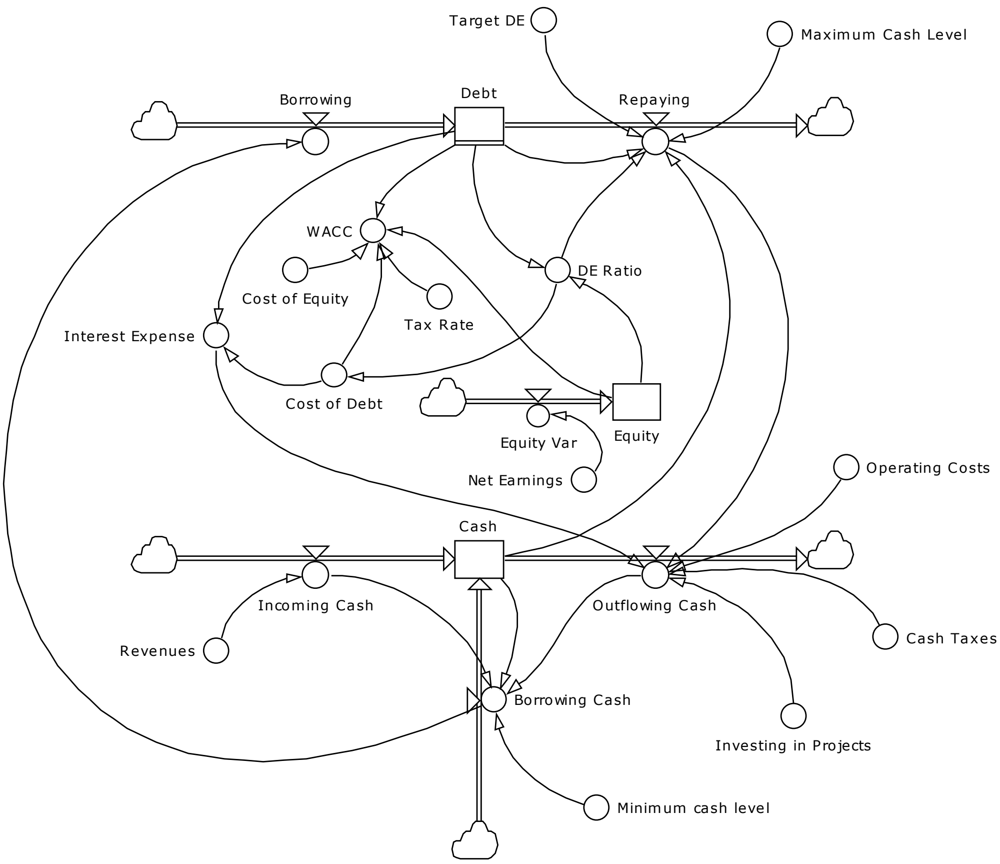

Figure 10 – Stock-flow diagram of the Finance sector

The Finance sector (see the stock-flow diagram in figure 10) of the simulation model deals with the cash flow and debt of the ESCO firm. The cash flows into the firm via revenues from customers (EPC adopters), and via funds borrowed from debtholders. Cash flows out of the firm to pay the operating costs, taxes, investments in projects, capital interests, and debt. When the level of cash does not allow the firm to meet the financial obligations, the funds needed are borrowed (Borrowing Cash) which determines the inflow rate of Debt. The stock Debt is decreased by the debt Repaying rate which is determined by the debt to equity ratio (DE Ratio), the desired ratio (Target DE), and available cash over the maximum desired cash level. The cost of debt, as an annual percentage rate, is a function that increases as the DE (debt to equity) ratio increases. The cost of debt influences the value of WACC (weighted average cost of having equity holders and debt holders). The WACC is used to calculate the capital charge.

6. Model Simulation

The simulation of the present model helps managers and policy makers to understand the underlying dynamics of developing an ESCO business venture. We assume that observing the behaviour of the model will provide insights into the real world scenarios the model represents. Decision makers define a set of cases and related assumptions then they simulate the model to explore and gather insights about the key factors and critical cause-effect relations that drive the value creation of that business venture in the long term. Particularly, it is instructive to analyse the sensitivity of the value creation by the firm to the initial value of parameters in the model. As example, this section presents some results of the model simulation.

