Why Do We Hesitate to Take Action Toward Implementation of Sustainable Technology?

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Abstract

This paper presents a system dynamics model which shows that there seem to be rational reasons for hesitation to invest in resource-saving projects. In contrast to classical marketing approaches dealing with decreasing resource and product prices a new kind of follower advantages in a market of increasing resource prices may constitute a waiting game which in turn can significantly delay the deployment of sustainable technologies. This new kind of follower advantages and the related hesitation to introduce a potential resource-saving new technology may be significant when anticipating the market diffusion of such a technology or designing policy to foster green economy. A price shock of resources, as shown by model simulations, might be a possible way to switch back from such a waiting game to a preemption game.

Keywords: deployment of sustainable technology, competition, preemption game and waiting game, technology substitution

1. Introduction

Over recent decades there has been a dramatic expansion of the volume and range of natural resources traded internationally. Today extreme quantities of almost every raw material are traded around the world – fuelling the rapid spread of industrialization and development that is defining the modern economic era. Although a number of factors have contributed to the "globalisation" of natural resources – including population growth, colonisation, industrialization, and the rise of developing countries (WTO 2010). Worries about the possible peak oil, extreme global warming effects and the many other resource and environmental challenges facing us today have reignited a complex, international debate about whether continued economic development will save or destroy the planet.

Competition advantages and investments in new technologies

Therefore, this paper wants to show that one the hand the increasing resource prices and thus increasing profitability makes a new time-based competition strategy necessary and on the other hand there exists some immanent technological uncertainties which are by themselves enough for switching "the timing competition [...] in a fundamental way from a preemption game to a waiting game" (Hoppe 2000).

Stalk published some very crucial statements about one specific source of competitive advantage-time (Stalk 1988). Stalk describes time as one of the major competitive advantages, which could be often seen in the former Japanese machine industry. Furthermore, this type of competitive advantage can be described as a very flexible one, which saves a lot of financial investments by creating a more time-efficient style of business.

Spence developed a model of competitive interaction and industry evolution in the presence of a learning curve (Spence 1981). His paper assessed the impact of learning spillover effects from one firm to the next in a multifirm competitive context.

Lieberman discussed especially the ideal moment a pioneer to start a business (Lieberman 1998). One of the most interesting arguments seems to be the that different kinds of uncertainty weakens the best moment in time for the pioneer and it could happen that early entrants use one kind of resource, which seems to be from a financial, long-term point of view, not very sustainable and cost-efficient. By analysing different publications in this scientific field Lieberman finally explains some more competitive advantages, for example that the timing for entering a new market seems to depend upon the company's strength and weaknesses. Generally speaking, the company's skills and orientation are crucial for the competitive advantage for example for investing in the production of a more resource-saving technology.

Modelling scenarios with anticipative technologies

This paper is focusing on two competitors with different strategies in different realistic scenarios, designed with the help of a system dynamics model. System dynamics as a methodology is widely used to describe and anticipate (see, e.g., Dubois 1998) changes in different markets, especially regarding technology substitutions (see, e.g., Maier 1995, Anderson 1996, Stamboulis 2004, Dattee 2007, Bosshardta 2008).

In comparison to other approaches we focusing on the situations that the product which both competitors produce is resource intensive. In other words a considerable cost-saving potential can be exhausted through adoption of certain resource-saving technology. In addition, this potential can be assumed to increase in the future due to growing resource prices. Interestingly, model simulations presented in this paper seem to provide evidence that this increasing potential leads to a possible follower advantage in a competition which in turn causes that competitors hesitate to timely start resource-saving projects.

New approach

Generally speaking, systems with immanent delays are more complex and make anticipation more necessary to compensate the negative effects from a managerial point of view (see Dubois 2008, Löfstedt 2010). In this paper, however, we are focusing on deliberately delayed investment to exploit follower advantages. This new kind of follower advantages and the related hesitation to introduce a potential resource-saving new technology may be significant when anticipating the market diffusion of such a technology or designing policy to foster green economy. We extend the fundamental work of (Anderson 2010) taking into account the approach of multilayered games of (Lozovanu 2009) and experimental design. As the authors mention in (Anderson 2010) the combination of mathematical results, experiments and software demonstrations is a fruitful one. The approach presented here tries to move this attempt towards the theory of anticipatory systems, esp. the detection of anticipatory effects within preemption games.

