An analysis of the innovative performance of the Dutch greenhouse horticultural sector

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1. Introduction

The Dutch horticultural sector is leading on the national and international agricultural market (Ministry of ANF, 2010a). This is especially true for the greenhouse horticulture (Huizing, 2007), which contributed for 1-2% to total Dutch GDP over the last ten years (Alleblas & Groot, 2000; Tavoletti & Te Velde, 2008). The greenhouse horticultural sector consists of a set of interrelated industries: floriculture, fruit and vegetables, and tree cultivation.

Innovation has played an important role in the success of the sector. As a reaction to the first agricultural crisis at the end of the nineteenth century, the national government appointed a special commission (Van Winden & Bakker, 1999a). Their recommendations led to improved research, extension and education which resulted in fast technological development. Innovations such as greenhouses and artificial substrates reduced the dependency on natural conditions and substantially increased crop yields and quality (Buurma, 2001). These and subsequent process innovations form the basis of the competitive success of the sector and still dominate the direction of technological change.

However recently, researchers have claimed that this success is starting to erode (e.g. Bakker et al., 2005; De Boon, 2005; Jonkers et al., 2005; Verstegen et al., 2005; Batterink et al., 2006; Huizing, 2007; De Rooij, 2008; Van Henten & Pekkeriet, 2008; Flowers & Foods, 2009). Increased international competition, a shortage of educated personnel and rising labour costs negatively affect the position of the Dutch greenhouse horticultural sector (see figure 1). Note that performance fluctuations are normal for each industry, but that the overall development shows a negative trend.

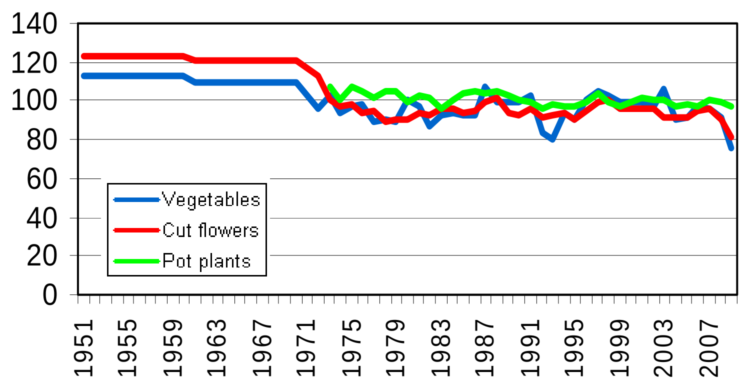

Figure 1: The average productiveness of Dutch vegetable, cut flower and pot plant greenhouse horticulturists measured as the turnover in euros / 100 euros of costs * 100 (data sources: Boot, 1995; LEI &CBS, 1974-1990; LEI, 2010a).

In this paper, we investigate whether the rate and direction of innovation still suit the challenges the sector is currently facing. This leads us to the following research question:

How can we evaluate and assess the chosen rate and direction of innovation of the Dutch greenhouse horticultural sector and what does this imply for the sector?

Innovation theory distinguishes four types of innovation: product-, process-, marketing- and organizational innovation (OECD, 2005). The importance of each type varies during the life cycle of an industry. In mature industries for example all four types of innovation are present, while in emerging industries product innovations are dominant (e.g. Anderson & Tushman, 1990; Utterback, 1996; Klepper, 1997). The Dutch greenhouse horticultural sector consists of a set of mature industries because profits are under pressure (see figure 1) and the amount of greenhouse horticultural firms gradually drops (see Annex I). We therefore expect to find all four types of innovation for this sector.

In evaluating the chosen rate and direction of innovation of the greenhouse horticultural sector, it is important to consider how industries and sectors innovate and grow. Two important bodies of literature address this issue. First, the 'Sectoral System of Innovation and Production' (SSIP) approach of Malerba (2002) contributes to understanding how sectors operate and evolve and the role of innovation processes in this. Second, the diamond framework of Porter (1998) presents a set of determinants that based on innovation influence the performance of industries. In this paper we argue that these two frameworks are complementary.

The aim of this study is to create a set of recommendations that help the sector to identify the determinants that influence the rate and direction of innovation of the Dutch greenhouse horticulture and to help them find areas of improvement in order to increase the sector's performance (section 8). For that purpose, the next section first presents the theoretical framework that integrates the frameworks introduced above into a new conceptual model. We operationalize this model in section 3 on the basis of a set of data sources (e.g. trade journals and patents) and a literature study. Sections 4-6 present the results of these analyses. Section 7 then discusses whether we applied correct operational measures for the studied concepts and whether the method of data collection is reliable.

2. Theoretical framework

This section first defines the four types of innovation that form the basis of this paper (2.1). Life cycle theory provides insights in which of these innovations become dominant in the different periods of the sectoral evolution (2.2). In order to understand the determinants that influence the rate and direction of innovation we study the frameworks of Malerba (2002) and Porter (1998). These two frameworks explain how sectors and industries respectively innovate and grow (2.3 and 2.4). As we argue that they are complementary, we end this section with a new conceptual model (2.5).

2.1 Innovation

The Oslo Manual of the OECD (2005: 46) defines *innovation* as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations". The OECD thereby distinguishes four types of innovation: *product*-, *process*-, *marketing*- and *organizational* innovation. Furthermore, the innovation at least needs to be new to the firm and does not necessarily have to be new to the whole industry or sector.

First, a *product innovation* is "the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics" (p. 48).

Second, *process innovations* involve "the implementation of new or significantly improved production or delivery methods. This includes significant changes in techniques, equipment and/or software" (p. 49).

Third, *marketing innovations* refer to "the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing" (p. 49). Product placement covers the introduction of new sales channels and new concepts for product presentation (e.g. IKEA's pre-furnished salesrooms). Product promotion includes the introduction of new brand names and new concepts for promoting a firm's goods and services (e.g. celebrity endorsement).

Finally, *organizational innovations* include "the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations" (p. 51). These three types of organizational innovations refer to the organization of business routines and procedures, responsibility distribution and decision making processes, and the organization of relations with other firms or non-firm organizations respectively.

2.2 Life cycle theory

Product and industry life cycle theory departs from the idea that different types of innovation become dominant as the industry evolves and grows (e.g. Anderson & Tushman, 1990; Utterback, 1996; Klepper, 1997). The development of an industry starts with the development of a new product. Because these new products still suffer from a relatively primitive design and much uncertainty, product innovations dominate the industry in the exploratory stage (Klepper, 1997).

As product development converges towards a dominant design, competition shifts to process innovations in order to produce more rapidly and cost-efficiently. Furthermore, economies of scale and specialization characterize the sector in this phase of its development (Alkemade et al., 2010: *in press*). Economies of scale and specialization lead to changes in the organization of the industry. For example, when competition shifts away from product innovation, coordination and control of the more sequentially interdependent business units become important (Utterback, 1996).

When industries eventually mature and consolidate (decrease in number of firms), they show a low amount of product innovations and competition on price through economies of scale and process innovations (Alkemade et al., 2010: *in press*). However, the possibilities for this are limited and cost advantages are often only temporary, leading to low profits. Firms could engage in marketing innovation which enables them to ask for high prices and thus to increase profits again. They may also develop new products that open up new life cycles.

Table 1 summarizes the innovation trajectories of each development phase.

Development phase	**Dominant innovation type**	**Aim of the innovation**
Exploration	Product innovation	New product New market
Growth	Process innovation Organizational innovation	Saving costs Improved product
Maturity	Marketing innovation Product innovation Process innovation	Product differentiation New life cycle Saving costs

Table 1: Expected innovation trajectory for each development phase (Alkemade et al., 2010: *in press*).

2.3 Malerba's Sectoral Systems of Innovation and Production

In order to understand how innovation comes about in sectors and industries, this section and the next one discuss the determinants that influence the rate and direction of innovation. In this section, we consider the 'Sectoral System of Innovation and Production' (SSIP) approach of Malerba. Malerba (2002: 250) defines an SSIP as "a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products". This system has a highly dynamic character which departs from a co-evolutionary perspective in which all system elements are closely connected and influence each others shape, growth, etc. Furthermore, the qualitative transformation of the system is more important than the quantitative growth of it.

The aim of this approach is to facilitate "integrated and consistent analyses of sectors in their interrelated features, understanding fully their working and transformation or comparing different sectors with respect to several dimensions (such as the type and role of agents, the structure and dynamics of production, the rate and direction of innovation and the effects of these variables on the performance of firms and countries)" (p. 248). Mainly based on evolutionary theory and innovation system literature, Malerba states that sectoral systems comprise of five building blocks (p. 251): (1) *knowledge base and learning processes*, (2) *basic technologies, inputs and demand, with key links and dynamic complementarities*, (3) *type and structure of interactions among firms and non-firm organizations*, (4) *institutions*, and (5) *processes of generation of variety and of selection*. Together these five building blocks determine the performance of the SSIP. As we are especially interested in innovation in this paper, we will now focus on the role of innovation for each of these five building blocks.

