Exploring the Dynamics of an Energy Service Venture for Energy Efficiency Policy

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Abstract

The development of a commercially viable and competitive market for energy performance contracting (EPC) services provided by energy service companies (ESCO) may contribute to realizing energy savings potential. In many countries, however, like Portugal, this market is still underdeveloped, far from its promised potential. This study provides new insight into this issue, focusing on how to develop a sustainable EPC industry from an energy service venture perspective. A system dynamics model representing an ESCO venture in the Portuguese market was created. The model simulation provides a helpful basis for accelerating learning regarding the policies and managerial processes that are critical for the success of the venture. The simulation of the base case produces an overall insignificant market value added and a low probability of success, mainly due to long sales cycles. The model is sensitive to the word-of-mouth (WOM) parameter, however, which suggests that effective policy interventions should consider initiatives that accelerate WOM among EPC adopters and prospects. Additionally, the model simulations indicate an efficient combination of incentive policies such as low interest rate, demonstration projects, and WOM initiatives as they significantly reduce the probability of failed ESCO ventures and consequently increase the widespread adoption of EPC.

Key words: Energy Efficiency Policy, ESCO, Energy Service Company, Energy Performance Contracting, Startup Modelling, Business Simulation, System Dynamics

1. Introduction

Energy performance contracting (EPC) projects focus on the deployment of comprehensive solutions for improving energy efficiency. EPC is a contractual arrangement between the beneficiary and the provider, an energy service company (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. According to many energy efficiency advocates and policy makers, the development of a competitive EPC market may contribute to realize the energy savings potential. In many European countries, however, this market is still underdeveloped and remains far below its promised potential. Regardless of the considerable number of studies on the factors affecting ESCO market, there has been little attention to analysing the business processes involved in an energy service business venture. Previous research has generally focused on what policies remove barriers to the adoption of EPC, not on understanding how these policies affect new ESCO ventures. An important question remains: what policies, including public ones, entrepreneurial strategies and managerial processes might increase the success of EPC business ventures?

This research focuses on how to develop a sustainable EPC industry from an energy service entrepreneur perspective. The key question is to understand the critical factors involved in an ESCO start-up and the dynamic interactions among those factors that will drive the economic success of that business venture and consequently increase the widespread adoption of EPC.

To explore and gather insight into 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 entrepreneurial processes and policies that are critical for the success of the venture.

2. Closing the Efficiency Gap through ESCOs and EPC

With the growing awareness of the serious consequences of climate change due to increased greenhouse gas (GHG) emissions, which are related to the energy consumption, many countries around the world have enacted policies to enhance energy efficiency. For example, in 2006, the European Commission (EC) published the Action Plan on Energy Efficiency, which aims at reaching a 20% energy efficiency improvement by 2020 (EC, 2006). Despite the improvement in energy efficiency over time, there is still great potential for further energy savings in most sectors (Deng et al., 2012; Worrell et al., 2009). Previous studies conducted in different countries and sectors have identified several barriers to energy efficiency (Rohdin et al., 2007; Sardinou, 2008; Thollander and Ottonson, 2008; Trianni et al., 2013, among others). Thus, realizing this potential requires the introduction of effective energy efficiency policies. According to many energy efficiency advocates and policy makers, most of this energy savings potential can be effectively reached through performance contracting and energy efficiency measures, and the main mechanism to achieve this goal is the development of a commercially viable and competitive market for EPC services provided by ESCOs (Steinberger et al., 2009; Painuly et al., 2003, Vine, 2005; Bartoldi et al., 2006; Soroye, 2010).

2.1 The nature of EPC and ESCOs

The Directive 2012/27/EU (EU, 2012) established the following terminology:

‘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 to 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 meeting the other agreed performance criteria.

Under EPC, 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 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). The present study focuses mainly on ESCO financing as this concept is assumed to be 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. Under an EPC agreement contract the energy savings are split in accordance with a pre-arranged percentage.

2.2 EPC and ESCO market – benefits and barriers

Recent research has examined the benefits and the role of ESCOs in closing the efficiency gap. For instance, Fang et al. (2012) provide evidence that ESCOs reduce energy use and Heiskanen et al. (2011) explore the role that entrepreneurs, such as ESCOs, have in setting diffusion paths to promote more energy efficient technologies. Okay and Akman (2010) analysed the relationships between the ESCO indicators and energy consumption per capita and conclude that the ineffectiveness of ESCOs or the lack of saturation of ESCO markets limit the reduction of energy use in most of the countries.

The application of the EPC mechanism for energy efficiency improvements has not been as widespread as expected, however, and many cost-effective investment opportunities still remain unexploited (Brow, 2001; Patari and Sinkkonen, 2014). As reported by Marino et al. (2011), the ESCO market in the European Union (EU) and neighbouring countries is far from utilizing its full potential even in countries with a particularly developed sector. Hannon et al. (2013) examined how ESCOs have co-evolved within the UK energy system and reported that the ESCO model has so far failed to become a major component of the energy sector.

Researchers describe various market failures and barriers (Goldman et al., 2005) limiting EPC adoption and the growth in ESCO market. Although each country and sector is different, several common factors impeding ESCO business have been reported such as non-compatible legal frameworks, public procurement and accounting rules; lack of incentives and appropriate forms of finance; short track record and low awareness among customers and financial institutions; heavy capital needs; long project cycles; and a lack of technical, business, market, financial, and management skills (Bartoldi et al., 2006; Bartoldi et al., 2014; Hansen, 2011; 2008; Marino et al., 2010; Mills et al., 2006; Okay and Akman, 2010; Patari and Sinkkonen (2014); Soroye and Nilsson, 2010; Taylor et al., 2008; Vine, 2005).

2.3 EPC and ESCO market in Portugal – present status

In May 2008, the Portuguese Government published the National Energy Efficiency Action Plan. The objectives were to cut 10% of final energy consumption by 2015 and at the same time create and promote ESCOs and EPC. Then, in 2010, the Portuguese National Energy Strategy promoted energy efficiency aiming at a 20% reduction in final energy consumption by 2020. That strategic plan reinforced that the development of the ESCOs and EPC market was a priority, as this would create an energy efficiency industry with long term relevance (Zorrinho, 2010).

The present status of the Portuguese EPC industry was described by Bartoldi et al. (2014). The markets for energy services and efficient technologies have been developing since 2008, mainly supported by the energy efficiency programmes of the government. Some of those programmes require industries to perform energy audits and to present and implement energy efficiency projects containing specific measures to reduce energy consumption. However, the main driver for the growth in the EPC market in Portugal is assumed to be public procurement, given the weakness of the private sector. Thus, in 2011, the Portuguese government established new procurement rules to facilitate long term EPC agreements between ESCOs and public administration and launched a programme that focuses on the refurbishment of public buildings via ESCO services.

The Portuguese EPC market has been growing at a slow rate, however (Bartoldi et al., 2014). Only a few firms have declared that they are ESCOs (as members of the National ESCO Association) and most of these companies are small. There are few reported cases of EPC based projects. Some companies declare that they are using EPC, although 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 many of those firms reported several difficulties.

There has been considerable focus on what policies remove barriers to the adoption of EPC, but relatively little focus on and understanding of how these policies affect new ESCO ventures. Thus, new insight into this issue is required that focuses on how to develop a sustainable EPC industry from an energy service venture perspective. It is important to understand the dynamics of that business venture 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 and the growth of the ESCO market.

3. Research Objectives and Methodology

3.1 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 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.

3.2 Methodology

The system dynamics (SD) methodology has been used to study the dynamic and complex nature of socioeconomic systems in a wide range of domains (Sterman, 2000). Various fields within public policy studies have used this approach to study complex problems. In particular, SD has a valuable track record for studies in the energy sector (for example: Dyner and Larsen, 2001; Dyner et al., 2009; Ford, 1997, 2008; Gary and Larsen, 2000; Miller and Sterman, 2007; Shin et al., 2013). The pertinence and legitimacy of using SD in such strategic studies stem from its ability to capture structural mechanisms such as feedback loops, accumulation of flows into stocks, and time delays. These attributes combine to create models with nonlinear and often non-intuitive behaviour, which can often provide useful insight into the behaviour of the real world system being modelled (Sterman, 2000).

To explore and gather insights on the research questions, a SD model was developed with the code Powersim (Powersim, 1993–2016) that represents the marketing, the human resources, the operations, and the financials for a new ESCO firm. The simulation of that model was used for analysing and explaining the development of key variables and their impact on firm performance.