In the following section 2 we introduce a system dynamics model which we use to calculate the return on investment (ROI) of resource-saving projects in a competitive context. Section 3 presents several simulated scenarios of price development which reveal more details of follower advantages in a market of increasing resource prices. In section 4 we conclude our contribution.

2. A system dynamics model

From a business point of view decisions are made on the basis of an expected return on investment. Attention is also paid on comparisons to competitors to compensate the influences of external factors. In the following we introduce a system dynamics model step-by-step, i. e, as a set of sub-models which are built on one another successively. The model can be used to find the optimal timing to start a resource-saving project in a competitive context.

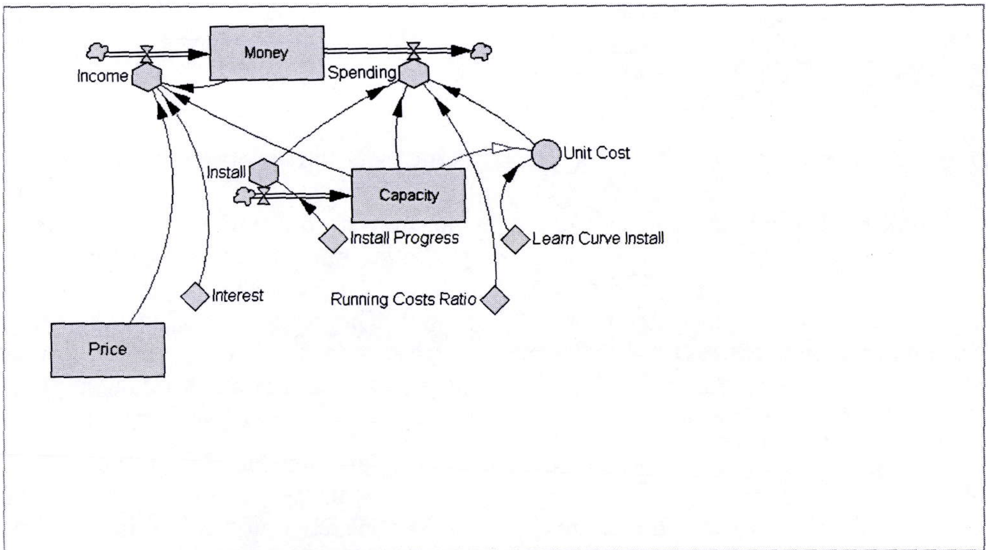

Figure 1. Profit calculation for investment in resource-saving capacity

Description of the system dynamics model step-by-step

As defined in the first sub-model shown in fig. 1 the revenue of a company achieved through a resource-saving project is given by the sum of investment and production incomes, whilst the spending consists of costs for installation and maintenance. The model takes into account that the development of "Unit Cost" obeys an internal learning curve. The decision problem is to find the optimal timing to start the installation of resource-saving capacity to maximise the stock "Money" within in a longer period of time, say 20 years.