First of all, innovation strongly depends on *knowledge and learning processes*. Knowledge differs across sectors on three dimensions: opportunity, accessibility and cumulativeness. Opportunity refers to the actors that are responsible for innovation within the sectoral system. Accessibility is "the opportunity of gaining knowledge that is external to firms" and depends on the presence of knowledge or education institutes and the possibility of absorbing and imitating products and processes of competitors (p. 251). The cumulativeness of knowledge refers to "the degree by which the generation of new knowledge depends upon current knowledge" (p. 252). It can act as a barrier to entry when new firms have to make considerable investments in knowledge or technologies to catch up with the incumbents.

Second, *basic technologies, inputs and demand, with key links and dynamic complementarities* have a large influence on the range of behaviour and organization of firms within a sectoral system. Heterogeneous firms handling similar technologies facing similar demand and undertaking similar production activities, develop similar learning patterns, organizational forms and behaviour. Here, demand refers to both demand size and demand sophistication, i.e. demand for higher quality products. This building block especially stimulates innovation when there are technological dependencies, called dynamic complementarities. Dynamic complementarities exist when the sectoral system can only benefit from new technologies if innovation enables the integration of these new technologies with the incumbent ones.

The third element of the SSIP is the *type and structure of interactions among firms and non-firm organizations* (e.g. research institutes and universities). A key feature of the SSIP approach is that these firms and non-firm organizations are heterogeneous in terms of competencies and knowledge which stimulates them to interact. Resulting complementarities in knowledge bases and capabilities lead to innovation. *Institutions*, the fourth element, influence the way in which firms act and interact. These refer to common habits, laws, standards, rules and established practices and thus include both formal and informal institutions.

Finally, sectoral systems differ in terms of *processes of generation of variety and selection*. Variety can be expressed in terms of institutions, firms, technologies, products or strategies and behaviour. The basic idea is that the generation of variety in one of these elements creates opportunities for innovation. Especially the creation of new agents is important because they bring in new knowledge that feeds the innovation process. Selection mechanisms eventually reduce heterogeneity and decide which firms, technologies or products survive.

2.4 Porter's diamond framework

Opposed to Malerba, Porter (1998) is especially interested in the competitive advantage of industries (product or service). He defines an industry as "a group of competitors producing products or services that compete directly with each other" (p. 33). Porter states that sustained competitive advantage mainly relates to an industry's ability to achieve high productivity levels and, more important, to increase productivity over time. Firms that remain dependent on past successes will be imitated and lose market position. Productivity is "the value of the output produced by a unit of labour or capital" (p. 6) and depends on either the efficiency with which products are produced or the products' quality and features.

For an industry to increase its productivity over time, it should constantly improve and upgrade a set of so called determinants. Together these determinants form the diamond (see figure 2), and 'individually' and 'jointly' influence the competitive advantage of an industry. On the one hand, the strength of a determinant depends on the strength of the others. On the other hand, advantages in one determinant can also upgrade advantages in other determinants.

Porter distinguishes four determinants that reside in the environment of the industry: (1) *factor conditions*, (2) *demand conditions*, (3) *related and supporting industries*, and (4) *firm strategy, structure and rivalry*. Porter thus implies that the industry's performance especially depends on the conditions of its environment

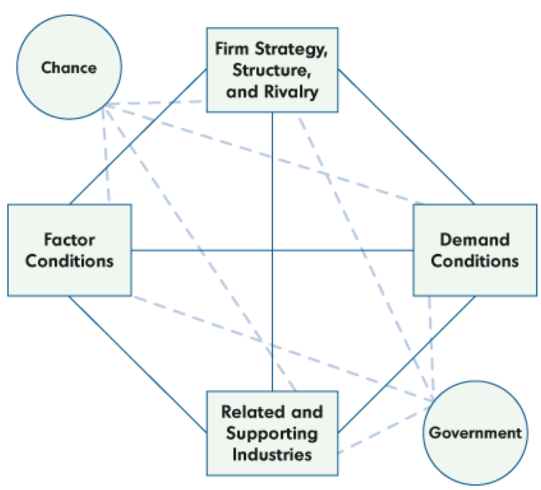

Figure 2: The determinants of national advantage (Porter, 1998).

It is not necessary to have advantages throughout the whole diamond. However, in more sophisticated industries, competitive advantage often results from a combination of advantages in different determinants that create self-reinforcing conditions. The reason is that for sophisticated industries, competitive advantage fundamentally depends on the rate of improvement and innovation. We will now again consider the role of innovation for each of the determinants.

First, *factor conditions* refer to “the inputs necessary to compete in any industry”, among which human-, physical-, knowledge-, and capital resources and infrastructure (p. 73). The inherited stock of factor conditions is less important than the rate with which they are produced and upgraded. Especially so called specialized and advanced factor conditions contribute to the competitive advantage of the industry. Advanced factors include “modern digital data communications infrastructure, highly educated personnel such as graduate engineers and computer scientists” (p. 77). Specialized factors involve “narrowly skilled personnel and infrastructure with specific properties” (p. 78). Innovation is thus important to circumvent selective factor disadvantages (e.g. scarce resources) or to create specialized and advanced factor conditions.

Second, d*emand conditions* refer to “the nature of home demand for the industry’s product or service” and cover both the quality and quantity of demand (p. 71). Home demand has not rendered less significant despite increasing globalization. Industries profit from home demand, because of physical and cultural proximity that facilitates communication. Especially the quality of home demand is important, since a more sophisticated home demand asks for higher quality products with an extensive set of features that pressures firms to engage in innovation and which ultimately leads to productivity growth.

The third determinant considers “the presence or absence in the nation of *supplier and related industries* that are internationally competitive” (p. 71). The main advantage of having strong supplier and related industries is in collectively creating high standard products by means of innovation. “The exchange of R&D and joint problem solving lead to faster and more efficient solutions” (p. 103). Firms profit from suppliers by having access to new ideas, methods and technologies. Suppliers profit from firms by having test sites to test the potential of new technologies. Straightforward transactions between firms and its suppliers are thus not sufficient.

Finally, *firm strategy, structure and rivalry* reflect the context in which companies are created, organized and managed and the nature of domestic rivalry. Nations succeed in industries where the organization of firms and company goals fit the sources of competitive advantage. For example, Germany is especially successful in methodical product and process improvement because of the technical background of many company CEOs. Also rivalry plays an important role since this creates the pressures to innovate. “The fear of loss often proves more powerful than the hope of gain” (p. 49).

Next to these four determinants, there are two additional variables that influence the determinants. *Chance* events are “occurrences that have little to do with circumstances in a nation and are often largely outside the power of firms (and often the national government) to influence” (p. 124). Examples are major technological breakthroughs, wars and financial crises. The *government* refers to governmental actions that shape or influence the four determinants (e.g. education policies and technology subsidies).

2.5 The frameworks combined

We thus seek the determinants for the rate and direction of innovation in the building blocks of the 'Sectoral System of Innovation and Production' approach of Malerba (2002) and the determinants of Porter's (1998) diamond. The scope of both frameworks differ as Malerba studies sectoral systems and Porter considers industries. In this paper, we argue that both frameworks are related as a sector consists of a set of interrelated industries. Table 2 shows on what concepts the authors agree and to what extent they are complementary.

Malerba (2002)	Porter (1998)
Knowledge and learning processes	Overlap: The importance of high quality knowledge resources Complementary: Porter focuses on the presence of these resources, while Malerba considers the related processes
Basic technologies, inputs and demand with key links and dynamic complementarities	Overlap: The importance of demand conditions Complementary: Malerba also considers basic technologies and dynamic complementarities
Type and structure of interactions among heterogeneous firms and non-firm organizations	Overlap: The importance of interactions Complementary: Porter considers potential interactions while Malerba studies real interactions
Institutions	Overlap: The importance of formal and informal institutions
Processes of generation of variety and of selection	Complementary: Porter does not describe this element

Table 2: Complementarity and overlap between the frameworks of Porter (1998) and Malerba (2002).

First, Porter agrees that *knowledge resources* are important to feed the innovation process. However, while Porter especially focuses on the static quality of these resources, Malerba is interested in how accessible these resources are and is thus more process oriented.

Second, Malerba uses Porter's *demand conditions* to understand how demand influences the organization and competencies of firms. Malerba also assigns an important role to technologies and technological dependencies and how they lead to innovation. Porter is more indirectly interested in these technologies. He states that "access to abundant factors is less important in many industries than the technology and skills to process them effectively or efficiently" (p. 14). Porter is in that sense thus more interested in how the static quality of the *factor conditions* influences the creation of new technologies.

Third, both authors attribute an important role to interactions in their model. Porter refers more to the potential of successful interactions that depends on the static quality of actors such as *related and supporting industries* or users (*demand*). The higher the quality of these determinants, the more feasible the interactions *will be*. On the contrary, Malerba discusses the interactions that really occurred.