The structure, parameters, and assumptions built into the model are supported by the literature reviewed and by the interviews and case studies. The methodological approach for capturing the critical variables and their relationships 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; Bartoldi et al., 2014; Goldman et al., 2005; Marino et al., 2010; OECD and IEA, 2007; Seefeldt, 2003; Soroye, 2010; Steinberger, 2009; Vine, 2005);
- The authors conducted informal semi-structured interviews to discuss the experience of energy efficiency experts, national authorities, EPC professionals, academics, and financial institutions regarding the development of a sustainable EPC business venture. The criteria for selecting the subjects were that they were involved and interested in the EPC business, and they were representative in the sense that they covered the most relevant stakeholders. The basic topic/question was "how to develop a successful EPC business venture?". The responses were coded in terms of critical factors and relationships.
- Qualitative content analysis of documents and texts about this subject was also applied, with the goal of identifying perceived factors, barriers, and cause-effect relationships that might explain and drive the market and business development. The texts surveyed include political, legal and regulatory documents, written interviews, papers issued by national and regional energy agencies, and communications presented in conferences and workshops on energy efficiency and EPC.
- The calibration of the model was performed using data collected from literature and the field. In particular, data gathered from an ESCO business venture during the period from 2009 to 2014 were used to establish the base case parameters and validate the results of the developed model.

4. Model Development

4.1 The Dynamics of an ESCO venture

The analysis of the data surveyed suggests some reinforcing (R) and balancing (B) feedbacks that could support the development of an ESCO venture if they were understood and considered by managers. Figure 1 depicts many of those loops.

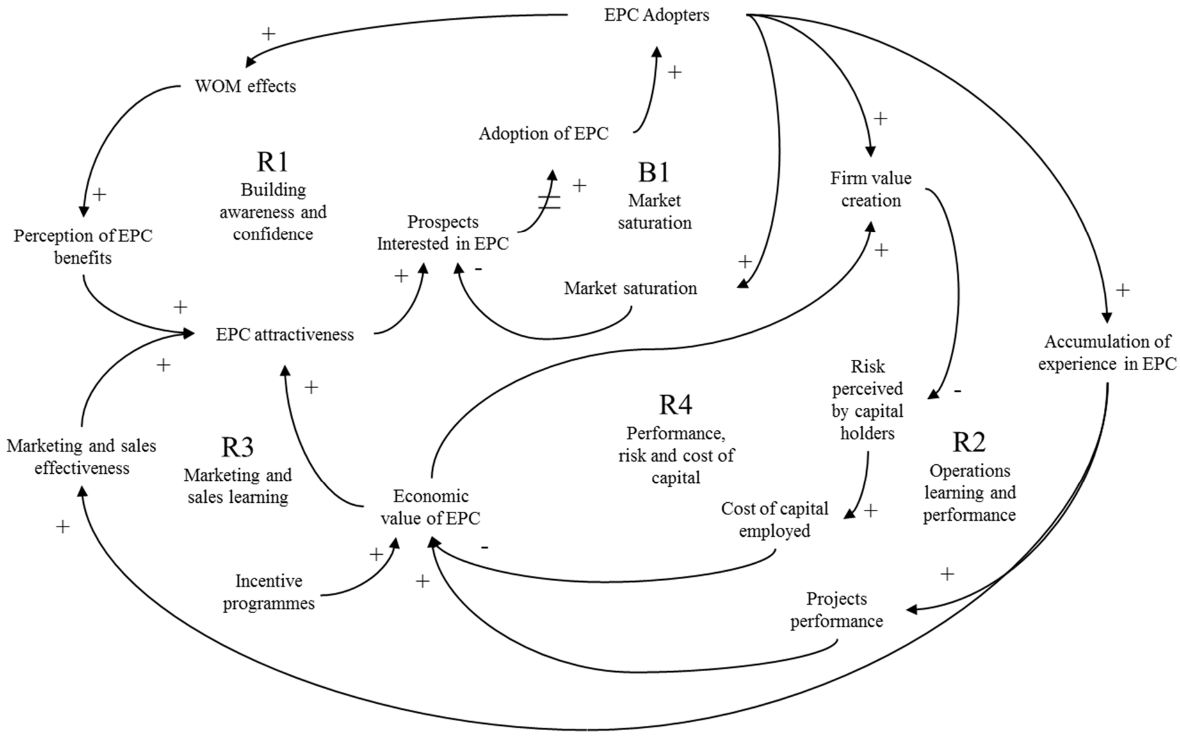

Figure 1 – Causal loop diagram representing the development of an ESCO venture

R1 – "Building awareness and confidence" reinforcing loop:

As reported in literature reviewed, 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. According to data gathered, the awareness and perception of EPC benefits play an important role in the adoption process. The benefits of EPC offered by the ESCO must be known and understood to improve its attractiveness. The ESCO case study revealed that the power of word-of-mouth (WOM) marketing among clients and government communication initiatives are determining factors to influence the EPC awareness and attractiveness.

The building awareness and confidence reinforcing loop is described as follows. 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 WOM concerning its benefits spreads. Once the adoption of EPC streams, the ESCO firm and prospects become more familiar with EPC. This process of building familiarity would increase the attractiveness of EPC. Additionally, the mutual trust between the ESCOs and the clients would be achieved, leading to increased comfort with EPC.

B1 - "Market saturation" balancing loop:
Market saturation induces a balancing loop that limits the growth of EPC adopters. The more the EPC adopters in the system, the fewer the potential projects and the lower the expected new profits from EPC.

R2 - “Operations learning and performance” and R3 - “Marketing and sales learning” reinforcing loops:

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. Thus, one of the most important reinforcing feedbacks is supposed to be the virtuous learning-accumulation of experience loop. This learning process will create and enhance the capabilities of the ESCO for marketing, selling, defining, and implementing EPC projects. As the ESCO employees are engaged in EPC projects they gain further experience and improve their technical, financial, marketing, sales, and management abilities to develop the market. Project design and future energy savings are enhanced, and most project processes become more productive and less costly. The higher economic value of EPC and the more effective marketing and sales increase EPC attractiveness and encourage further adoption.

R4 - “Performance, risk and cost of capital” reinforcing loop:

Estimating energy savings potential and performance verification involves 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. As the ESCO improves its capabilities and increases value creation through EPC business, shareholders will start seeing the EPC business as a less risky business or as a promising market niche and will gradually require a lower interest rate.

Incentive programmes:

It is assumed that subsidies and government programmes supporting energy efficiency projects and EPC may be useful to foster the initial moves of this industry. Financial incentives and programme deadlines played a powerful role in making EPC attractive for many clients. Beyond providing a source of financing, subsidy programmes presented firm deadlines, which fostered a sense of urgency for action that drives EPC adoption. Some examples are incentive policies to subsidize a part of energy audit costs or the interest rate on debt.

4.2. Simulation Model

This section presents a description of the simulation model. The model includes feedback relationships that represent the previously discussed dynamics. The simulation model is divided into five different modules (figure 2) that will then be described in more detail: Marketing (prospect chain), HR (Human Resources), Operations (this module addresses the assignment of HRs to business activities), Finance, and EVA (Economic Value Added).