6.1 Base Case

A base case was defined by using the parameter values and assumptions obtained from the data gathered in this research. The firm starts out with a service (EPC) that is not known by the market. There are 500 firms (potential prospects) that could benefit from EPC and are reachable by the ESCO. The initial capital invested (€2,000,000) is based on management's projections of how much capital is needed to develop the first projects. The venture starts with four employees (the minimum number of employees - project managers) focused on EPC sales, energy engineering, and project management. They have no experience advantage given that the EPC service has never been sold before. However, it is assumed that the employees will learn and become more productive over time after implementing EPC based energy projects. This case considers a maximum of fifteen employees.

Figures 12a-12g illustrate the ESCO performance over the 15-year duration of the simulation model. Due to the long sales cycle, the time required to accumulate EPC adopters will be lengthy, as it requires that potential prospects have progressed down the sales cycle to become interested prospects, audit adopters, and finally EPC adopters. For the first three years there are no full EPC adopters. The first projects are implemented in the fourth year. Managers would expect to have approximately 30 EPC based projects implemented by 2028 (figure 11a). As shown in figure 11c, the number of relevant employees maintains around the minimum capacity (four project managers) until the ninth year. As the flow of prospects increases, the number of employees is adjusted, reaching 12 project managers by the year 2028. Figures 12d and 12e show the behaviour of the financial variables Capital employed, Equity, Debt, Cash, Cost of debt, and WACC. In the first three years, the firm does not have any implemented project and spends all of the initial €2M of capital (€ 1M from initial equity and € 1M from initial debt). The firm does not go bankrupt because in the fourth year the revenues start to come from the first EPC based projects, and those revenues are just enough to pay its few employees and overhead costs. Figures 12f-12g illustrate the economic performance of the ESCO over the 15-years period. Net earnings become positive after the fourth consecutive year of negative value. For the first five years the economic value added (EVA) is negative. And in the following five years there is no significant positive EVA. Thus, there is no record of significant EVA after ten years, and the firm starts to develop a reasonable positive EVA flow after "only" about twelve years (a long time for capital holders to be patient). The market value added (MVA) is always negative. It means that this business venture does not create value. Considering that the assumptions included in this case are realistic, the simulation results suggest that the business venture is not viable as it does not add value in the long term.

EPC Adopters

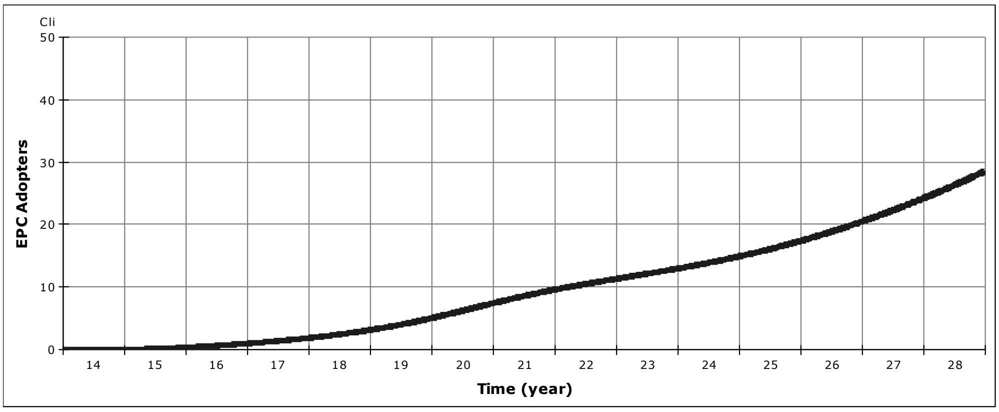

Figure 11a: Base case - Behaviour of stock EPC Adopters over 15 years

Prospect Flow Rates

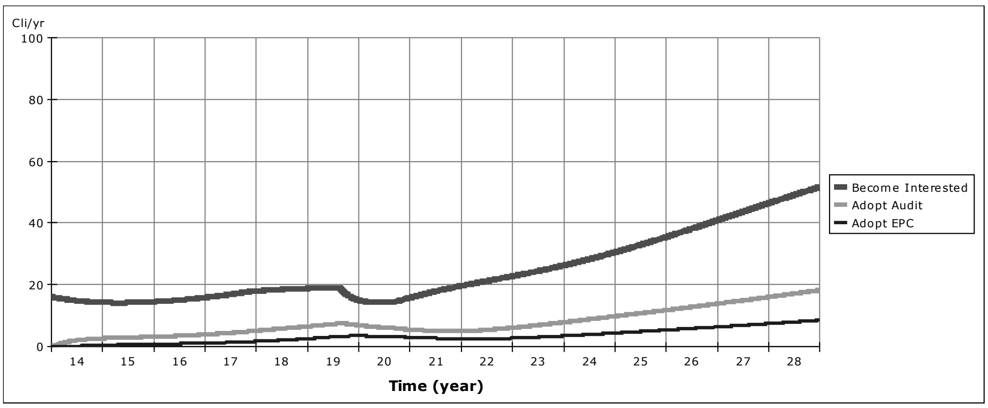

Figure 11b: Base case - prospect flow rates (Become interested, Adopt audit, and Adopt EPC) over 15 years