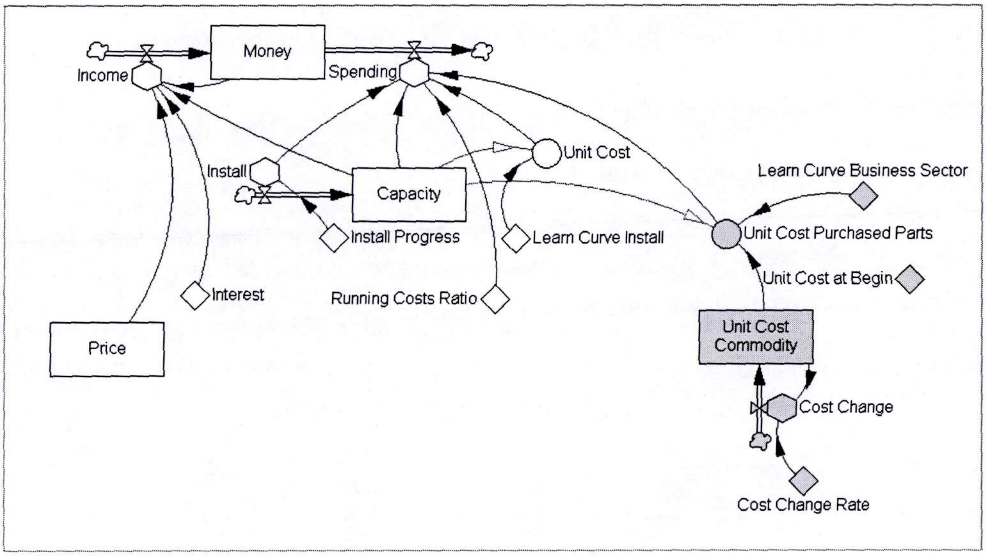

Figure 2. Commodities and business sector specific parts and services

To install resource-saving capacity one does not only need internal but also external services and purchased parts. This leads us to the sub-model depicted in fig. 2. We assume that purchased parts (and services) consist of business sector specific ones on the one hand and commodities on the other hand. The costs of the business sector specific parts (and services) obey a business sector specific learning curve. We assume that the price of the resource to be saved and the prices of commodities are independent from the behaviour of the actor under consideration.

A deciding input parameter of this model is the price development of the resource to be saved. While uncertainty of price development remains, in contrast to the conventional concept of the time-based competition (Stalk 1988) in which a moment of time as early as possible is desired, this model shows that, under certain conditions, there exists an optimal timing to start the installation of the resource-saving capacity (fig. 3).