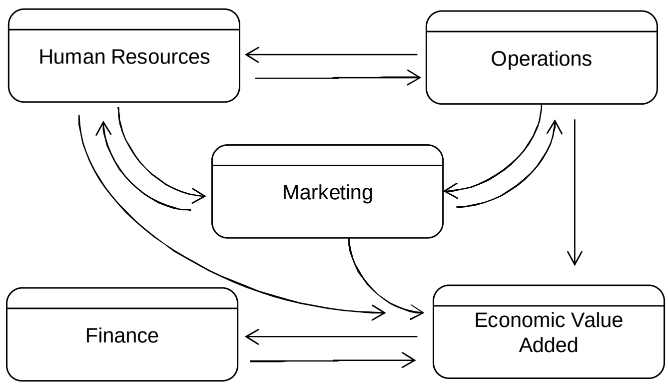

Figure 2 – Modules of the simulation model

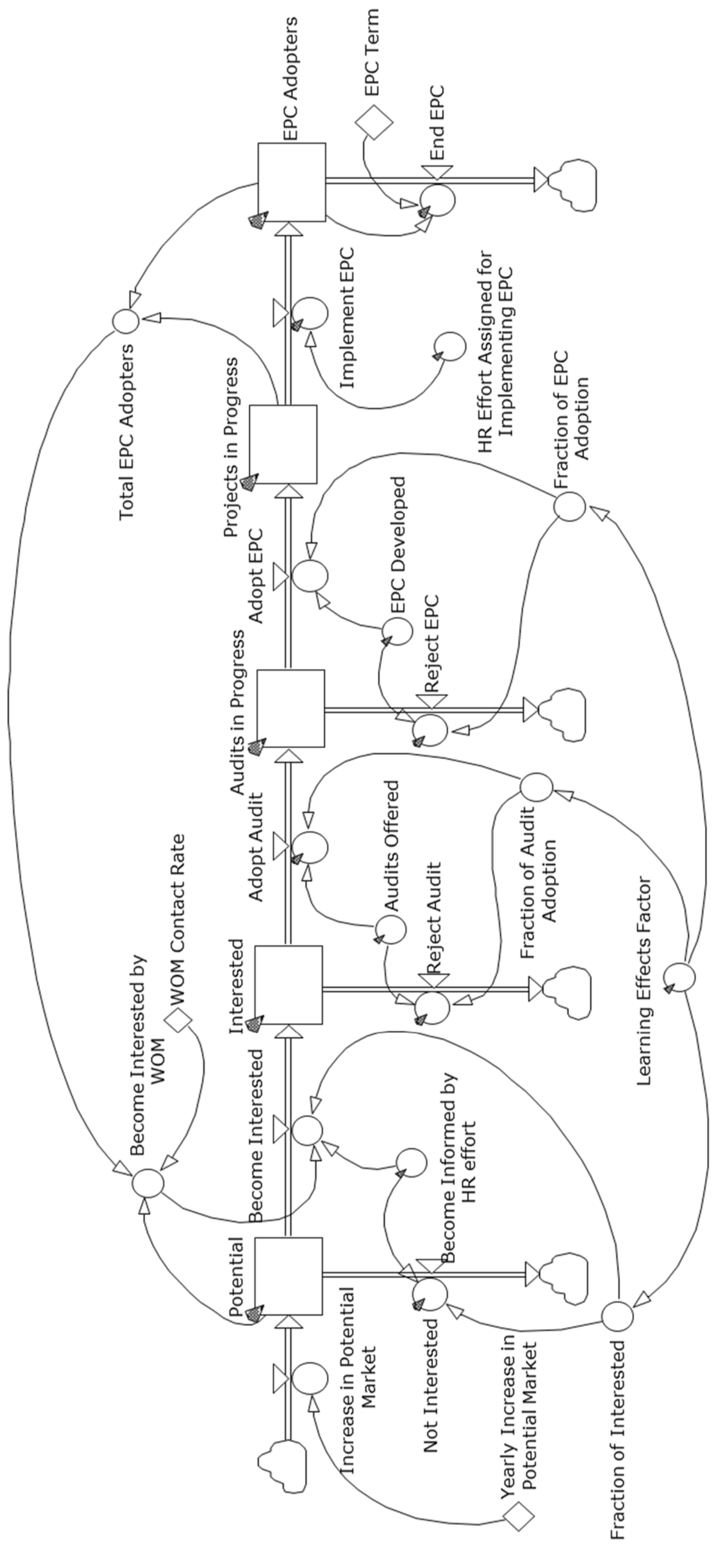

Figure 3 – Simplified stock-flow diagram of the marketing module

Marketing module

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. Similarly to the model of Miller and Sterman (2007), 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 to more closely represent the process of market development. Figure 3 shows a simplified stock-flow diagram of this module. The stock of potential EPC adopters was disaggregated into “Potential”, “Interested”, “Audits in Progress”, “Projects in Progress” and “EPC Adopters”.

The “Potential” stock consists of public or private organizations 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. These are potential customers that have been selected by the ESCO, which will apply marketing and sales efforts to inform or persuade them to adopt the EPC.

“Interested” represents the organizations with commercial buildings that are capable (legally, 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 for special sales efforts to convince the decision makers of these organizations to learn more about EPC. Once potential clients have become aware of EPC and form a favourable perception of the EPC, they flow from Potential to Interested. This flow is dependent on marketing and sales effort and WOM. The effect of WOM is modelled according to Sterman (2000, p333) and Morecroft (2007, pp166-174). As more organizations decide to adopt EPC with the ESCO, persons from those organizations will come in contact with persons from other organizations and spread word about their EPC benefits. From this point forward, it is assumed that the WOM effect is no longer relevant.

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

“EPC Adopters” are organizations that have contracted EPC and implemented the associated energy efficiency project. Once the energy audit has been performed, the ESCO presents the client with an EPC offer. The clients flow 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 that are influenced by experience and learning effects. At this stage, it is also assumed that WOM is not relevant.

Human Resources module

The Human Resources module of the model (see figure 4) is based on the structure of labour and hiring of Sterman (2000, p758). The stocks in this model module are HR (human resources) and HR Experience. 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 to Hire” is determined by

“Minimum HR Needed”, which is influenced by the total effort desired for performing business operations.

The stock “HR Experience” represents the cumulative job experience 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 labour 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 job challenges. The coflow measures the average and total effective experience of the employees (Miller and Sterman, 2007).

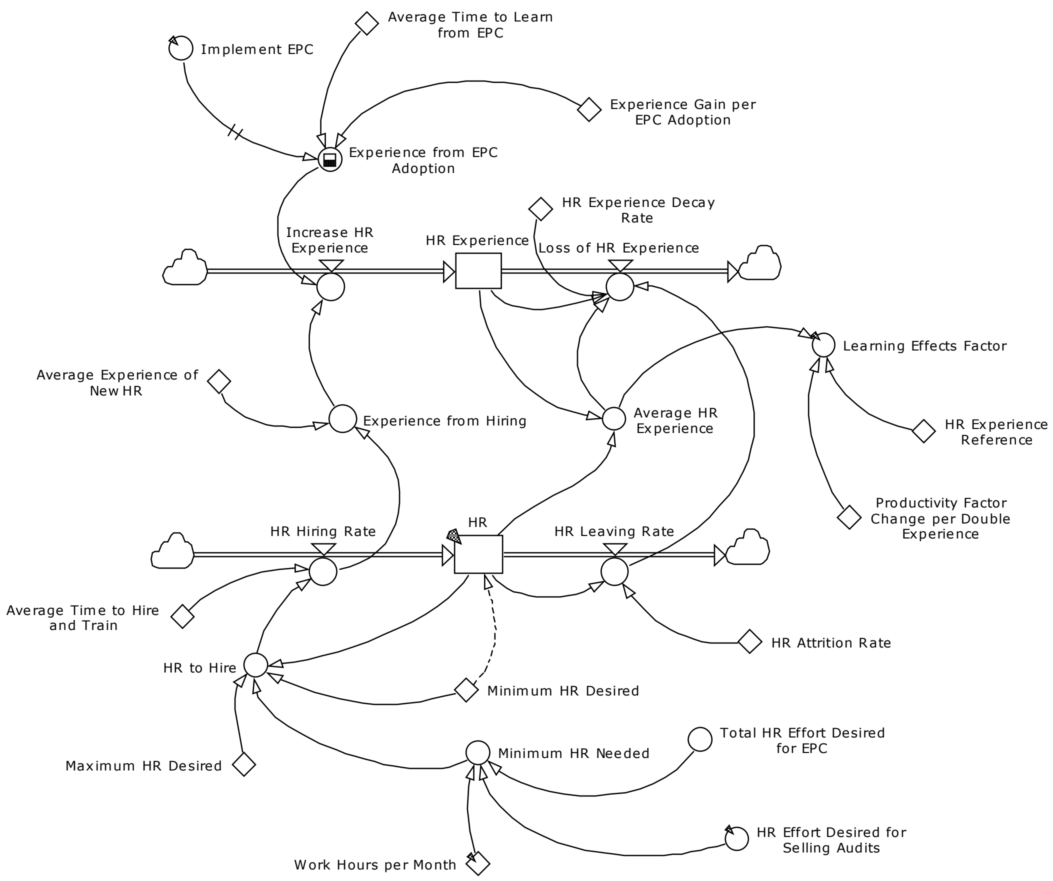

Figure 4 - Stock-flow diagram of the HR module

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, as well as the revenues and costs regarding the implementation and exploitation of energy efficiency projects.

Operations module

In the Operations module, activities are prioritized and assigned to employees according to certain business policies. 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 in the marketing module (figure 3). 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 module

The EVA module of the model describes how the ESCO creates value. In this module, some variables related to revenues, costs, capital and value creation are calculated from the status and flow of resources in the firm. A stock 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 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 EVA. The net revenues produced by EPC projects are represented by a stock variable. The inflow of that stock is determined by the rate of EPC implementation and the learning effects factor. The outflow represents the reduction of firm revenues due to the termination of EPC term.

Finance module

The Finance module of the simulation model addresses the cash flow and debt of the ESCO firm. The cash flows in via revenues from customers (EPC adopters) and via funds borrowed from debt holders. The cash flows out 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 its financial obligations, the funds needed are borrowed, which determines the inflow rate of debt. The debt stock is decreased by the debt repayment rate, which is determined by the debt to equity (DE) ratio, the desired DE ratio, 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 capital), which is used to calculate the capital charge.

4.3 Model Parameters

In this study, data collected from an ESCO business venture during the period 2009 to 2014 were used to estimate and calibrate the parameter values and assumptions of the developed model. For instance, the parameters that drive the flows that accumulate the stocks of clients in the adoption cycle were determined from quarterly data available in the ESCO sales reports. The complete list of parameters and assumptions with correspondent definition and source is presented in an appendix included in the supporting materials.