Work Force

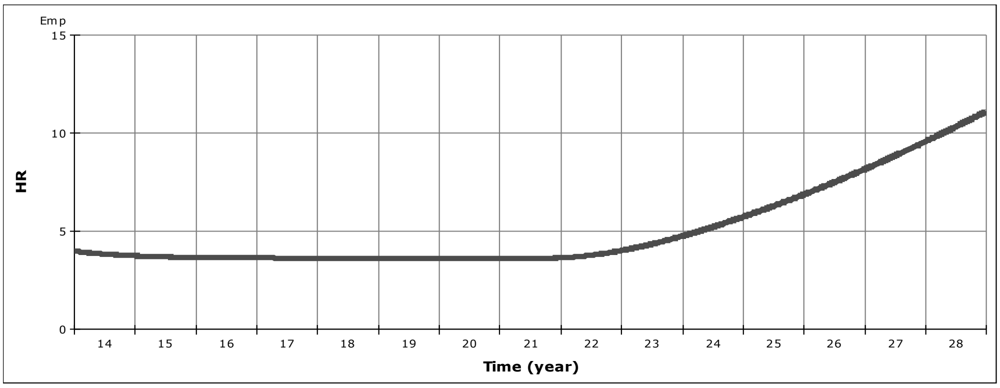

Figure 11c: Base case – Number of employees (project managers) in the ESCO over 15 years