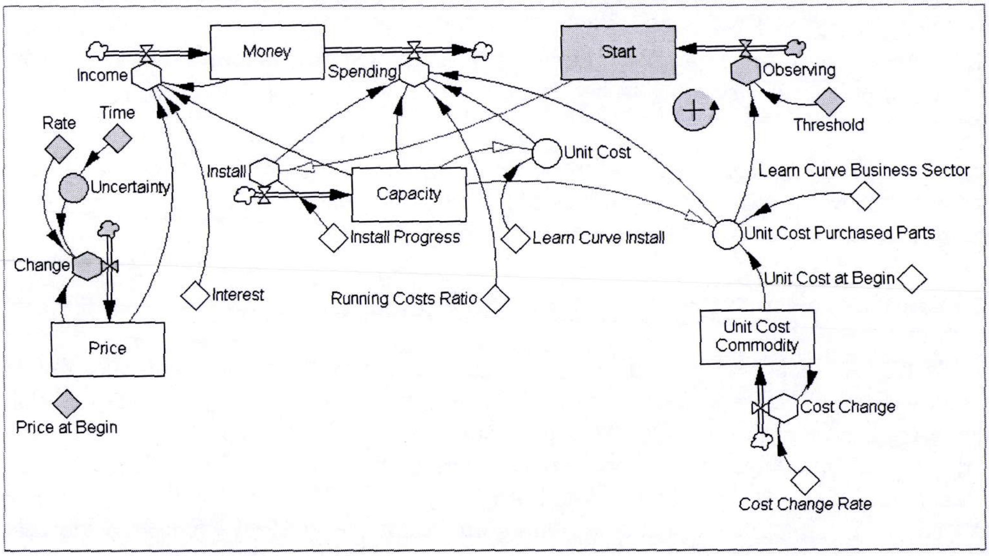

Figure 3. Price development of the resource to be saved

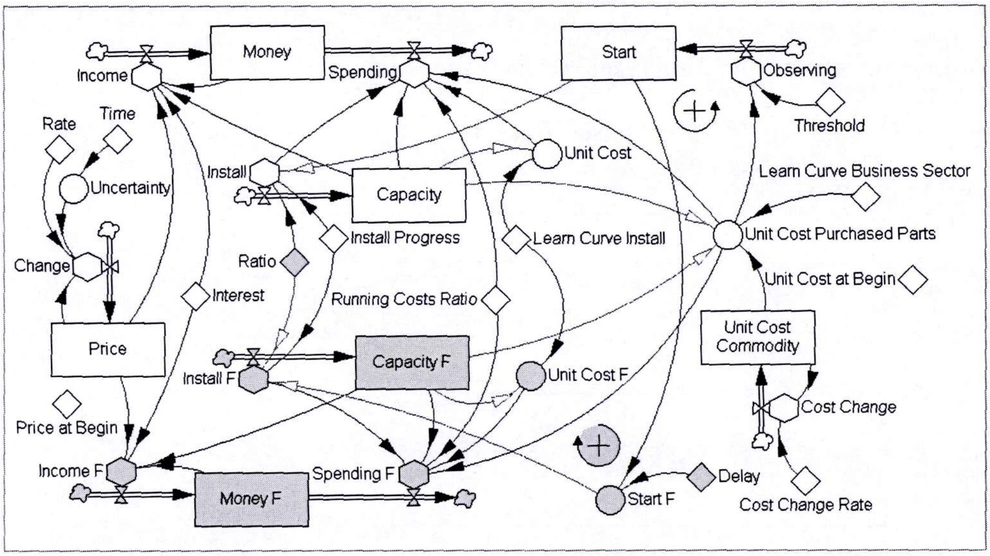

Figure 4. The complete model: two competitors in a business sector

The complete model

The last step to complete the model is to take a follower ("Money F") in the same business sector into account. After the pioneer company started its resource-saving project, there always exists an optimal moment of time, when a follower company producing same products can start its project in the same way. Because the pioneer and the follower share the same learn curve of business sector the supply market for the purchased parts and services will become cheaper for the follower than for the pioneer (fig. 4).

This system dynamics model will be used in the following chapter for further explanations of the existence of different kinds of uncertainty, which arise not only on a macro-economic but especially on a micro-economic level.

3. Follower advantages - scenario development

In this section we present now different scenarios based on the system dynamics model which we introduced in section 2 to demonstrate a follower advantage in a market with increasing resource prices. The starting parameters used for the model simulation are explained in following: The resource price is at 60 money units and has a change rate of 5%/a. Additionally, the parameter install progress is set to 1000 units within a year. The unit costs of commodities at the beginning are set at 300, closely connected the cost change rate is set to -5%/a. The business sector specific parts and services have a cost level starting at 100 so that the starting value of "Price of purchased parts and services" is 400 in all scenarios.

Optimal timing for adopting resource-saving technology

The both parameters to be optimised from the points of view of the competitors are "Threshold" and "Delay".

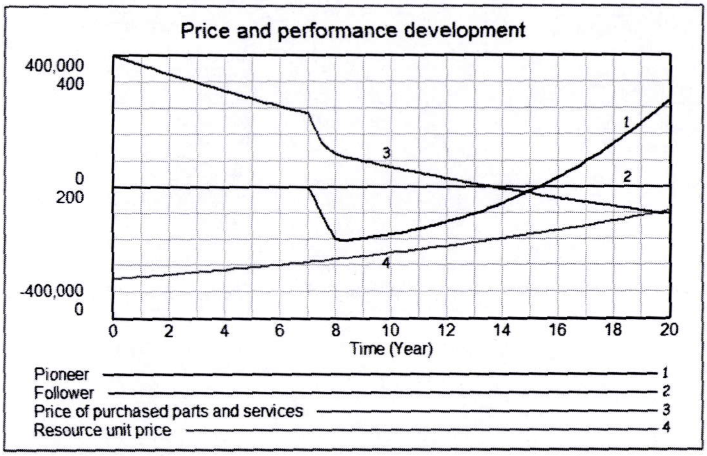

Figure 5. The optimal timing to start adopting resource-saving technology is the 7th year

Fig. 5 shows the first scenario where the optimal timing to start adopting resource-saving technology is the 7th year. Both the price of purchased parts and services and the pioneer's financial outcome (curve 1) is decreasing significantly in that year due to the initial investment by the pioneer. In this first scenario the follower does not take any action (curve 2). The development of the prices of purchased parts and services and the one of resource are displayed as curve 3 and curve 4 in all figures of this section.