4.4 Model Validation

According to Sterman (2000), the validation process should establish confidence in the appropriateness of a model for a certain purpose. Structural and behavior validation tests suggested in the literature were carried out to verify the model assumptions. A structure verification test aims to analyze whether the model structure is consistent with relevant descriptive knowledge of the real system (Sterman, 2000). Behavioural validation tests are used to test how consistently model outputs match real world behaviour (Barlas, 1996).

4.4.1 Structure verification

As described in section 4.2, the main model structures are those included in the marketing and human resources modules which are derived from system dynamics literature and past research. In the marketing module, the series of stocks used as a client choice pipeline has been modelled to represent the clients at various stages in the adoption cycle (Miller and Sterman, 2007; Warren, 2008, pp 345-356). The effect of WOM that influences the flows included in the adoption cycle is modelled according to Sterman (2000, p333) and Morecroft (2007, pp166-174). The co-flow structure applied in the human resources module is based on the structure of labour and hiring of Sterman (2000, p758), and takes into account the experience of the employees (Sterman, 2000, p505; Miller and Sterman, 2007; Warren, 2008, pp258-261). Thus, it can be assumed that those model structures represent the existing knowledge of the system.

4.4.2 Behavior tests

Behavioral validation tests were used both to calibrate the parameters and assumptions of the model and to verify how simulation model results match real world behavior. Empirical data gathered from an energy service venture during the period 2009 to 2014 (six years) were used to validate the results of the developed model. For instance, the client choice pipeline structure attempts to replicate very specific aspects to the ESCO industry. Thus, special attention was paid to the determination of parameters that drive the flows that accumulate the prospect stocks in the client adoption cycle.

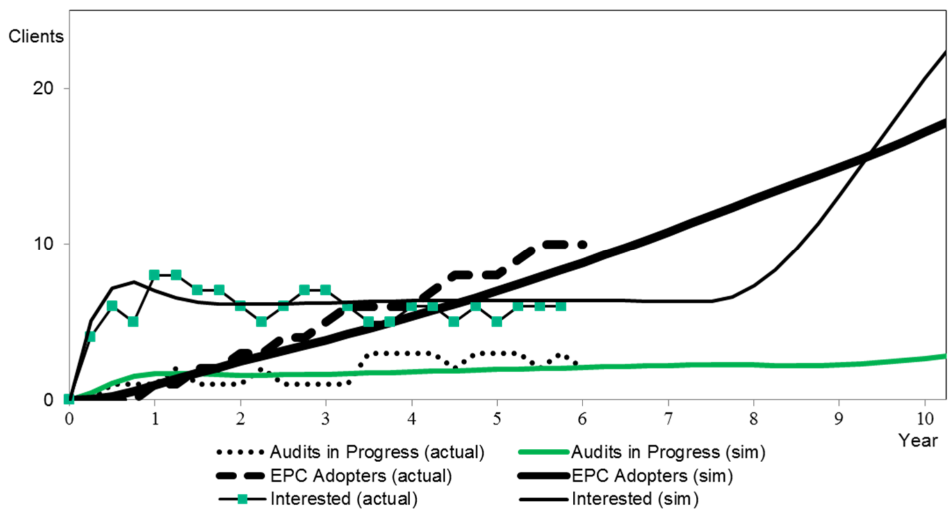

Figure 5: Base case - Comparison of observed and simulated values

In a first step, the simulation results for the stock variables Interested (prospects interested in EPC), Audit in Progress, and EPC Adopters are plotted against the historical data for six years as a visual comparison. Figure 5 illustrates both the simulation results and the historical data about those stock variables. In order to test a model for its appropriate behaviour, statistical measures of correspondence between model simulation results and observed data can be applied (Sterman, 2000). Then, the simulation results and the empirical data were further used to calculate statistical measures as those presented in table 1.

Table 1: Statistical measures of deviations between simulation results and observed data

	Model Variable		
Stastical Measure	Interested (Prospect)	Audits in Progress	EPC Adopters
Mean Deviation	0,36	-0,15	-0,81
Mean Deviation (%)	6,08%	-7,91%	-16,36%
Mean Absolute Deviation	0,83	0,67	0,91
Mean Absolute Deviation (%)	13,87%	36,65%	18,44%
Root Mean Square Deviation	1,00	0,77	1,11
Root Mean Square Deviation (%)	16,67%	42,08%	22,32%

5. Model Simulation

5.1 Base Case

The firm starts out with a service (EPC) that is not known by the market. There are 600 firms (potential prospects) that could benefit from EPC and are reachable by the ESCO. The initial capital invested (€1 M) is based on management's projections of how much capital is needed to develop the first projects. The venture starts with five employees focused on EPC sales, energy engineering, and project management. They have no experience advantage given that the EPC service has never been sold before. It is assumed, however, that the employees will learn and become more productive over time after implementing EPC based energy projects.

Table 2 and figures 6a-6h illustrate the firm 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 two years there are no full EPC adopters. The first projects are implemented in the third year. Managers would expect to have approximately 33 EPC based projects implemented by year 15 (figure 6a).

As shown in figure 6c, the number of relevant employees maintains approximately the minimum capacity (five project managers) until the ninth year. As the flow of prospects increases, the number of employees is adjusted, reaching 13 project managers by the year 15. Figures 6e and 6f show the behaviour of the financial variables Capital employed, Equity, Debt, Cost of debt, and WACC. In the first two years, the firm has just one implemented project and spends a great portion of the initial €1 M of capital (from initial equity). In the third year, the revenues start to come from the first EPC based projects, and those revenues are just sufficient to pay its few employees and overhead costs. Figures 6g-6h illustrate the economic performance of the ESCO over the 15-years period. Accumulated net earnings become positive after the sixth consecutive year of negative value. For seven years, the EVA is negative, and in the following two years, there is no significant positive EVA. Thus, there is no record of significant

EVA after nine 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 MVA only becomes positive in the 15th year, which means that this business does not add value in the first fourteen years. As such, the simulation results suggest that the business venture is only viable in the long term. Additionally, as seen in table 2 and figure 6h, the MVA (by year 15) of the simulated firm is not significant (€105 K).

Table 2: Base case - performance over 15 years

Simulation time (years)	Work force (project managers)	Learning effects factor (0-1)	Interested prospects	EPC adopters	Accumulated net earnings (K€)	Market value added (K€)
1	5	0,64	7	0	-111	-236
3	5	0,68	6	3	-205	-494
5	5	0,78	6	5	-141	-601
10	5	0,99	21	15	841	-588
15	13	0,97	41	33	7,099	105