Capital Employed

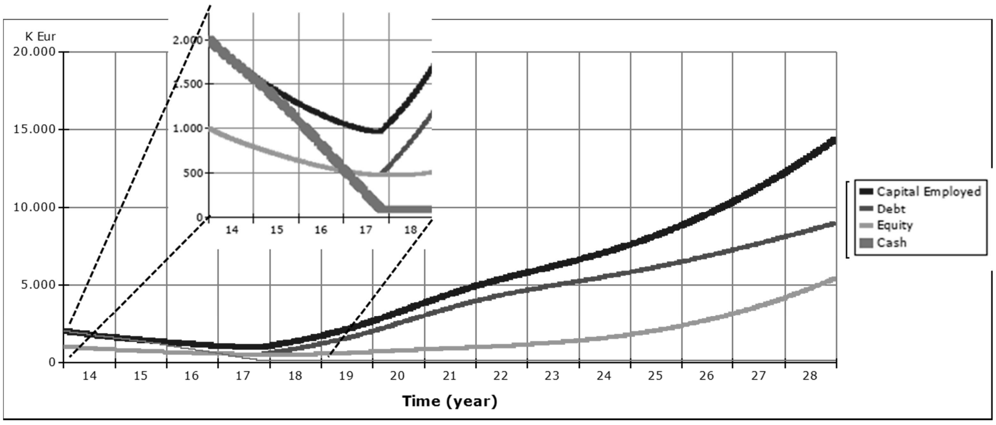

Figure 11d: Base case – Capital employed, debt, equity, cash over 15 years

Cost of capital

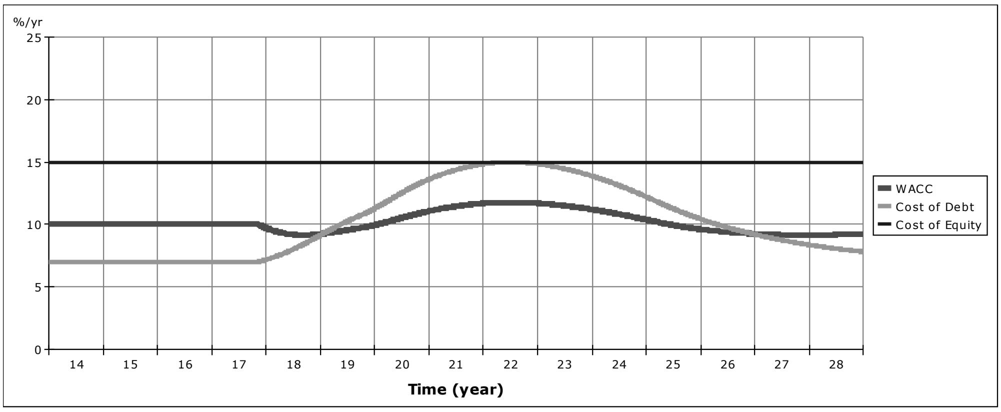

Figure 11e: Base case – Cost of capital over 15 years

Net earnings and economic value added

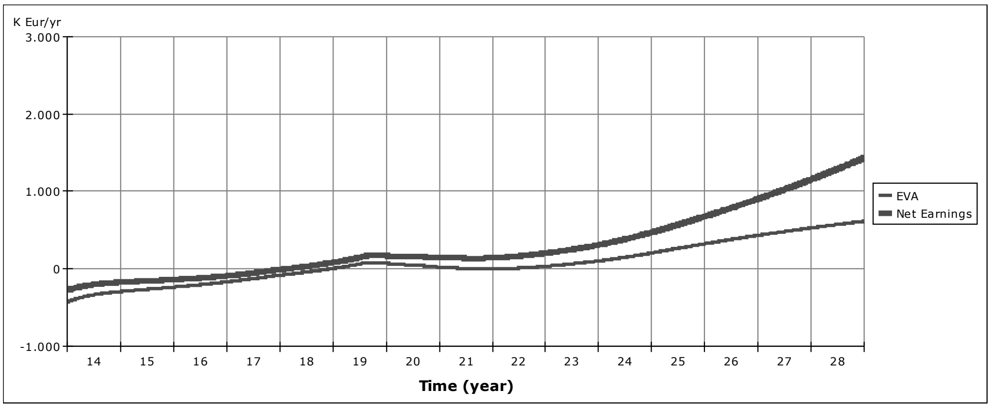

Figure 11f: Base case - Performance over 15 years – Net earnings and EVA

Market value added

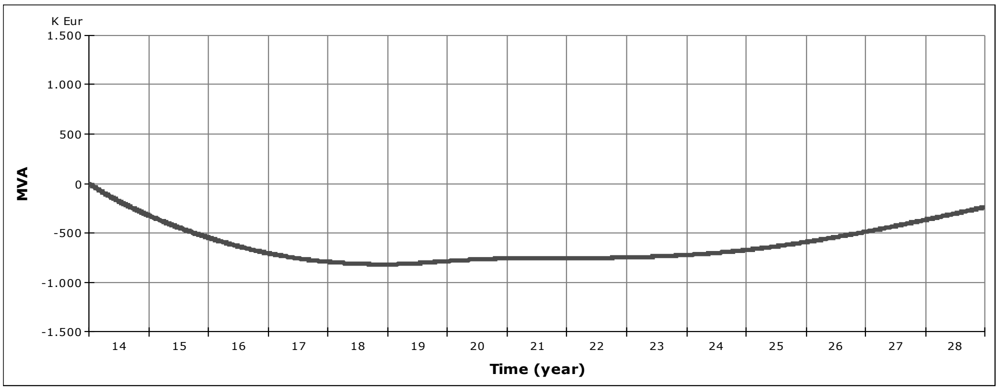

Figure 11g: Base case - Performance over 15 years – Market value added (MVA)

6.2 Analysing the sensitivity of the ESCO performance to key factors

The simulation of this model allows managers to analyse the sensitivity of firm performance to key factors and interactions. For example, we present the simulation results regarding the variation of the work force, word-of-mouth contact rate, and interest rate on debt parameters.

Effect of work force

An initial condition that is critical to the success of the venture is the size of the initial staff. The ESCO starts with a certain minimum number of project managers (with marketing and energy engineering responsibilities). The main task of these employees is to develop a market and feed the prospect pipeline. This work force is costly because the firm does not have any revenues yet. As such, this business venture should avoid an overabundance of personnel, as that would drain their cash flow. But the firm must have enough personnel who must also be skilful enough to effectively sell and develop EPC projects. As clients begin to adopt EPC, additional employees are needed to implement and run energy projects. But what happens if the ESCO starts with a higher initial number of employees? What is the initial number of relevant employees that maximizes the venture value added?