Fourth, both authors refer to the importance of formal and informal institutions. Porter's formal institutions especially refer to the *government* and his informal institutions (e.g. attitudes towards authority and norms of interpersonal interaction) to the *firm strategy, structure and rivalry*.

Finally, Porter is less explicit on processes of generation of variety and selection. He agrees with Malerba that new businesses bring in new knowledge into the industry/sector. You could however say that chance events (e.g. technological discontinuities or financial crises) and the availability and accessibility of capital and physical resources and infrastructure could for example be sources of variety generation or selection. However, again, for Porter this would relate to a more static perspective.

As we think that although these two approaches overlap, we use both frameworks as they are complementary in some respects. However, common elements are only discussed once. From table 2 it becomes clear that Porter (1998) mainly focuses on the static quality of his diamond's determinants. The diamond framework is therefore useful for describing the elements that influence the rate and direction of innovation of the industry. On the contrary, Malerba (2002) considers the processes that are important for the performance of the sector. The SSIP approach is therefore especially useful for understanding the dynamics of the determinants that influence the rate and direction of innovation of the sector. This complementarity is expressed in the following questions. Typical questions by Porter are: Are their specialized knowledge institutes? Are there technologically sophisticated related and supporting industries? Typical questions by Malerba are: How do firms learn from knowledge institutes? How do firms and their suppliers interact with each other?

The frameworks are furthermore complementary in the sense that Malerba applies a more internal focus for understanding the performance of sectoral systems, while Porter is especially interested in an industry's environment. However, be aware that what can be the environment according to Porter, can be within the system of Malerba. While Porter separates the industry from its environment, Malerba considers all links and interdependencies between related industries and services that together form the boundaries of his sectoral system.

Integrating both models thus leads to a more complete view of the determinants that influence the rate and innovation of sectors. We speak of sectors as sectors consist of a set of interrelated industries. This leads us to the conceptual model of figure 3.

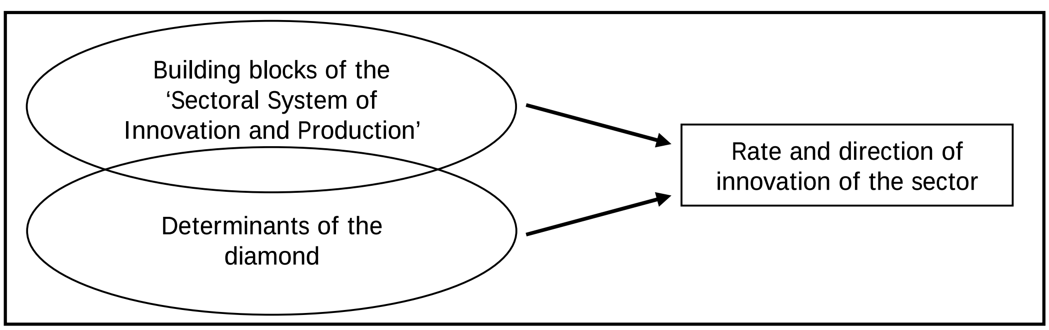

Figure 3: Conceptual model.

3. Methodology

This section operationalizes the conceptual model of figure 3 that considers four types of innovation: product-, process-, marketing- and organizational innovation. We first collect data on the rate and direction of innovation for the Dutch greenhouse horticultural sector on the basis of a set of different data sources. These data sources consider popular innovation indicators such as patents and subsidies and other indicators such as product announcements (3.4). Since these data sources contain either qualitative or quantitative data, we operationalize the innovations on such a level that both qualitative and quantitative data are taken into account (3.1).

To some extent, these data sources also contain information on the determinants that influence the rate and direction of innovation. For the remaining part, a literature study provides insights in the independent variables of figure 4. We first operationalize the diamond (including the overlapping concepts of Malerba) since Porter presents an extensive set of indications that support the operationalization process (3.2). After this, we operationalize the remainder of Malerba's building blocks that did not show any overlap with the determinants of Porter (3.3).

3.1 Operationalization of innovation

In this paper, we distinguish product-, process-, marketing- and organizational innovations (OECD, 2005). In practice, it can sometimes be difficult to differentiate between these four types of innovation. Table 3 shows the results of the operationalization process. We discuss below how these innovations differ.

Type of innovation	**Operationalized definition**
Product innovation	New crops that differ from old crops on the basis of shape, colour, taste, smell, quality measures (e.g. longer expiry date, better disease resistance)
Process innovation	Technologies that improve crop yield or quality or reduce production (e.g. labour and energy) costs
Marketing innovation	Newly entered markets, branding strategies, new presentation concepts, promotion campaigns and changes in product packaging
Organizational innovation	Changes in the organization of work, distribution of responsibility, new cooperation forms or chain integration

Table 3: Operationalized definitions of product-, process-, marketing- and organizational innovation.

The distinction between product and process innovation can be problematic for the horticultural sector as both types of innovation may lead to higher quality products. When product quality increases because of new technologies, it is a process innovation. On the contrary, when improved product quality depends on genetic adaptations of the crop, it is a product innovation.

Then, product and marketing innovation both consider the concept of product design, which is problematic as horticultural products often consist of both crop and packing. However, the OECD (2005) claims that for products such as food, packaging is "the main determinant of the product's appearance" to be considered by a marketing strategy (p. 50). As a result, marketing innovations refer to changes in packaging while product innovations include changes in crop characteristics such as taste and colour. Since marketing innovations consist of changes in product design and packaging, product placement and product promotion, we also study branding strategies, new presentation concepts, promotion campaigns and newly entered markets.

Also process and organizational innovations strongly relate as they both aim at reducing costs through new and more efficient ways of production and internal organization of the firm (OECD, 2005). We therefore draw a line on the basis of the considered activity. Process innovations primarily relate to the implementation of new technologies and software. For the greenhouse horticulture, process innovations therefore refer to technologies that improve crop yield or quality or reduce production costs. Organizational innovations especially relate to people and changes in the organizations of firms and refer to changes in the organisation of work, distribution of responsibility, new cooperation forms and chain integration. The replacement of personnel with machines is a process innovation as it involves the introduction of new technologies.

In sum, the operationalized definitions of table 3 contribute to measuring the rate and direction of innovation of the Dutch greenhouse horticultural sector. On the one hand, we measure the rate of innovation by accumulating all innovations that satisfy the definition conditions and that we find in the data sources of section 3.4. On the other hand, we determine the direction of innovation by comparing the amount of innovations for each of the four categories and by qualitatively studying the type of innovation (e.g. focus on energy saving technologies or products with a better taste).

3.2 Measuring Porter's diamond

In order to assess how the determinants affect the rate and direction of innovation of the Dutch greenhouse horticultural sector, we use a literature study. As this literature study especially considers descriptive literature, the results will be in the form of a narrative that explains the development of the determinants over time. Table 4 shows the determinant dimensions that together form the basis of the narratives. We measure these dimensions on the basis of a set of diagnostic questions that we discuss below.

Determinant	**Dimensions**
Factor conditions	• Availability, quality and costs of human resources • Availability, quality and costs of physical resources • Amount and quality of knowledge resources • Availability and accessibility of capital resources • Quality, user cost and type of infrastructure
Demand conditions	• Size and quality of demand
Related and supporting industries	• Quality of suppliers
Firm strategy, structure and rivalry	• Strategy and structure of firms • Structure of rivalry
Chance	• Acts of pure invention • Major technological discontinuities • Political decisions by foreign governments • Wars • (Financial) crises
Government	• Presence and quality of legislation • Presence and quality of subsidies

Table 4: Dimensions of the determinants of Porter's diamond (based on Porter, 1998).

First, the following questions measure the *factor conditions*: Is there enough qualified personnel and what are the related labour costs? Does the industry profit from its climate, geographic location or abundant low-cost and high-quality soil, water, and the like? Are there specialized greenhouse horticultural research institutes? How do horticulturists get financed? Does the nation have a feasible transportation and communication system? These questions measure not only the presence of factor conditions but also whether they are advanced and specialized.

Second, *demand conditions* distinguish the size and quality of demand for Dutch greenhouse horticultural products. We measure the size of demand by quantitatively scanning production and export statistics. The quality of demand depends on questions such as: Are domestic buyers highly sophisticated and demanding buyers? Do national buyers' needs anticipate foreign demand?

Third, we gain insights in the quality of related and supporting industries by asking questions such as: Are the nation's suppliers internationally competitive? And are interactions between firms and its suppliers especially of the buyer-seller type (access to inputs) or are they involved in a mutual process of innovation and upgrading?

Fourth, with respect to *firm strategy, structure and rivalry* we first consider the strategy and structure of firms. As the Dutch greenhouse horticultural sector has long been characterized by the so called research-extension-education triptych (see also the introduction) we study the following questions: How did this triptych come about? What informal institutions (e.g. attitude towards authority) have been important for the success of this sectoral structure? Is this sectoral structure still successful? Rivalry refers to the structure of rivalry and thus to the question whether competition occurs on price, product features or marketing for example.