Follower advantage under increasing resource price

Fig. 6 shows that a follower (curve 2) is able to outperform the pioneer (curve 1) if the follower starts his resource-saving project about 3/4 year later.

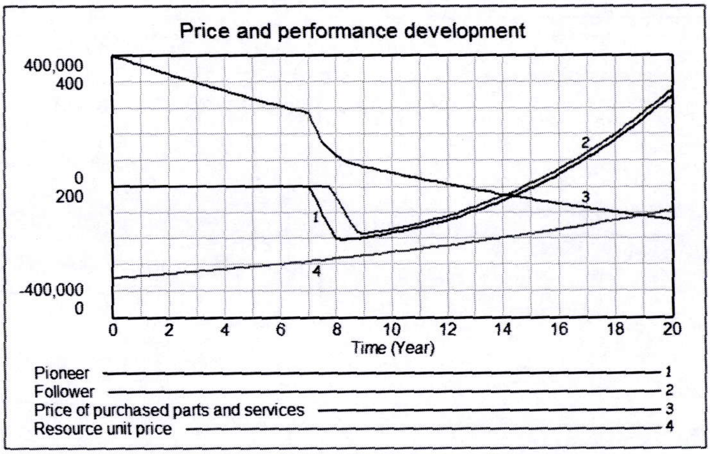

Figure 6. However, a follower can easily outperform the pioneer in this case

To evade the follower advantage the pioneer must postpone the start of his resource-saving technology project to the 13th year, as shown in fig. 7. Notice that in this case the financial outcome is worse than in the previous scenario for *both* competitors.

A counter-check: decreasing resource price

To counter-check our simulation a decreasing resource price is assumed in the next scenario (fig. 8). Consequently a totally different picture occurs. If the resource price decreases the follower always loses against the pioneering company regardless of the timing by the pioneer.

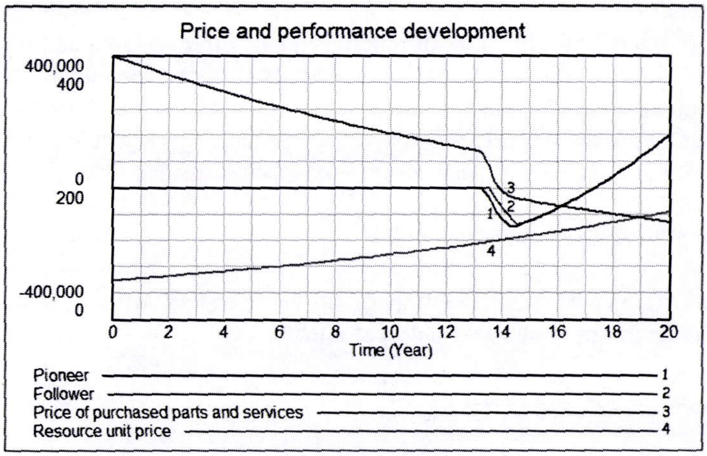

Figure 7. To evade being outperformed the "pioneer" must postpone the start to the 13th year!

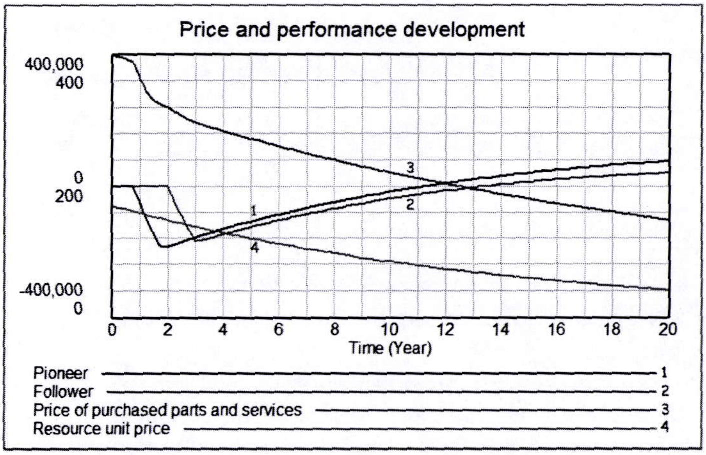

Figure 8. If the resource price were decreasing we had a totally different picture – The follower would always lose.