	Case A	Base Case	Case B	Case C
Minimum Number of Project Managers	3	4	5	6
Initial investment	1,000 K€	1,000 K€	1,600 K€	2,300 K€
5 years accumulated net earnings	-157 K€	-487 K€	-979 K€	-1,403 K€
10 years accumulated net earnings	1,709 K€	382 K€	-169 K€	-1,304 K€
15 years accumulated net earnings	7,839 K€	4,448 K€	3,442 K€	928 K€
15 years market valued added	321 K€	-238 K€	-969 K€	-2,109 K€

Table 1 – Effect of the initial number of employees on performance

Table 1 presents a sensitivity analysis of the ESCO performance to the size of initial staff. The model is simulated using four cases with different initial number of relevant employees (minimum number of project managers): the base case (four employees) and other three cases using three, five, and six employees. As the initial number of employees increases, the economic performance becomes worse. Additionally, in order to face higher staff costs and avoid bankruptcy, the ESCO has to increase the initial investment. On the opposite, assuming the ESCO could start with only three project managers, the market value added would be positive. We can conclude that with too few employees, the ESCO may not perform properly and consequently be unable to fill the prospect pipeline, and with too many employees, the firm may be unable to generate sufficient positive cash flow and require a higher initial investment.

Effect of WOM contact rate

The firms will rarely adopt EPC without being assured of its benefits, namely from existing adopters. Unfortunately, the time required to accumulate EPC adopters to spread the benefits of EPC will be lengthy as it requires that potential prospects have progressed down the sales cycle to become interested prospects, audit adopters, and finally EPC adopters. In that stage, in order to accelerate the ESCO profitability, it is important to take advantage of the word-of-mouth potential. The assumption here is that the ESCO would foster the word-of-mouth phenomenon by promoting specific initiatives like technical seminars to demonstrate the success of some projects.

Table 2 shows a comparison of five cases using different WOM contact rates: the base case which considers three prospects per adopter per year, and other four cases. As presented in figure 11e, the base case produces a negative market value added (MVA). By using a goal seeking process, we find that a contact rate of 3.53 prospects/ adopter/year will produce zero market value added. The other cases represent improved word-of-mouth effects and are defined by setting the WOM contact rate parameter as 6, 9, as 12 prospects per adopter per year.

	Base Case	Case A	Case B	Case C	Case D
WOM Contact Rate (prospects/adopter/year)	3	3.53	6	9	12
5 years accumulated net earnings	-487 K€	-473 K€	-412 K€	-337 K€	-283 K€
10 years accumulated net earnings	382 K€	600 K€	1,671 K€	2,787 K€	3,430 K€
15 years accumulated net earnings	4,448 K€	5,700 K€	9,625 K€	12,284 K€	13,782 K€
15 years market valued added	-238 K€	0 K€	712 K€	1,152 K€	1,371 K€

Table 2 – Performance associated with different WOM contact rates

Figures 13a-13e show what happens when the contact rate parameter is augmented up to 9 prospects per adopter per year. As can be seen by comparing figures 12b and 13b, the prospect flow rates increase immensely, especially from 2018 to 2022. By the year 2028, the ESCO will be running more than 50 EPC based energy projects (figure 12a). As shown in figure 12c, the number of employees maintains around the minimum capacity (four employees) until the fifth year. Then, in order to respond to the increasing of prospects, the work force is augmented up to fourteen employees. Figures 13d-13e show the economic performance. For the first four years the variables economic value added (EVA) and net earnings are negative. Then, the firm starts to develop positive EVA and net earnings. Finally, setting that improved contact rate results in positive market value added (MVA) which means that in this scenario the new firm will be viable as it will create value in the long term. These results demonstrate that the model is very sensitive to changes in the WOM contact rate parameter. Thus, effective management or policy interventions should consider initiatives that could accelerate word-of-mouth among EPC adopters and prospects.