Finally, we measure *chance* by focussing on past wars, technological breakthroughs and crises. Then, the *government* refers to questions such as: Do Dutch greenhouse horticulturists get subsidized? Are there laws aimed at the greenhouse horticulture in particular? What legislation has pushed the innovative performance of the sector forwards? What legislation has hampered innovation?

In sum, this section contributes to understanding how the diamond's determinants have influenced the rate and direction of innovation of the Dutch greenhouse horticultural sector.

3.3 Measuring Malerba's SSIP

This section applies a similar procedure as the previous section. Also Malerba (2002) distinguishes a set of dimensions for the building blocks of his SSIP. As Malerba's model partly overlapped with that of Porter, this section only discusses those concepts that Porter (1998) did not take into account (see table 5).

First, in order to understand *knowledge and learning processes* we study the internal accessibility of knowledge (ability to adopt and imitate products and processes of competitors) for which interesting questions are: Do horticulturists consider each other as colleagues or rivals? Are there many knowledge spillovers between these horticultural companies? What type of knowledge is shared between horticulturists? Are there any unions or branch organizations that stimulate firms to share knowledge with each other? The main question with respect to the external accessibility of knowledge is how knowledge from human and knowledge resources as described by Porter flows towards the horticulturists. We then measure the sources of opportunity by looking at the actors that innovate within the sector. We gather this information on the basis of the data sources presented in section 3.4. Finally, the cumulativeness of knowledge considers questions such as: How many new firms enter the sector on a yearly basis? How can this be explained? For example, if entry is low this may be due to a lack of technological knowledge of new entrants.

Building block of sectoral system	Dimensions
Knowledge and learning processes	• Degree of internal accessibility of knowledge • Degree of external accessibility of knowledge • Sources of opportunity of knowledge • Degree of cumulativeness of knowledge
Basic technologies, inputs and demand with key links and dynamic complementarities	• Basic technologies • Dynamic complementarities
Type and structure of interactions among heterogeneous firms and non-firm organizations	• Interactions between actors
Processes of selection and variety generation	• Variety creation • Selection mechanisms

Table 5: Dimensions of the building blocks of Malerba's SSIP (based on Malerba, 2002).

Second, for *basic technologies* we discuss a set of technologies that have pushed the sector forwards and made cultivation more sophisticated and advanced. Whether the technologies are important is evaluated on the basis of the studied literature. Furthermore, with respect to *dynamic complementarities*, an important question is whether innovation was necessary to integrate new and old technologies with each other?

Third, we present a supply chain that supports to understand *the type and structure of interactions* among the actors within the Dutch greenhouse horticultural sector. Important questions are: Which actors do interact and which don't? For what reasons do or don't they interact? Is the interaction between actors problematic? Is the lack of some types of interaction in any way problematic for the sector?

Finally, we measure variety generation on the basis of the following questions: Do firms show large varieties in the technologies they use? Do firms differ with respect to the products they cultivate or the strategies they follow? What explains these rates of variety? The variety creation in firms is already discussed by the cumulativeness of knowledge. After this, we measure selection mechanisms by searching the literature for environmental regulation, spatial policies, or finance policies for example that may have led firms to end their business.

In sum, this section contributes to understanding how Malerba's building blocks have influenced the rate and direction of innovation of the Dutch greenhouse horticultural sector.

3.4 Data sources

In order to measure the rate and direction of innovation we use a set of data sources. These data sources cover the following indicators: patents, breeders' rights, subsidies, product announcements and the Horti Fair Innovation Award. Each of the following sub-sections discusses one of these data sources.

Patents

First of all, this study considers patents as an innovation output indicator in line with a long tradition of innovation studies. A patent is "a public contract between an inventor and a government that grants time limited monopoly rights to the applicant for the use of a technical invention" (Smith, 2005: 158). Since Dutch greenhouse horticultural products are non-technological (e.g. seeds, slips, vegetables and flowers), technical inventions especially relate to process oriented innovations in this study. The advantages of using patent databases are that they are freely available, that patent statistics are available for an extensive time period, that patents contain extra information (e.g. inventor and content) and that they are classified according to a detailed system that does hardly change over time. The disadvantages are that not all technologies are patented and that not all new technologies covered by a patent have commercial value (Smith, 2005).

In this paper, our patent analysis consists of two steps. The first step especially focuses on the rate of process innovation of the Dutch greenhouse horticultural sector by measuring the amount of greenhouse horticultural patents over time from 1900 onwards. Annex II shows the patent classes of our patent database (Espacenet) that refer to the greenhouse horticulture in particular. We determine whether these amounts of patents are large by comparing them with patents of foreign competitors. Based on a literature study, these nations are: Belgium, China, Denmark, France, Germany, Great-Britain, Israel, Italy, Mexico, Poland, Spain, and USA (see Annex III). This list accumulates competitors on vegetables, pot plants and cut flowers as most patent groups aim at general technologies that apply to each of the three industries. Furthermore, by comparing countries we compensate for the problem of having non-patented technologies as all countries face this problem.

The second step especially refers to the direction of process innovation of the sector as we map the amount patents for each sub-group of greenhouse horticultural patents in order to analyze the research strengths of the Netherlands compared to its competitors (see Annex II). On the basis of these two analyses we thus gain insight in both the rate and direction of primarily process innovations.

Breeders' rights

Breeders' rights can be considered as patents for new agricultural crops. Whether a vegetable or pot plant is new is determined by NAK Tuinbouw. In order for a breeder to receive a breeders' right the race must be 'Distinct, Uniform and Stable' - the so called DUS-criteria (NAK Tuinbouw, 2010). Furthermore, the race must not have been sold in The Netherlands one year before applying for the growers' right. The same is true for selling abroad, which must not have taken place for four years. As this data source especially refers to new crops, it contains a bias towards product innovations.

Again the analysis consists of two steps. The first step especially focuses on the rate of product innovation of the Dutch greenhouse horticultural sector by measuring the amount of greenhouse horticultural breeders' rights over time from 1970 onwards. We select the vegetables on the basis of Product board Horticulture (2010a) that presents a top 10 of sold vegetables in 2007: tomato, cucumber, pepper, salad and beans (some vegetables do not refer to the greenhouse horticulture). Accumulated data on these vegetables is available for the period of 2006-2010 in the breeders' rights database of NAK Tuinbouw. Flower Council (2010) presents a top 10 of sold cut flowers and pot plants in 2006. For cut flowers we select: rose, chrysanthemum, lily, amaryllis, cymbidium and anthurium. And for pot plants we select: phalaenopsis, pot anthurium, kalanchoë, pot rose, pot chrysant, hydrangea, spathiphyllum. Data on these crops is available for the period of 1970-2009. Furthermore, we accumulate all crop data as we are not interested in specific crops.

As the number of crops and the available data differ for each industry, we compare the amount of breeders' rights of these industries on the basis of an interview with Haegens (2010) of NAK Tuinbouw. We also use this interview for the second step of the analysis, where we ask for the direction of production innovations in the sector (e.g. focus on taste, shape or colour). On the basis of these analyses, we thus measure the rate and direction of primarily product innovations.

LNV subsidy: 'Cooperation for innovation projects'

Another popular indicator for measuring innovation is innovation subsidies. In this paper we consider the LNV subsidy database called 'Cooperation for innovation projects'. These subsidies are available for horticultural entrepreneurs who cooperate on the improvement of existing products, procedures or technologies, and the improvement of products, production technologies and organizational forms of firms (LNV, 2010). This data source thus considers all four types of innovation.

Data on this LNV subsidy is available for the period of 2007-2009. This innovation indicator is especially feasible for measuring the direction of innovation. We determine the direction of innovation by comparing the amount of product-, process-, marketing- and organizational innovations in this database.

Product announcements

Another indicator that we use is product announcements in trade journals (see Kleinknecht et al., 1992 and Wolters, 2003). Product announcements refer to the market introduction of innovations. This data source is thus probably biased towards product and marketing innovations. Compared to patents, these announcements have the advantage of measuring the performance at the end of the innovation process. Yet, the results are only representative for product announcements in trade journals (Wolters, 2003). Some companies will use other channels via which they promote their new products. Nonetheless, since other data sources also contain product innovations, this problem is less problematic.

Based on Wolters (2003), the analysis considers product announcements in two of the most popular trade journals in Dutch greenhouse horticulture: 'Vakblad voor de Bloemisterij' and 'Groenten & Fruit'. We especially focus on marketing innovations as we already study product innovations to a large extent on the basis of the breeders' rights. Furthermore, only the product announcements published in descriptive articles, novelty overviews or trade fairs are considered. We trust that the editors have checked the novelty of these marketing innovations before publishing it. Therefore, we did not include product announcements in advertisement, since the editorial staff does not check the novelty of these innovations.