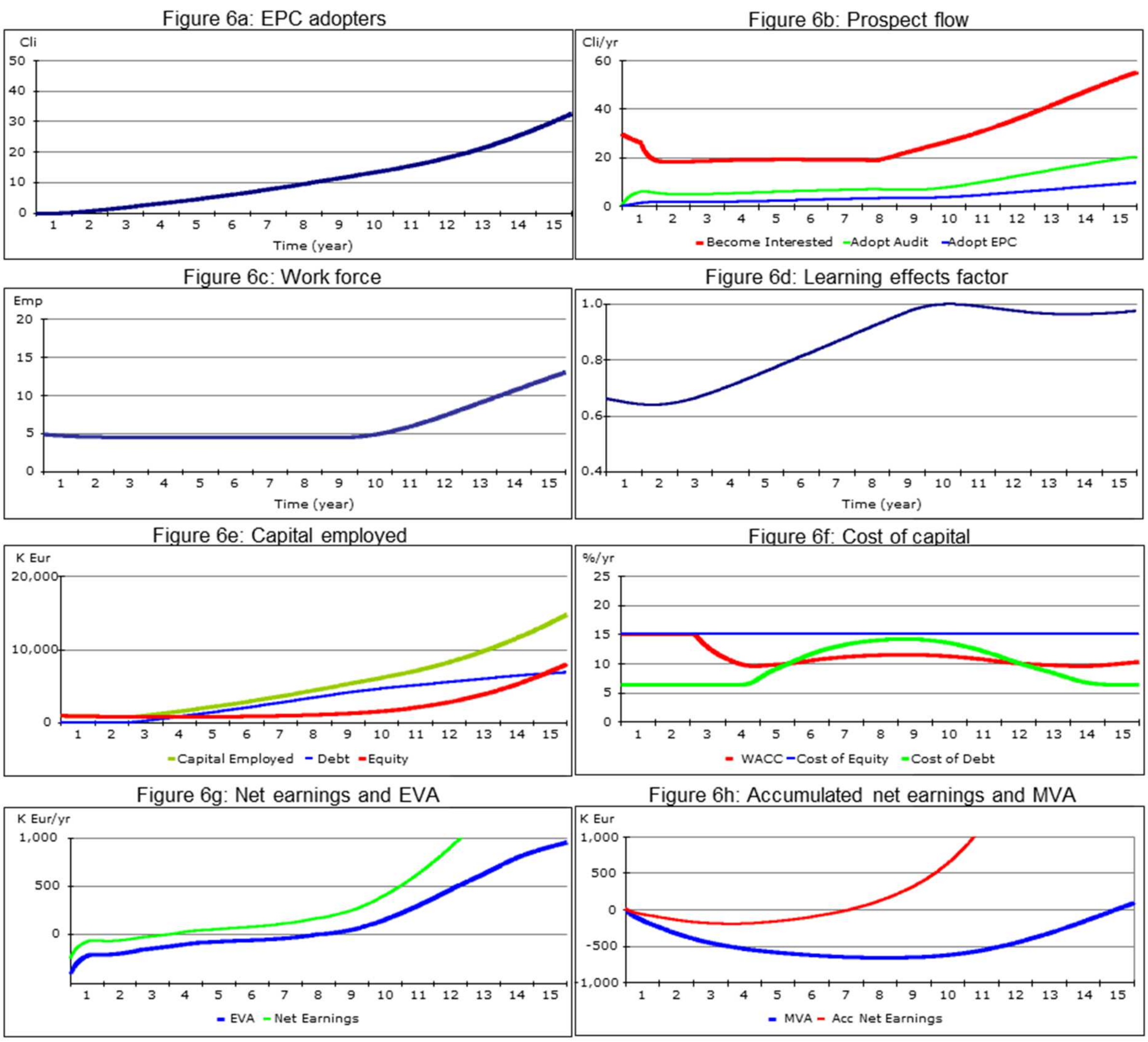

Figure 6: Base case - performance over 15 years

A risk analysis of the simulation model is performed (using the Monte Carlo sampling method provided by Powersim software with 1000 iterations) with regard to the uncertainty of some critical assumptions that are defined according to a normal probability distribution rather than fixed values. The analysis considered the following model assumptions and respective standard deviations: Net Savings per EPC with 10% standard deviation, Investment per EPC with 10% standard deviation, Time to Inform Prospects with 25% standard deviation, Time to Adopt Audit with 25% standard deviation, Time to Develop EPC with 25% standard deviation, and Time to Implement Project with 25% standard deviation. This risk analysis varies the values of those assumptions to calculate a probability distribution for the MVA variable. Figure 7 shows the range in which that the MVA falls with different certainty levels (MVA curves of 10%, 25%, 50%, 75%, and 90% percentiles). For instance, a value of 90% means that 90% of the simulation runs gave MVA below the 90% percentile curve. On the other hand, it also means that 90% of the simulation runs gave MVA above the 10% percentile curve, and so on. As seen in figure 7, MVA values (by year 15) are low and very sensitive to changes in the assumptions, which make it more difficult for the firm to succeed. Indeed, the poor MVA 50% percentile value (€24K) indicates that the base case firm has approximately a 50% probability of failure (corresponding to negative MVA).

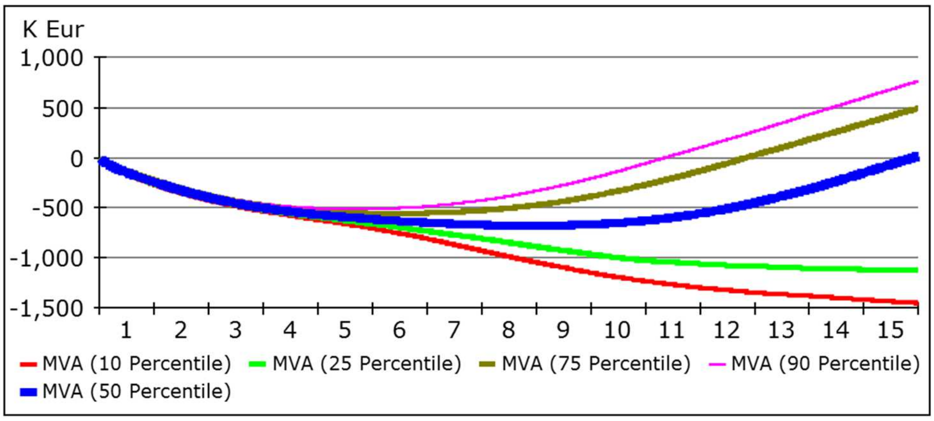

Figure 7: Base case – MVA risk analysis

In summary, considering that the assumptions included in the base case are realistic, the simulation results suggest that an ESCO venture with proper management processes can succeed in the long term. The sensitivity analysis of the model shows, however, that such a business venture would be risky as it would have an approximately 50% chance of adding value.

5.2 Analysing the sensitivity of the ESCO performance to business strategies

The present study focusses on the determination of government policies that would improve the odds of success of ESCO ventures; however, the present simulation model also supports decision makers to explore and learn about the dynamics of managerial processes and strategies as they are able to assess the performance effects of each. For instance, managerial strategies may involve alternative marketing, financial, staff, and operations policies and decisions that will impact and determine that venture success.

5.3 Analysing the sensitivity of the ESCO performance to government policies

The following sections explore the dynamic effects of energy policy on an ESCO business venture. Some government policies recommended in the literature to develop an energy services industry are selected for assessment through simulation, such as initiatives to improve

WOM, low interest rates, energy audit subsidies, public procurement for EPC, and demonstration projects. By generating scenarios over time, the model simulates the performance impacts of those policies.

5.3.1 Effect of WOM initiatives

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 potential prospects to have progressed down the sales cycle to become interested prospects, audit adopters, and finally EPC adopters. At that stage, to accelerate the ESCO profitability, it is important to take advantage of the WOM potential. The assumption here is that a set of government and ESCO initiatives would foster the WOM phenomenon by promoting specific events such as technical seminars to demonstrate the success of some EPC projects. Table 3 shows a comparison of four cases using different WOM contact rates: the base case, which considers three prospects per adopter per year, and three other cases. As presented in figure 6h, the base case produces a low MVA (€105 K). The other cases represent improved WOM effects and are defined by setting the WOM contact rate parameter as 4.5, 6, and 9 prospects per adopter per year.

Table 3 – Performance associated with different WOM contact rates

	Base Case	Case A	Case B	Case C
WOM Contact Rate (prospects/adopter/year)	3	4.5	6	9
3 years MVA (k€)	-494	-482	-554	-614
5 years MVA (k€)	-601	-567	-636	-696
10 years MVA (k€)	-588	-429	-286	-210
15 years MVA (k€)	105	483	942	1,201

Figures 8a-8e show what happens when the contact rate parameter is augmented by up to 9 prospects per adopter per year. As shown by comparing figures 6b and 8b, the prospect flow rates increase immensely, especially from year 4 to year 9.

By the year 15, the ESCO will be running 80 EPC based energy projects (figure 8a). As shown in figure 8c, the number of employees hovers around the minimum capacity (five employees) until the fourth year. Then, to respond to the increasing number of prospects, the work force is augmented by up to 23 employees. Figures 8d-8e show the economic performance. For the first four years, the variable EVA is negative, after which point the firm starts to develop positive EVA. Finally, setting that improved contact rate results in a reasonable positive MVA (€1.2 M), which means that in this scenario the new firm will be viable because 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 WOM among EPC adopters and prospects.