EPC Adopters

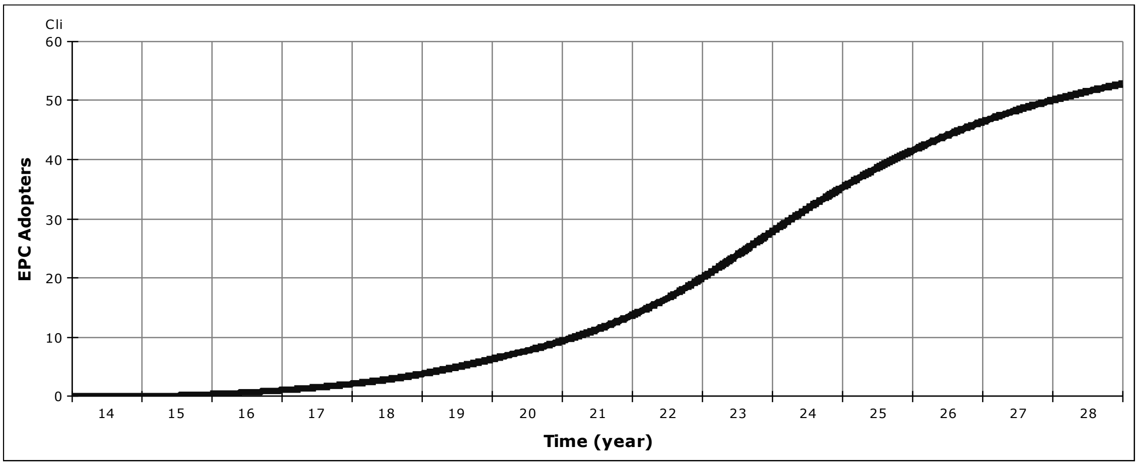

Figure 12a: Improved WOM case - behaviour of stock “EPC Adopters” over 15 years

Prospects Flow Rates

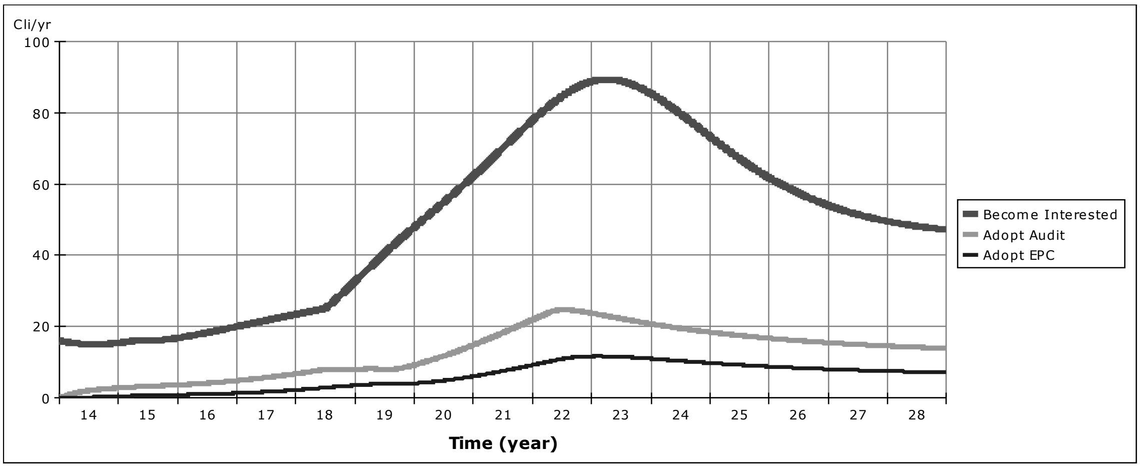

Figure 12b: Improved WOM case - behaviour of prospects flow rates (Become interested, Adopt audit, and Adopt EPC) over 15 years

Work Force

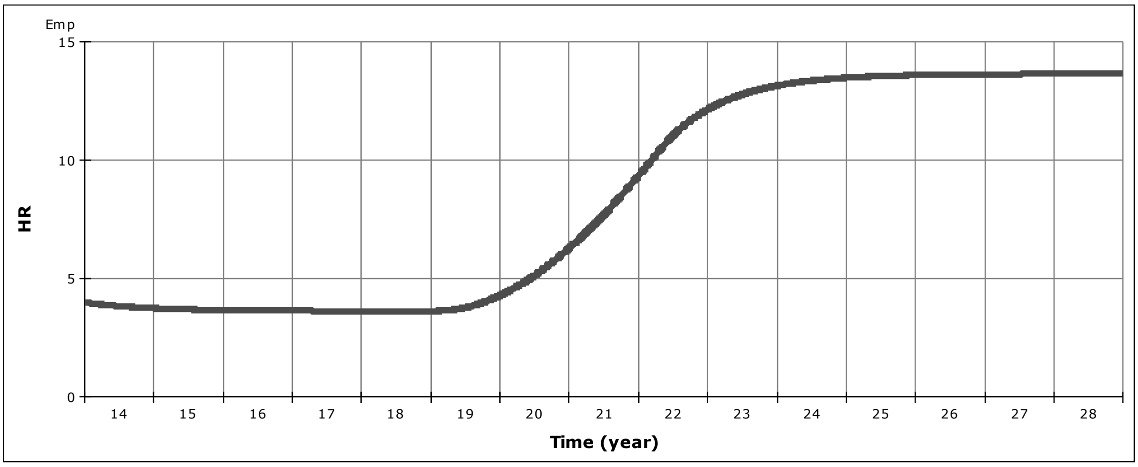

Figure 12c: Improved WOM case – number of employees (project managers) in the ESCO over 15 years