The analysis consists of two steps. First, we gather data on the amount of marketing innovations over the period of 2005-2009 for each trade journal as a measure for the rate of marketing innovation of the Dutch greenhouse horticultural sector. 'Groenten & Fruit' measures the rate of marketing innovation for vegetables and 'Vakblad voor de Bloemisterij' measures the rate of marketing innovation for floricultural products. Second, we measure the direction of marketing innovation by studying whether most innovations relate to product design and packaging, product presentation or product promotion. On the basis of these analyses, we thus measure the rate and direction of primarily marketing innovations.

Horti Fair Innovation Award

The Horti Fair Innovation Award is coupled to a yearly recurrent horticultural fair at which all actors come together and have the opportunity to see the latest developments on the areas of technology, marketing, cultivars, etc (Horti Fair, 2010). The award distinguishes categories such as trade/services, technique, supply and production. Since most of these categories relate to new products or technologies, this data source probably favours process-, product- and marketing innovations. The strength of this data source is that an international jury with a highly diverse background selects only those innovations that are most new and innovative to the sector.

Data on this innovation award was available for the period of 2005-2009. This innovation indicator is especially feasible for measuring the direction of innovation. We determine the direction of innovation by comparing the amount of product-, process- and marketing innovations in this database.

Figure 4 summarizes all data sources and reflects what type(s) of innovation they measure. Overall, this section contributes to measure the rate and direction of innovation.

<table>
<tr><td>Product innovation:
Breeders' rights
Horti Fair Innovation Award
LNV subsidy
Literature study</td><td>Process innovation:
Patents
Horti Fair Innovation Award
LNV subsidy
Literature study</td></tr>
<tr><td>Marketing innovation:
Product announcements
Horti Fair Innovation Award
LNV subsidy
Literature study</td><td>Organizational innovation:
LNV subsidy
Literature study</td></tr>
</table>

Figure 4: All indicators and the type(s) of innovation they measure.

4. Innovative performance of the sector

Table 6 presents an overview of the accumulated amount of innovations for each data source described above (see 4.1 for more specific data on the rate of innovation). These results confirm the expected biases as depicted by figure 4, except for the LNV subsidy indicator for which we found no product innovations. On the basis of table 6, the direction of innovation seems to be primarily focused on product and process innovations (see 4.2 for more specific data on the direction of innovation). Organizational and marketing innovations are strongly underrepresented. This is contradictory to life cycle theory, which states that mature industries engage in product, process as well as marketing innovations (e.g. Anderson & Tushman, 1990; Utterback, 1996; Klepper, 1997).

An interview with Drs. Van Galen (2010) confirmed that these results are representative for the sector. Van Galen (2010) is researcher at the Agricultural Economic Institute (LEI), and is an expert on the area of innovation in the agricultural and horticultural sector (e.g. see the 'Innovation Monitor' in Van Galen & Ge, 2009). The interview was furthermore used for studying the reasons behind these results (see section 5 and 6).

	Process innovation	**Product innovation**	**Marketing innovation**	**Organizational innovation**
Patents	3.090			
Breeders' rights		5816		
LNV subsidy	14		1	5
Product announcements			203	
Horti Fair Innovation Award	51	31	9	
Total	**3155**	**5847**	**213**	**5**

Table 6: Amount of innovations for each individual data source.

4.1 Rate of innovation of the Dutch greenhouse horticultural sector

In this section we discuss the rate of innovation for process-, product- and marketing innovation respectively.

Process innovation

Figure 5 shows the total amount of Dutch greenhouse horticultural patents over time compared to its international competitors. Germany and the US have managed to show a steady increase in their technology development from the end of the 19th century onwards. France and Great-Britain on the contrary show a decrease in patents for the last decades. Countries such as The Netherlands have started much later with their technology development but have already surpassed France and Great-Britain on the yearly number of new patents.

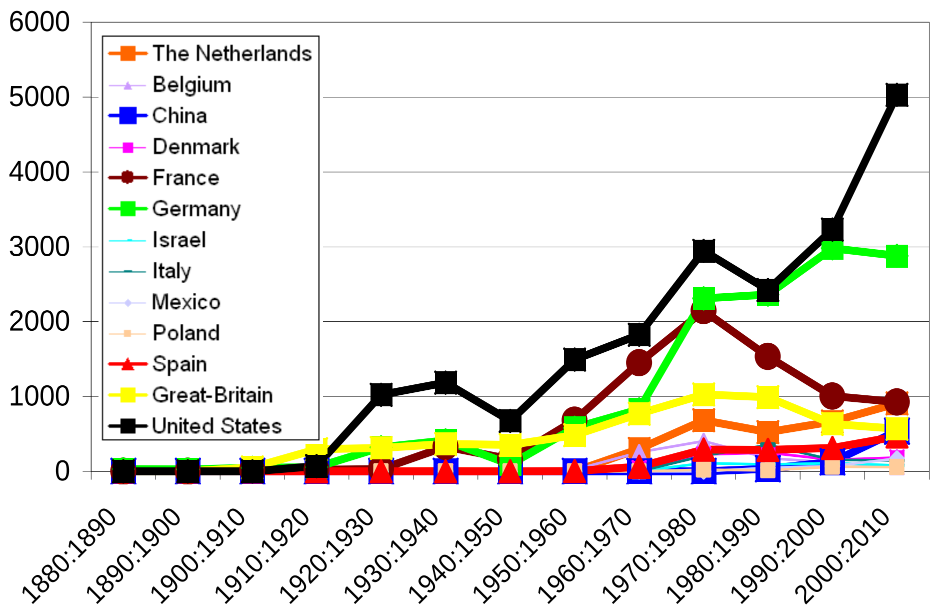

Figure 5: Total amount of patents divided by time period and nation (data source: Espacenet).

Figure 6 then results from the accumulation of patents over time. Next to Germany and the US, the Netherlands have the largest slope steepness, which indicates a strong technology development rate. It is logical that the Netherlands possess less patents on an absolute level, since it has a small population compared to Germany, Great-Britain, the US and France.

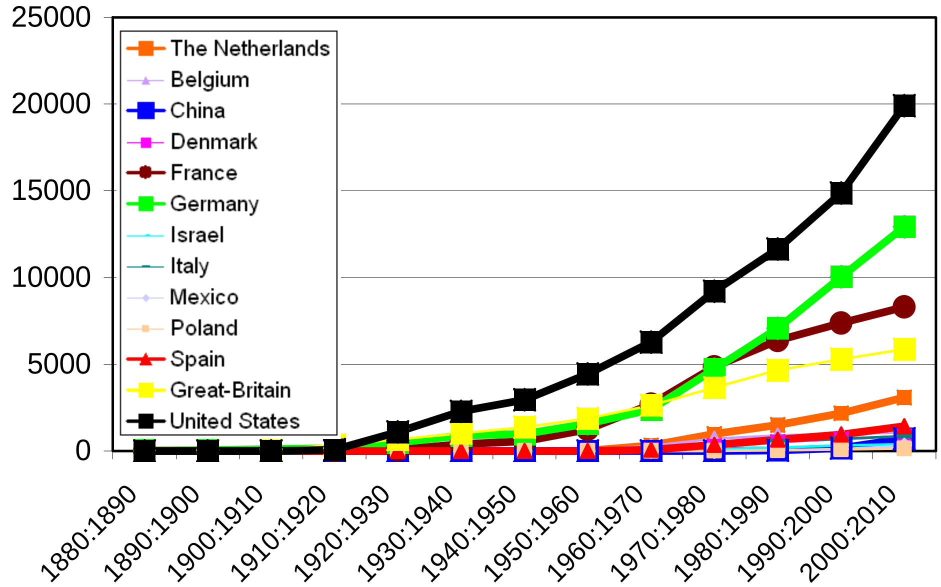

Figure 6: Total number of patents accumulated over time for each nation (data source: Espacenet).

So, although the performance of the sector decreased over the last years, the amount of patents is still increasing. We can therefore assume that the rate of process innovation does not affect the performance of the sector to a large extent.

Product innovation

Figure 7 shows the accumulated amount of assigned vegetable breeders' rights in the period of 2006-2010 (total of 589). Because of data limitations, it was not possible to measure the rate of innovation for vegetable product innovations.

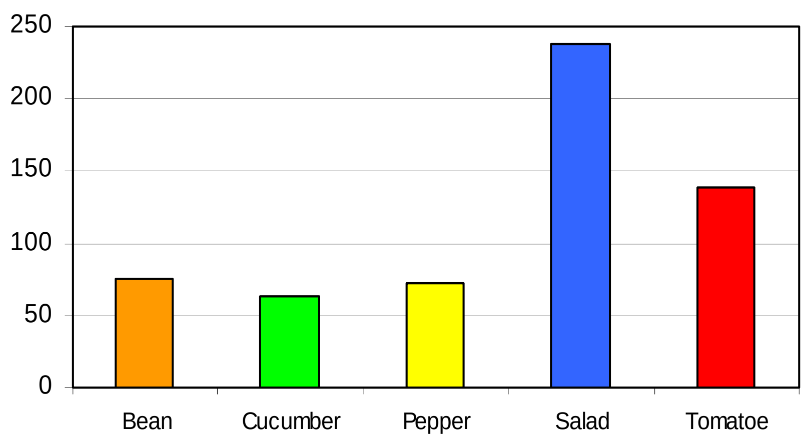

Figure 7: Accumulated amount of assigned breeders' rights for greenhouse vegetables in the period of 2006-2010 (data source: NAK Tuinbouw).