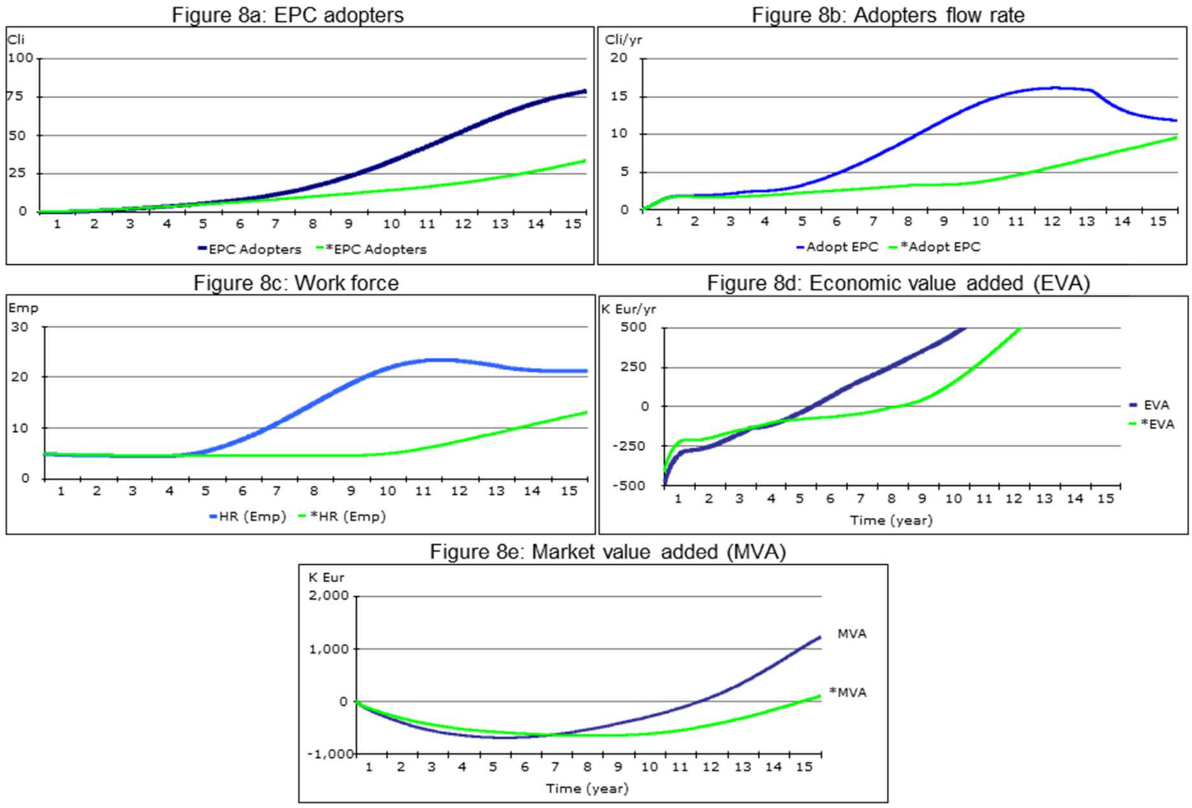

Figure 8: Improved WOM case - performance over 15 years
'*' curves refer to the base case simulation

5.3.2 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 4 compares three incentive levels: 5%/year, 2.5%/year, and 0%/year interest rate on debt for the first 10 years. As shown, a lower interest rate on debt significantly increases the economic performance. 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) incurred in the base case from year 5 to year 12 (as displayed in figure 6f).

Table 4 – Effect of financial incentive (low interest rate on debt) on the ESCO performance

	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
3 years MVA (k€)	-494	-492	-490	-487
5 years MVA (k€)	-601	-572	-550	-528
10 years MVA (k€)	-588	-215	-104	2
15 years MVA (k€)	105	523	615	699

5.3.3 Effect of energy audit subsidy

Another common type of policy is to subsidize a portion of the energy audit costs (Bartoldi et al., 2014). The expected result of this policy is to stimulate energy audits to be used as the basis for EPC projects by lowering the up-front costs to the client. It is assumed that a subsidy programme would increase the fraction of energy audit adoption from 20% to 50%. Table 5 shows the simulation results for a three year subsidy scheme assuming five different impact factors: 1.2, 1.3, 1.4, and 1.5, corresponding to increasing the fraction of audit adoption by 20%, 30%, 40%, and 50%, respectively. A MVA of €1 M is achieved by setting the impact factor as 1.71. Figures 9a-9b present some simulation results for case D, which considers an impact factor of 1.5.

Table 5 – Effect of energy audit subsidy

	Base Case	Case A	Case B	Case C	Case D
Impact of audit subsidy on audit adoption rate for a three years subsidy programme	100%	120%	130%	140%	150%
3 years MVA (k€)	-494	-445	-422	-400	-379
5 years MVA (k€)	-601	-541	-512	-485	-458
10 years MVA (k€)	-588	-393	-306	-226	-153
15 years MVA (k€)	105	428	559	678	788

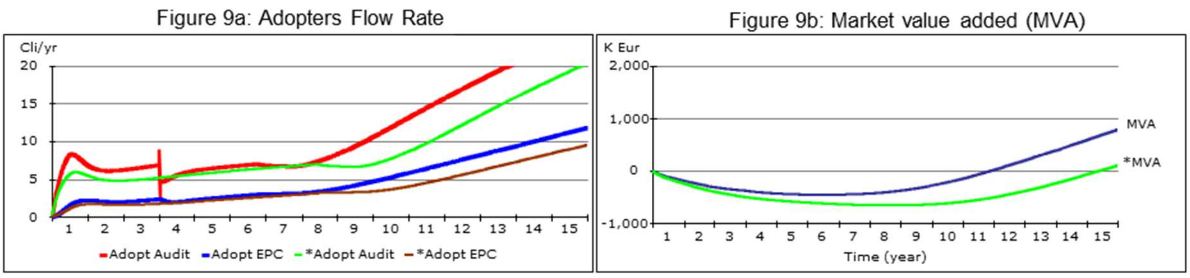

Figure 9: Audit subsidy programme case (case D) - Performance over 15 years
'*' curves refer to the base case simulation

5.3.4 Effect of public procurement programme

The promotion of public tenders for implementing EPC projects in public buildings could be a supportive policy measure. In this initiative, government energy authorities select certain public buildings for EPC project implementation in partnership with ESCOs. A stock representing those public buildings is defined to accommodate that policy measure in the model structure. These public buildings will be submitted to energy audits, project development, and EPC agreements.

In the present study, a three-year programme for improving energy efficiency in public buildings is simulated in which ESCOs are called on to propose their energy audit and EPC offers. It is assumed that a certain number of public projects will be available to the startup firm. Table 6 compares three levels for the programme calling rate in terms of average number of public buildings per year: 1, 2, and 3 buildings per year. As shown, this type of policy measure could be very beneficial for an ESCO startup. Figures 10a-10d present some simulation results for case C, which considers a calling rate of three buildings per year.

Table 6 – Effect of public procurement programme on the ESCO performance

	Base Case	Case A	Case B	Case C
Public EPC projects - yearly calling rate for a three years programme	0 pp/year	1 pp/year	2 pp/year	3 pp/year
3 years MVA (k€)	-494	-478	-462	-446
5 years MVA (k€)	-601	-576	-553	-530
10 years MVA (k€)	-588	-484	-384	-291
15 years MVA (k€)	105	329	540	743

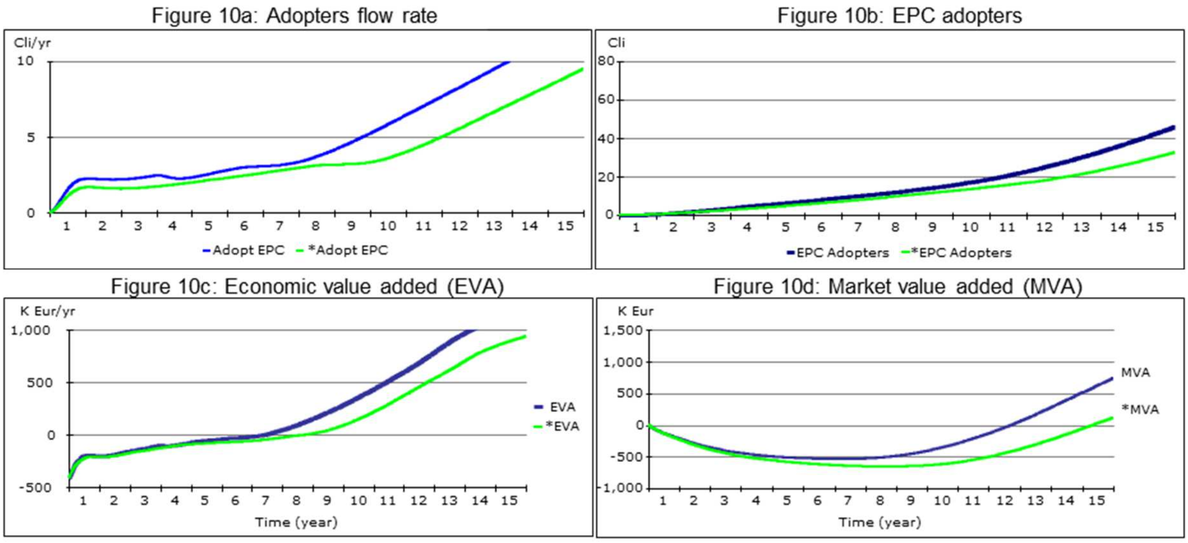

Figure 10: Public procurement case (case C) - performance over 15 years
'*' curves refer to the base case simulation

5.3.5 Effect of demonstration projects programme

A demonstration programme is another policy measure that could be applied by government authorities to promote ESCOs, particularly in countries where there is a lack of experience and awareness concerning energy services and projects on an EPC basis. In a demonstration programme, ESCOs are called to develop and implement EPC based projects. Energy authorities select a set of private and public buildings that are suitable to serve as pilot and demonstration projects to display the benefits of energy efficiency projects based on EPC. Those buildings have had energy audits and are capable (legally, economically and technically) of adopting EPC. By engaging in this type of programme, the startup firm has the opportunity to accelerate learning on EPC processes. On the other hand, the results of these learning processes will be disseminated to improve knowledge, awareness, and trust surrounding EPC and ESCOs. The model development considers a stock variable representing those demonstration projects to permit the evaluation of that policy measure.