Net earnings and economic value added

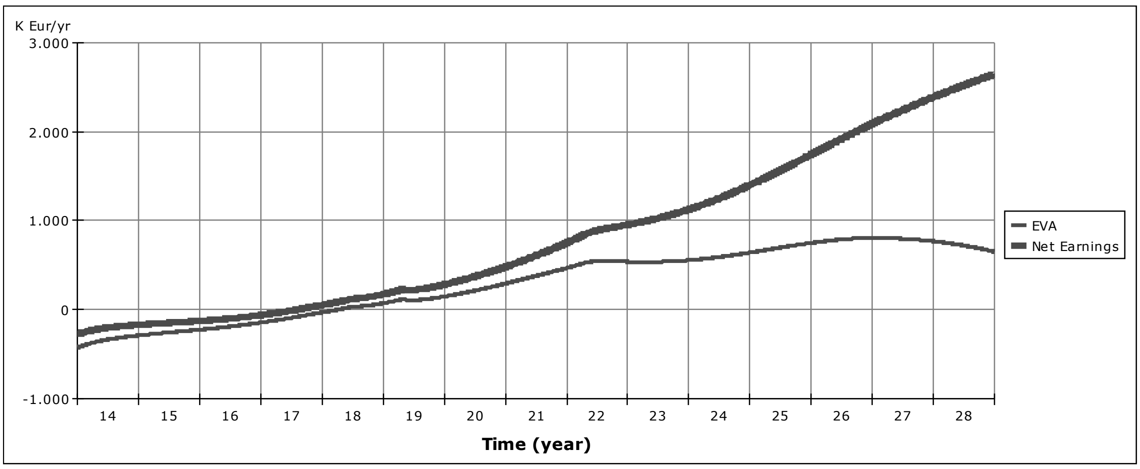

Figure 12d: Improved WOM case - Performance over 15 years – Net earnings and EVA

Market value added

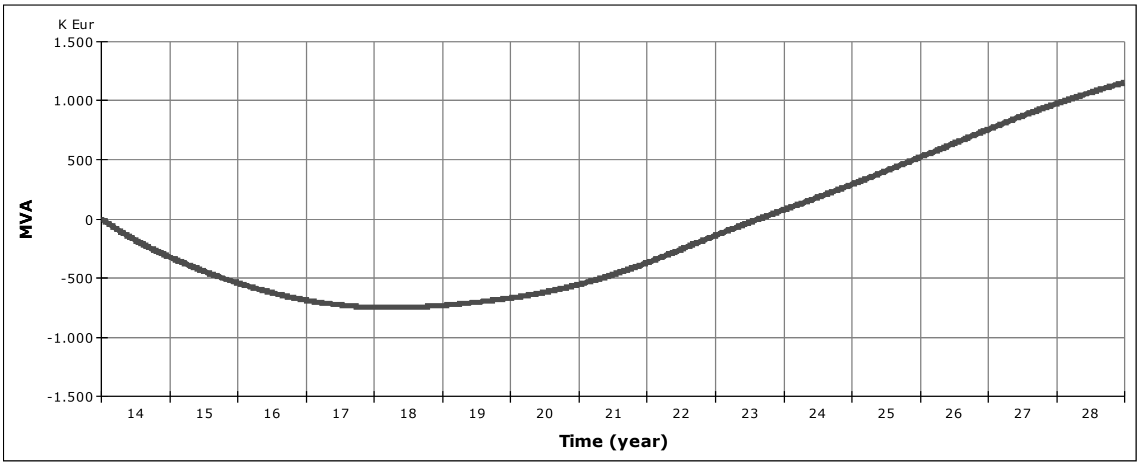

Figure 12e: Improved WOM case - Performance over 15 years – Market value added (MVA)

Effect of interest rate on debt

As mentioned in the literature review, it is assumed that financial incentives could play an important role in this business venture. A common type of financial incentive policy is to subsidize the interest rate on debt. The result of this policy is to lower the financial cost of the ESCO, enabling higher profits without affecting the costs and attractiveness to the client firms.