Figure 8 presents the amount of assigned breeders' rights for both pot plants and cut flowers. Since the data does not separate between the rose and the pot rose, the anthurium and the pot anthurium, and the chrysanthemum and the pot chrysanthemum, the figure combines both floricultural products. The figure has an inversed U-shape, indicating that the amount of assigned breeders decreased after

1993. However, from 1993 onwards many breeders applied for European breeders' rights rather than Dutch breeders' rights as there was no cost difference anymore and the European breeders' rights enabled them to protect their crops over a larger area (Haegens, 2010). Overall, the amount of breeders' rights assigned to Dutch breeders has been relatively stable.

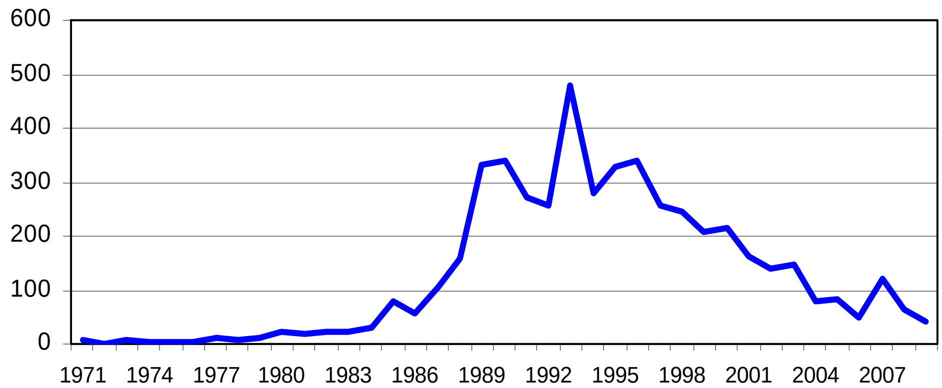

Figure 8: Total amount of assigned breeders' rights for greenhouse floricultural products in the period of 1970-2009 (data source: NAK Tuinbouw).

So, although the performance of the sector decreased over the last years, the amount of yearly assigned breeders' rights have been relatively stable. We can therefore assume that the rate of product innovation does not affect the performance of the sector to a large extent.

Marketing innovation

Figure 9 presents the amount of product announcements for both vegetables and floricultural products in the period of 2005-2009. On the basis of this figure, we see a negative trend for the amount of marketing innovations over the last years. This may imply that the decreasing performance of the sector over the last years (figure 1) relates to a decreasing amount of marketing innovations. However, take into account that the available data is limited compared to the amount of product and process innovations

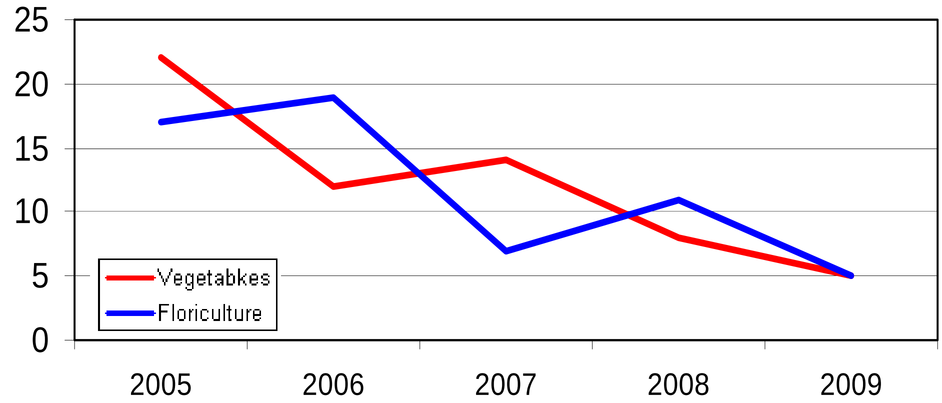

Figure 9: Total amount of product announcements for greenhouse vegetables and floricultural products in the period of 2005-2009 (data sources: 'Groenten & Fruit' and 'Vakblad voor de Bloemisterij).

4.2 Direction of innovation of the Dutch greenhouse horticultural sector

In order to determine the direction of innovation, the LNV subsidy and Horti Fair Innovation Award data sources are particularly useful as they contain most innovation types. Furthermore, these data sources give insight in the type of product and process innovations that the sector pursues for example (e.g. process innovation aimed at saving costs or creating more colourful flowers). We complete the latter results with data from the other three data sources.

First, table 7 presents the results for the LNV subsidy indicator. This table supports that the direction of innovation is especially aimed at process innovations. Most of these process innovations relate to saving energy and labour costs and to a lesser extent to improving product yield or quality (the patents do also support this statement). Then, the only marketing innovation refers to functional foods. And, the organizational innovations especially aim at improving supply chain communication and to facilitate a knowledge flow from customer to grower. Improving the knowledge flow from customers to horticulturists is especially important for facilitating product and marketing innovations.

	2007	*2008*	*2009*
Product innovation	0	0	0
Process innovation	8	5	8
Marketing innovation	1	0	0
Organizational innovation	2	0	3

Table 7: Classification of innovations for the LNV subsidy indicator.

Second, table 8 presents the results for the Horti Fair Innovation Award indicator. This table supports that the direction of innovation is primarily aimed at process and product innovations. Again, these process innovations mainly relate to saving energy and labour costs and to a lesser extent to improving product yield or quality. The product innovations especially relate to changes in the colour and shape of floricultural products (the breeders' rights support this statement). Haegens (2010) of NAK Tuinbouw agrees that the amount of product innovations is largest for floricultural products because of the trend sensitiveness of this industry. Product innovations for vegetables especially focus on crop resistance. In other words, floricultural product innovations are especially market oriented, while vegetable product innovations are more production oriented. The marketing innovations especially refer to changes in the packaging of cut flowers.

	2005	*2006*	*2007*	*2008*	*2009*
Product innovation	10	4	4	6	7
Process innovation	6	11	14	10	10
Marketing innovation	2	3	1	2	1

Table 8: Classification of innovations for the LNV subsidy indicator.

Finally, both the patent database and the product announcements add data on the type of process and marketing innovations that the sector pursues respectively. On the basis of the patent database, we present the research specialization of the seven best scoring countries on total greenhouse horticultural patents (see figure 6) in figure 10. The Netherlands do not score highest for any of the greenhouse horticulture related patents. Furthermore, in line with the country ranking, the US, France, Great-Britain and Germany show high scores for almost all subclasses. The Netherlands are specifically scoring high for A01G5, A01G9 and A01G31, approaching France and Great-Britain. These patent classes are related to ‘floral handling’, ‘forcing frames and greenhouses’, and ‘hydroponics’ respectively.

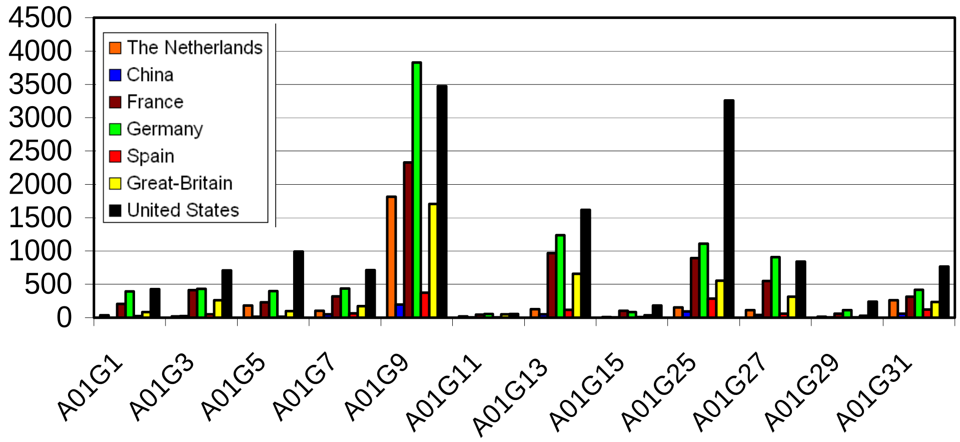

Figure 10: Total amount of patents for every category of greenhouse horticultural patents (data source: Espacenet database).

Table 9 then presents an overview of the type of marketing innovations that we found in the trade journals ‘Vakblad voor de Bloemisterij’ and ‘Groenten & Fruit’. For vegetables we see that three specific types of marketing innovations are dominant: 1) marketing innovations aimed at product packaging and design, 2) Introduction of new sales channels 3) Branding. The same is true for floricultural products except for the introduction of new sales channels.