Table 7 – Effect of demonstration projects programme

	Base Case	Case A	Case B	Case C
EPC demo projects - yearly calling rate for a three years program (dp/year)	0 dp/year	1 dp/year	2 dp/year	3 dp/year
3 years MVA (k€)	-494	-481	-475	-516
5 years MVA (k€)	-601	-539	-496	-473
10 years MVA (k€)	-588	-138	217	534
15 years MVA (k€)	105	953	1,658	2,219

The present study explores a three-year demonstration programme. It is assumed that a certain number of demonstration projects will be available to the startup firm. Table 7 presents the simulation results considering three levels of calling rate in terms of average number of demonstration projects per year: 1, 2, and 3 projects per year. Figures 11a-11e present some simulation results for case C, which considers a calling rate of three demonstration projects per year. Figure 11e in particular shows the acceleration of the learning processes as the associated effect occurs approximately three years before the base case. These results suggest that this type of policy measure can be very effective as it contributes expressly to the success of that business venture.

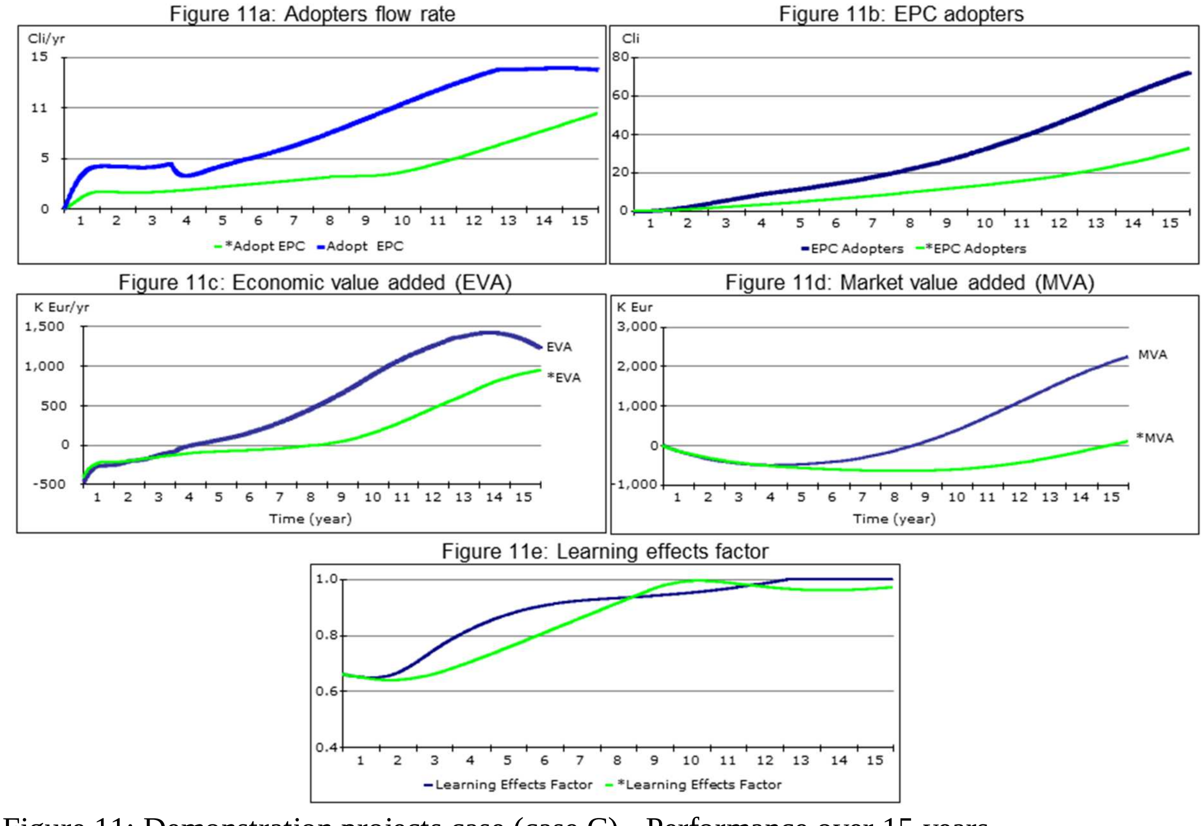

Figure 11: Demonstration projects case (case C) - Performance over 15 years
'*' curves refer to the base case simulation

5.4 Effect of combining policies

The preceding section examined the potential impact of that several factors related to several government policies on improving the performance of an ESCO venture. As revealed by the base case simulation results, an ESCO venture with proper management processes can succeed without government policies in place. The sensitivity analysis of the model shows, however, that such a business venture would have approximately 50% chance of doing so. As each one of the above fostering policies is implemented in the simulation model, the firm does significantly better than the base case. Thus, supportive government policies would provide the venture a much higher chance of succeeding and achieving wide adoption of EPC. This section analyses and explores the effect of combining the following government policies:

A - Improved WOM contact rates: this represents a set of government initiatives that would foster and take advantage of the WOM phenomenon. Due to these initiatives, it is assumed that the WOM contact rate parameter would be improved from 3 to 6 prospects/adopter/year.

B - Financial incentives: a government measure that provides a low and fixed interest rate on debt. This scenario assumes that the ESCO will benefit from a 2.5%/year interest rate on debt for the first 10 years.

C - Audit subsidies: in this government policy, a portion of energy audit costs is subsidized, to lower the up-front costs to the client. A three-year subsidy programme is assumed, during which the fraction of energy audit adoption would increase by 30%.

D - Public EPC projects: a government procurement programme (for three years) for implementing EPC projects in public buildings. It is assumed that on average, two public projects per year would be available to the startup firm for the three year programme.

E - Demonstration projects: this policy measure consists of a three year demonstration programme promoted by energy authorities to show the benefits of EPC. This scenario assumes that on average, two demonstration projects per year would be available to the startup firm for the three year programme.

Table 8 – Effect of incentive policies on the ESCO performance over 15 years

		Risk Analysis							
	Market Value Added (k€)	MVA (5 perc)	MVA (10 perc)	MVA (25 perc)	MVA (50 perc)	MVA (75 perc)	MVA (90 perc)	MVA (95 perc)	Likelihood of negative MVA (%)
Base case	105	-1,622	-1,454	-1,120	24	500	774	900	49%
A - Improved WOM contact rate	942	-2,036	-1,725	-694	823	1,365	1,835	2,051	36%
B - Financial incentive	615	-152	66	360	572	795	988	1,089	8%
C - Audit subsidy	743	-1,605	-1,409	-882	488	859	1,145	1,287	41%
D - Public EPC projects	540	-1,686	-1,495	-1,056	465	963	1,277	1,428	42%
E - Demonstration projects	1,658	-2,050	-1,715	-256	1,543	2,099	2,541	2,776	29%

Risk analysis: MVA (over 15 years) sensitivity analysis (Monte Carlo sampling method with 1000 iterations) with regards to the variation of the following assumptions (normal distribution with 10% standard deviation): Net Savings per EPC (normal distribution with 10% standard deviation); Investment per EPC (normal distribution with 10% standard deviation); Time to Inform Prospects (normal distribution with 25% standard deviation); Time to Adopt Audit (normal distribution with 25% standard deviation); Time to Develop EPC (normal distribution with 25% standard deviation); Time to Implement Project (normal distribution with 25% standard deviation).

Table 8 presents a comparison of these five policy measures in terms of MVA to the startup firm. As shown, implementing of any of the policies results in significantly better economic performance than in the base case. The simulated ESCO produces nearly €0.54 M (audit subsidy policy) to €1.658 M (demonstration projects policy) of MVA by year 15. Overall, the firm produces a positive EVA sooner in the presence of those favourable policies. Most importantly, the venture's probability of failure has been reduced substantially. The MVA figures from risk analysis (5%, 10%, 25%, 50%, 75%, 90%, and 95% percentiles) indicate that those government measures enable the reduction of the likelihood of negative MVA. Unsurprisingly, the interest rate reduction policy produced the better improvement of the simulated firm in terms of risk exposure.

Table 9 shows how the possible combinations of government policies impact the expected market value of the simulated firm. As shown, the maximum performance is achieved by combining all five policy measures (A, B, C, D, and E), producing €5.427 M of MVA by year 15. If just four measures are to be selected, the greatest performance impact comes from the A, B, D, and E policies (€5.171 M of MVA by year 15, corresponding to 95% of maximum MVA). Then, in terms of the three measure combination, the A, B, and E policies provide the best performance (€4.617 M of MVA by year 15, corresponding to 85% of maximum MVA). Concerning the implementation of two policies, the greatest MVA is obtained by combining B and E (€2.602 M of MVA by year 15, corresponding to 48% of maximum MVA). Table 10 presents the impact of the most efficient combinations of policy measures on the ESCO performance. As shown, the greatest performance impact is generated by combining the A - improved WOM measure with the E - demonstration projects initiative.