Table 3 compares three levels of incentive: 5%, 2.5%, and 0% interest rate on debt for the first 10 years. As can be seen, a lower interest rate on debt increases significantly the economic performance. As indicated by figures 12e and 14, by benefiting from this incentive, the ESCO avoids the very high interest rates on debt due to the financial stress (high debt to equity ratio) occurred in the base case from 2017 to 2026.

	Base Case	Case A	Case B	Case C
Financial incentive - interest rate on debt for the first 10 years	No incentive	5% /year	2.5% /year	0% /year
5 years accumulated net earnings	-487 K€	-428 K€	-363 K€	-297 K€
10 years accumulated net earnings	382 K€	1,625 K€	1,971 K€	2,286 K€
15 years accumulated net earnings	4,448 K€	6,913 K€	7,393 K€	7,816 K€
15 years market valued added	-238 K€	293 K€	408 K€	514 K€

Table 3 – Effect of financial incentive (lower interest rate on debt) on the ESCO performance

Cost of capital

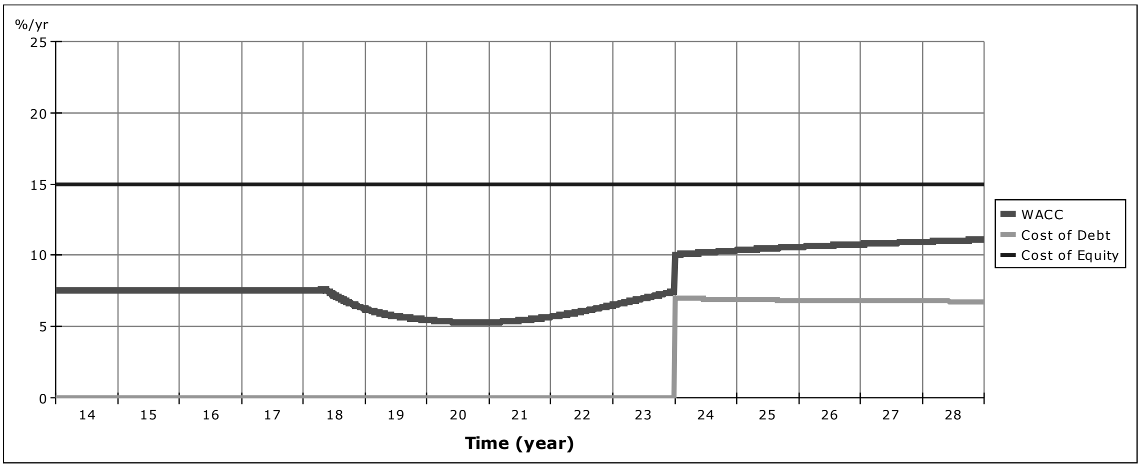

Figure 13: Financial incentive case (0% interest rate on debt) - cost of capital

7. Conclusion

This paper describes the development of a system dynamics model for exploring and learning about the dynamics of launching a new ESCO venture. The key question is to understand the critical factors involved in a startup ESCO and the dynamic interactions among those factors that will drive the economic success of that venture. In order to capture the critical variables and their interrelation to be included in the simulation model, a review of existing literature on factors and barriers facing the EPC industry was performed and relevant primary and secondary data were acquired through informal semi-structured interviews and qualitative content analysis of documents. Those factors were analysed and considered in a qualitative modelling process which involved causal and stock-and-flow diagramming. The following phase addressed the quantitative estimation of parameters, relationships and initial conditions, as well as the test for consistency with the purpose and boundary. From the simulation of the base case we can conclude that due to the long sales cycle, the time required to accumulate EPC adopters and build up revenue is very lengthy and that causes an overall negative market value added. Some simulations were performed to analyse the sensitivity of ESCO performance to key factors. The initial staff should not be too large otherwise the business venture may be unable to generate sufficient positive cash flow. The results showed that the model is very sensitive to changes in the WOM contact rate parameter which suggests that effective management or policy interventions should consider initiatives that could accelerate word-of-mouth among EPC adopters and prospects. Also, the model simulations point out that a policy to subsidize the interest rate on debt would provide an important support to this business venture.

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