	Groenten & Fruit	**Vakblad voor de Bloemisterij**
Marketing innovations aimed at product packaging and design	27	41
Marketing innovations aimed at product placement		
** Introduction of new sales channels*	26	5
** New concepts for product presentation*	8	8
Marketing innovations aimed at product promotion		
** New concepts for promoting a firm’s goods or services*	12	5
** Branding*	33	38
Total	**106**	**97**

Table 9: Number and type of marketing innovations (data sources: ‘Vakblad voor de Bloemisterij’ and ‘Groenten & Fruit’).

With respect to the former, changes in product packaging and design mainly relate to improvements in product presentation or the provision of product information (on healthiness, sustainability, preparation tips and growers). A difference between vegetables and floricultural products is that the latter mostly aims at a better presentation of the product because of the trend sensitiveness of the industry (Cornelis & De Jong, 2010; Haegens, 2010). As vegetables are first of all a basic need, packaging is also aimed at providing product information on the healthiness of the product or on how to prepare the products. Furthermore, new packages were developed to cook vegetables or to pack portions of vegetables for small households.

Then table 9 shows that most initiatives for the introduction of new sales channels are pursued for vegetables. Two popular examples are the creation of snack vegetables and vegetable plants for at home production. The former opens up a new market as vegetables now serve purposes other than diner. Vegetables could now for example be sold at gas stations next to supermarkets. ING (2009) claims that fruit sales at gas stations have increased with 45% over the last three years and will thus also be a potential market for snack vegetables. With respect to home grown vegetables, garden centres and construction markets may be penetrated as these markets aim at the do-it-yourself customer segment.

From table 9 it also becomes clear that branding is a popular form of product promotion. According to Van Galen (2010), only recently firms have started to engage in consumer branding. Before, most brand names served business-to-business purposes. Examples of brand names are Il giardino tradizionale, TropiQ, Esperit Elements, Air So Pure and Vitamini. Brand names aim at making the customer aware of the differentiated characteristics of the products.

In sum, we see that the rate of most innovations still increases although the performance of the sector as presented by figure 1 decreases. We can therefore conclude that the rate of innovation does not or hardly influence the profits in the sector and that we thus have to evaluate the direction of innovation within the sector.

With respect to this direction of innovation, we found two results that contradict life cycle theory. First, the results showed that the direction of innovation is especially in favour of product and process innovations and that marketing and organisational innovations are underrepresented. On the contrary, the life cycle theory states that mature industries engage in product, process as well as marketing innovations.

Second, product innovation in mature industries especially relate to creating new life cycles. However, product innovation in the Dutch greenhouse horticultural sector mainly relates to improving product quality for vegetables and changing the shape, colour and smell for floricultural products in line with the trend sensitiveness of the industry. Despite anticipating on these trends, the horticulturists are not able to translate these product innovations into profits.

In order to create a set of policy recommendations we therefore analyze the underlying determinants that influence the direction of innovation in the Dutch greenhouse horticultural sector in the next two sections. We expect that competition in the Dutch horticultural sector still too much focuses on price which leads to lower profits over time as was claimed by Alkemade et al. (2010: *in press*). As marketing innovations have the potential to demand for higher prices and increase profits, we study what hampers the sector from pursuing marketing innovation and what leads the sector towards focussing op product and process innovations.

5. Porter analysis

Based on the results of section 4, we now study the determinants that have influenced the direction of innovation in the Dutch greenhouse horticultural sector. This section discusses these determinants from the perspective of Porter’s diamond.

5.1 Firm strategy, structure and rivalry

In this section we first discuss the strategy and structure of firms after which we analyze the structure of rivalry.

Strategy and structure of firms

The structure of the horticultural firms significantly changed over the past 50 years. Around 1950, most horticulturists owned a so called 'mixed company' (Vijverberg, 1996). This type of company cultivated a collection of vegetables, flowers and fruit, partly in the open ground and partly under glass. An important characteristic of this period is that there is much uniformity in the structure of the horticultural companies (Van den Ham & Postma, 2007).

From the end of the 1950s onwards, most of these companies substitute open ground cultivation by cultivation under glass (Vijverberg, 1996). Furthermore, specialization and the division of labour characterize this period. Especially an increase in the complexity of horticultural technologies initiated this specialization in horticultural activities. For example, the introduction of hybrid seeds made it impossible for growers to keep seed cultivation in their own hands. Furthermore, in the 70s, the breeding of young vegetable plants has practically been completely transferred from the horticultural company to specialized companies. A similar process occurred for cut flowers and pot plants somewhat later.

Next to this specialization, horticulturists also externalized those activities that required considerable investments (Vijverberg, 1996). Examples are soil disinfection, glass cleaning and greenhouse repair. For these activities it is more inexpensive to hire them than to buy them. Over the years more parts of the past conduct of business became independent.

As a result, in the 1980s, the specialized glass company was the leading firm structure (Vijverberg, 1996). This type of company only cultivated one crop or one crop group at most (e.g. blossoming pot plants). Cultivation in the open ground only played a small or minor role. Compared to the times of the mixed company, there was thus much more diversity in the structure of firms.

With respect to the strategy of firms also much changed for horticulturists. In times of the mixed company the strategy was mainly determined by the so called research-extension-education triptych (OVO-triptych). The success of this top-down structured triptych depended for a large part from a high level of consensus and collectiveness among politics, society and the horticultural sector originating from the common goal to increase production, lower the cost price and increase product quality of horticultural products (Rutten & Van Oosten, 1999; Van den Ham & Postma, 2007). When firms eventually specialized, the effectiveness of this model decreased and the firms needed to determine their own strategy. Let us now first consider the OVO-triptych in more detail.

Right after the Second World War, there was thus a high degree of consensus and collectiveness among society, politics and the horticultural sector originating from the common goal to increase production, lower the cost price and increase product quality of horticultural products (Rutten & Van Oosten, 1999; Van den Ham & Postma, 2007). On the one hand, this collectiveness was expressed in sector wide financial contributions to general research programmes (e.g. obliged fees by growers and research subsidies by the government) and unanimity in research topics that would stimulate sector innovation (Van Galen, 2010). On the other hand, horticulturists established unions and study clubs that bought collective inputs and discussed mutual cultivation and management related problems (Van Winden & Bakker, 1999a; Vijverberg, 2007).

Because of this high degree of consensus and collectiveness, the top-down structured research-extension-education triptych (OVO-triptych) became successful (Van den Ham & Postma, 2007). This sectoral structure primarily invested in process innovations in line with the aim to increase production and lower the cost price of horticultural products. Technological knowledge – which easily translated into new technologies – developed by research institutes flowed to horticulturists via education and extension (advisors). The horticulturists were only expected to deal with new technologies designed and communicated by the OVO-triptych (Van den Ham & Postma, 2007). The system thus aimed at a uniform development of practices, which was realistic as the structure of most mixed companies was similar.

Horticulturists also did not ask for specific applications as most companies were similar and accepted the goals and the means to achieve these goals created by the top. With respect to innovation policy this situation was fruitful as policy could be made less explicit and almost without conflicts (Rutten & Van Oosten, 1999). Also, investments in such a system are almost without risks and generate high benefits on a short term.

The success of the system furthermore depended on the fact that specially established organizations performed each of the activities (research, extension, education) and that through the chain were able to perfectly communicate with each other (Van Dijk et al., 1993; Rutten & Van Oosten, 1999). Because of this unambiguousness and this sharp task division, the sector was able to show a high rate of dynamics.

In sum, the OVO-triptych thus especially stimulated at the development of process innovations. The system was able to achieve this goal because of the adaptation and alignment of management practices, the education system and informal institutions such as norms and values (Van den Ham & Postma, 2007). On the contrary, because the top aimed at a uniform development of companies there was little space for organizational innovation.

According to Riezebos & Zimmermann (2005), this also explains why the amount of marketing innovations was low for the sector. An important driver for a branding strategy is competition. As cooperation played an important role in the history of the Dutch greenhouse, branding strategies were limited.

However, from the 1980s onwards the model became less effective for a couple of reasons (Rutten & Van Oosten, 1999; Van Galen, 2010):

- Changing societal attitudes towards horticultural production methods (changing *demand conditions*)
- Changing government policies
- A growing notion that the vitality of a company and the company branch falls and stands with knowledge, and therefore knowledge is now seen as a more scarce good that should not be shared (see section 6.1)
- An increasing firm diversity

First, societal priorities shifted towards food safety and the effects of food production on the landscape and the environment as prosperity rose and food production was brought back at a satisfactory level. As a result, sector consensus decreased as not everybody was convinced anymore that the OVO-triptych transformed and transported the objective truth (Van den Ham & Postma, 2007). The goals of top and bottom diverged and sometimes even goals were conflicting (Rutten & Van Oosten, 1999; Van den Ham & Postma, 2007). A top-down policy structure thus became less effective. Second, this also influenced the horticultural policies in the form of a withdrawing government on the area of market and price policy and an acting government on the area of environment and nature policy (Rutten & Van Oosten, 1999).