Table 9 – Effect of combined policies on the ESCO performance (MVA over 15 years)

	Market value added over 15 years (K€)			
	Base Case	A - Improved WOM	B - Financial incentive	A B
A - Improved WOM	942			
B - Financial incentive	615	1,826		
C - Audit subsidy	743	1,666	1,335	2,459
D - Public EPC projects	540	1,464	1,080	2,664
E - Demonstration projects	**1,658**	2,489	**2,602**	**4,617**
C D	931	1,848	1,383	3,192
C E	1,939	2,695	2,938	4,952
D E	1,977	2,646	3,229	**5,171**
C D E	2,185	2,796	3,503	**5,427**

By interpreting the data from table 10 using a Pareto analysis, it is interesting to observe that a combination of the three measures A, B, and E produces 85% of maximum performance (corresponding to the five measure combination). Table 11 and figures 12a-12f illustrate the firm performance over the 15-year duration of the simulation model under those three policies. The differences between this A-B-E scenario and the base case are immediately identifiable. There is a clear acceleration of the EPC adopters' accumulation process, as seen from the behaviour of the prospects flow rate and stock presented in figures 12a and 12b. There are expected to be approximately 88 EPC based projects implemented by year 15 (figure 12b), in comparison to 33 adopters occurring in the base case. The number of relevant employees increases to up to 23 in the tenth year, whereas in the base case it stays steady around the minimum capacity until the ninth year (figure 12c).

Table 10 – Effect of the most efficient combinations of policy measures on the ESCO performance (MVA)

Simulation time (years)	Base Case	E	B-E	A-B-E	A-B-D-E	A-B-C-D-E
3 years MVA (k€)	-494	-475	-383	-350	-327	-263
5 years MVA (k€)	-601	-496	-202	-60	42	149
10 years MVA (k€)	-588	217	1,100	2,247	2,766	3,105
15 years MVA (k€)	105	1,658	2,602	4,617	5,171	5,427
%/ ABCDE 15 years MVA	2%	31%	48%	85%	95%	100%

A – Improved WOM contact rate = 6 prospects/adopter/year
B - Financial incentive - 2.5%/year interest rate on debt for the first 10 years
C - Audit subsidy - 30% increase in fraction of audit adoption for a three years subsidy program
D - Public EPC projects - 2/year calling rate for a three years program
E - Demonstration projects - 2/year calling rate for a three years program

Table 11: A-B-E initiatives case - Performance over 15 years

Simulation time (years)	Work force (project managers)	Learning effects factor (0-1)	Interested prospects	EPC adopters	Accumulated net earnings (k€)	Market value added (k€)
1	5	0.64	7	0	-89	-216
3	6	0.75	25	6	20	-350
5	11	0.80	45	13	881	-60
10	23	0.93	55	50	9,177	2,247
15	23	1.00	39	88	30,739	4,317

Equity remains lower than debt until approximately the eleventh year, at which point cash flow from EPC starts to exceed capital expenditures in new projects, which enables debt repayment (figure 12d). Figures 12e-12f compare the economic performance of the simulated firm ESCO to the A-B-E and base case scenarios. In the base case scenario, the EVA is negative for seven years, there is no record of significant EVA after nine years, and the firm begins to develop a reasonable positive EVA flow after only approximately twelve years of simulation time. In the A-B-E scenario, on the other hand, with those government policy measures in place, the investment has strong positive returns (EVA) after three years, almost nine years earlier than the base case (figure 12e). With respect to MVA, figure 12f shows that the combination of the policies also displays a more favourable behaviour as MVA becomes positive in the fifth year, ten years earlier than the base case. Figure 13 presents the results of a risk analysis for the A-B-E scenario regarding the uncertainty of some critical assumptions, which is compared to the similar analysis performed for the base case and presented in figure 7. As can be observed in figure 13, although MVA values (by year 15) are also very sensitive to changes in the considered assumptions, the probability of failure (corresponding to negative MVA) seems to be quite low, which indicates that starting an ESCO venture under these conditions will have a greater chance of success.

Figure 12: A-B-E initiatives case - Performance over 15 years
'*' curves refer to the base case simulation

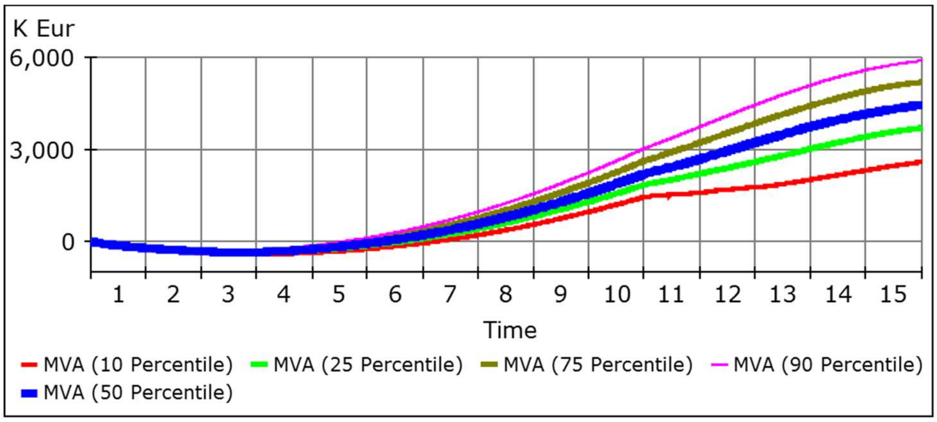

Figure 13: A-B-E initiatives case – MVA risk analysis

In summary, we conclude that the combination of the above government policies (improved WOM contact rate, low interest rate on debt, and demonstration projects) seems to provide the most efficient and robust incentive scheme as they may significantly improve the expected market value of the simulated firm and reduce the probability of failure of ESCO ventures. In other words, the simulations show that the most efficient measures are those that can accelerate learning on EPC processes and take advantage of the WOM effect to change the potential adopters' attitudes regarding EPC in a sustained way, along with financial incentives to assure a competitive cost of capital.

Considering the results of the simulated firm, it is valid to ask whether it is rational for private investors to invest in these ventures at all. For the base case venture, which takes 15 years to achieve profitability, the answer is likely no. Too many hazards could occur over that period of time that would cause the ESCO to fail. If adequate management strategies are followed and the referenced government policies are in place, however, then it would be a good decision to invest in an ESCO with attributes similar to the one modelled.

It must be emphasized that the simulation is not reality. The model developed here is meant to be used as a learning tool; it is not predictive. Actual value creation will vary quite widely and be sensitive to factors outside the scope of this business model. It is possible a real ESCO could do better than the simulated one. Further, there are many factors that are not taken into account in the model that could cause a real venture to underperform and to have a higher probability of failure. The simulation model does, however, provide evidence that the combination of these government policies will significantly reduce the probability of failure of ESCO ventures, improve the value added on investments in these companies, and consequently, increase the odds of success (and the widespread adoption of EPC) from what they would have been otherwise.

6. Conclusion

The development of a commercially viable and competitive market for EPC services provided by ESCOs is considered to be a necessary way to improve energy efficiency by 20% by 2020 and thus contribute to the 20% emission reduction target for greenhouse gases, as assumed by the European Commission (EC 2007) and the Portuguese Government, for the European Union and Portugal, respectively.

Against the initial expectations in Portugal, however, only a few firms are engaged in EPC ventures, and many of those firms reported several difficulties (Bartoldi et al., 2014). Thus, the usefulness of our study is to aid in understanding the critical factors involved in an ESCO startup and the dynamic interactions among those factors to help policy makers and managers to define effective policies, strategies, and managerial processes. Our methodological approach was to build a SD model with mathematical equations relating parameters, which allows computer simulations of different effects.

From the simulation of the base case, we concluded that the overall insignificant MVA and the low probability of success of ESCO result from the long sales cycle, which stems from the length of time required to accumulate EPC adopters in this emergent market and then build up revenue.

Some simulations analysed the sensitivity of ESCO performance to firm policies. The results showed that the MVA is highly sensitive to changes in the WOM contact rate parameter, which suggests that effective management or policy interventions should consider initiatives that could accelerate WOM among EPC adopters and prospects. Other simulations analysed the sensitivity of ESCO performance to public policies that promote energy services. The results showed that low interest rates, energy audit subsidies, public procurement, and demonstration projects produce a positive EVA sooner than in the base case. Most importantly, the venture’s probability of failure is reduced substantially. Unsurprisingly, the interest rate reduction policy produced the better improvement of the simulated firm in terms of risk exposure.

Finally, the simulations show that a combination of WOM acceleration policy and public policies focused on low interest rate and demonstration projects significantly increase the MVA and reduce the probability of failure of ESCO ventures, consequently increasing the potential for widespread adoption of EPC within a virtuous industry cycle.

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