Anticipation and policy design

It becomes apparent that there is a new kind of follower advantages which is only observable under increasing resource prices. This new kind of follower advantages and the related hesitation to introduce a potential resource-saving new technology may be significant when anticipating the market diffusion of such a technology or designing policy to foster green economy.

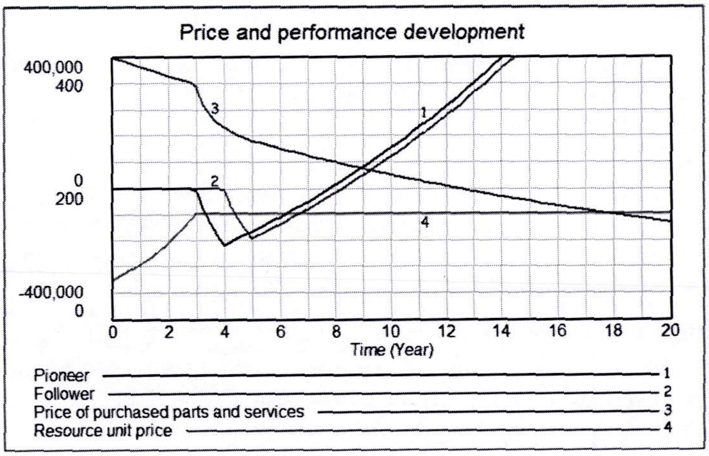

Figure 9. A price shock may encourage the pioneer

As shown in fig. 9 a price shock followed by a period of time of stabilised resource price may encourage the pioneer to timely start his resource-saving project to gain a pioneer advantage. In this way it is possible to switch the waiting game back to a preemption game (see section 1).

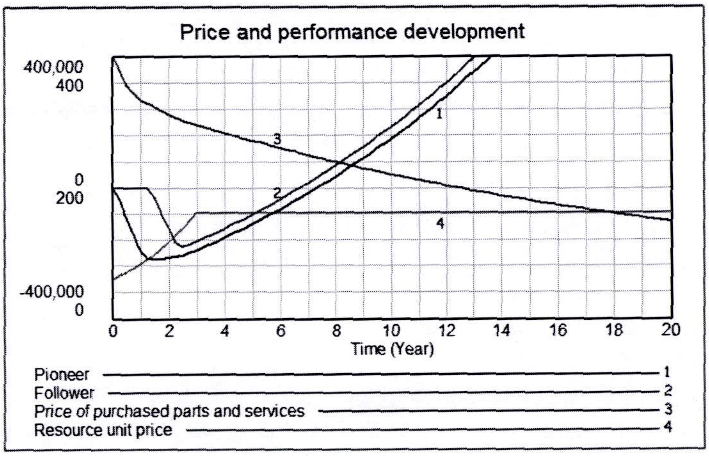

Figure 10. Even then the pioneer can still be too early

However, fig. 10 shows that even then the pioneer can still be too early in starting his resource-saving technology.

4. Conclusion

This paper first attempts to analyse and second to model the main arguments which seem to be relevant why we often hesitate to take action toward implementation of sustainable technology. Generally speaking, natural resources are indispensable for the functioning of all sectors of modern economies, and for achieving and maintaining high standards of living in all countries. More specifically, they are primary inputs in the production of all manufactured goods. Natural resources provide the energy needed to transport people and goods from place to place, to light our cities, and to heat our homes and places of work.

Our system dynamics model shows in a simplified two-firm setup that in a market of increasing resource prices there is a new kind of follower advantages regarding the timing to start investment in resource-saving projects. As demonstrated in section 3 using system dynamics simulation this kind of follower advantages is a rational and anticipatable reason of hesitations towards a 'green' pioneer role. Continually increasing resource prices change the technology competition from a preemption game to a waiting game. A possible resource price shock might be one potential way to switch back from a waiting game to a preemption game. Further research, f. i., in a combined way between system dynamics and agent-based modelling, may address a multi-firm context with individual influential factors and provide more insight into a market of increasing resource prices.

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