Third, the supplier industry developed a more diverse set of crops and technologies (product and process innovations) which resulted in more diverse and a specialization of horticultural companies (Van Broekhuizen et al, 1997; Hillebrand en Koole, 1999; de Lauwere et al, 2002; Van Galen, 2010). The one-size-fits-all solutions created by the OVO-triptych were thus less effective. Because of the lack of tailor made solutions, the collectiveness of research decreased. The knowledge infrastructure changed from supply driven to demand driven (see section 6.1.2) (Van den Ham & Postma, 2007).

These developments required the horticulturists to develop a new set of competencies and thus to change their strategy and management practices (Van den Ham en Hagelaar, 2005). However, although the market changed, new strategies still built upon former management practices and competencies. A reason for this is for example that the educational background of most horticulturists hardly changed (see section 6.2).

As a result, most horticulturists chose a production oriented rather than a market oriented strategy (e.g. Van Dijk en Van der Ploeg, 1995; Hoeve & Drost, 2002; Riezebos & Zimmermann, 2005; ING, 2009). On the one hand, market oriented firms focus on their consumer and competitors and are well adapted to their environment in terms of their organisation and product offering as well as their positioning in the market (Riezebos & Zimmermann, 2005). On the other hand, product oriented firms do not focus on the market but on the (quality of the) product.

The results of this study partly confirm this statement. For the vegetable industry, it is true that the greenhouse horticulturists follow a product oriented strategy aimed at both process and product innovation in order to save costs and increase product quality (i.e. crop resistance) respectively (see section 4.2). However, according to Heagens (2010) the floricultural industry is more market oriented as this industry uses product innovations to adapt to trends and thus to adapt to their environment in terms of their product offering. However, as figure 1 showed, this industry is not able to translate this strategy into increased profits.

So, although the environment of the firms changed, most management practices, the educational background and informal institutions remained unchanged. As a result, the strategy of most Dutch greenhouse horticulturists still aims at product and process innovations.

Rivalry

The success of the Dutch greenhouse horticultural sector thus depended to a large extent on cooperation. This is contradictory to Porter, who claimed that rivalry pressures firms to innovate. However, also rivalry played an important role in the history of the sector. Rivalry first came from horticulturists abroad. Later on, also rivalry among the Dutch greenhouse horticulturists increased.

International competition increased for two reasons. First, international competition increased thanks to the surge in production right after the Second World War, the market changed from a supply to a demand driven market (Van Meijl et al., 1999). Second, international competition also increased when Dutch horticulturists became able to extend their cultivation season thanks to a rapid technological development (Van Galen, 2010). While in the early days cultivation was bound to summer production, process innovations enabled them to also supply the market during winter usually performed by the Mediterranean countries.

The increased international competition also changed the competition structure. Before, the Dutch products always showed a high quality compared to that of foreign products (Van Meijl et al., 1999). Since also other countries increased their product quality, this now only became a prerequisite to export. As a result, competition shifted towards competition on price and product differentiation.

According to Van Galen (2010), product and process innovations were important instruments in the struggle against competition from countries such as Spain. In order to compete with these low cost countries today, process innovations especially aim at saving labour and energy costs. Product differentiation aims at developing new crops not provided for by competitors.

Nowadays, competition on price has also become more local because of an increasing power of supermarkets. Consumer statistics show that the market share of (large) supermarkets in the spending of households on food has increased from 51% in 1995 to 65% in 2005 (Silvis et al. (2009). This now makes them the most important food sales market just like in many other EU countries. As a result, more horticulturists decided to directly deliver to supermarkets rather than sales via the auction in order to secure income. Because of this, the power of the supermarkets grew as they were able to play the growers off against each other on price (Cornelis & De Jong, 2010; Van Galen, 2010).

In sum, market changes influenced the sector especially in the direction of competition on price but also on product differentiation. As a reaction, the sector chose to invest in process innovations to save production costs and in product innovations to achieve product differentiation. Furthermore, these changes undermined marketing innovations. Since supermarkets want to remain able to switch among suppliers when there is a considerable cost difference, they do not accept branding for example (Cornelis & De Jong, 2010; Van Galen, 2010). Branding could cause the lock-in of products.

5.2 Factor conditions

This section discusses the physical-, capital-, human- and knowledge resources of the factor conditions determinant. The literature does not give any indications on how the greenhouse horticultural infrastructure influenced the direction of innovation within the sector.

Physical resources

The physical resources form the basis of the Dutch horticultural success that started at the end of the nineteenth century (Van Winden & Bakker, 1999b; Silvis et al., 2009). The soil was fertile, there was a broad availability of sweet water and there was a positive moderate sea climate. The impoldering of Dutch polders from 1867 onwards created more space for horticulture. Probably most important was the strategic position of the Netherlands relative to large foreign horticultural markets and the sea (Vijverberg, 1996; Van Winden & Bakker, 1999b; Silvis et al., 2009).

The Dutch climate was not suitable for year round production and the cultivation of crops such as tomatoes. This changed with the introduction of glass around 1900 (Van Winden & Bakker, 1999a). There were already some early examples from the seventieth and eighteenth century that show the use of glass for melon cultivation in the Netherlands (Vijverberg, 2007). From the 1900s onwards the area under glass significantly increased which enabled growers to advance the cultivation of vegetables and to grow exotic crops such as tomatoes and cucumbers. This probably also explains why section 4.2 shows a specialization of the Netherlands in forcing frames and greenhouses.

With the discovery of the greenhouses and other specialized and advanced technologies (see section 6.2), the influence of natural establishment criteria such as the climate, the soil quality and the availability of water changed. Vijverberg (1996) analysed the importance of (the quality and quantity of) natural establishment criteria for covered cultivations such as the greenhouse horticulture. He concluded that natural radiation of the sun is the most important criterion divided into the total yearly radiation and the radiation distribution over day or year. If the radiation is more evenly distributed, it is better utilized. For example, Scandinavian countries perform comparable to the Dutch greenhouse horticulture with a lower overall radiation rate but with more sun hours a day and thus a better distribution. Also, although the Mediterranean countries have a much higher radiation level, water is their limiting factor. Then, much light does not have a positive effect on production.

Although you would expect that the high technological standard of the Dutch greenhouse horticulture has circumvented much problems such as water and CO2 supply, warmth and even light (assimilation lighting), the competitive position of the Dutch greenhouse horticulture is threatened. According to Vijverberg (1996), assimilation lighting hardly plays any role compared to the influence of natural radiation on production. When Mediterranean countries thus become able to circumvent their problems with water or CO2 supply - problems that are much easier to circumvent -, they will have an advantage over the Netherlands because of their more feasible natural radiation conditions.

Compared to other countries, the Netherlands also suffer from limited space and high land and energy prices. Land availability is low because of a high population density and claims on the green space (Zandvliet & Sijses, 2007; Silvis et al., 2009). Together with an intensive use of land for agricultural purposes this also led to high land prices (Silvis et al., 2009). Next to this, gas prices rise as the Netherlands run out of cheap gas.

The Netherlands thus suffer from a negative position of their physical resources. In order to compensate for these disadvantages, the Netherlands primarily engaged in process innovations. While at first these process innovations primarily related to increasing yield and the cultivation of a more extensive set of crops, they are now aimed at saving energy and land costs. Examples of the latter are cultivation on different levels or the construction of aquifers to store heat or water in the bottom (Boone et al., 2007).

Capital resources

In the early days, horticulturists were bound to so called consignation traders. These traders were monopolists as each of them served their own region (Vijverberg, 2007). They loaned money to horticulturists as an advance to their next harvest and supplied them with inputs. In return, the harvested crops were sold to the trader. They had considerable power because the distance between rural area and city was large and horticulturists did not have the time or personnel to bring their products to the market (Plantenberg, 1987). Overall this resulted in lower profits for growers (Van Winden & Bakker, 1999a; Vijverberg, 2007).

The establishment of the auctions from 1887 onwards meant the end of the consignation trade (Vijverberg, 2007). The aim of these auctions was to make the trade more transparent and to make the horticulturists independent of the individual traders (Vijverberg, 2007). Often, social pressure and action of local leaders was necessary to end the traditional way of selling and buying. Also the Union Westland, established in 1889, stimulated the auctions among horticulturists (Van Winden & Bakker, 1999a).

Because of the change in the trading system, horticulturists now needed a harvest credit independent of an individual trader (short term credit) (Vijverberg, 2007: 59). The development of the sector (investments in glass) also required the grower to have an investment credit (long term credit). These credits were provided by the Cooperative Farmer Loan Bank, established in 1910 (Van Winden & Bakker, 1999a).

Nowadays, this bank – now called the Rabobank – and other banks such as the ABN and the ING still provide most capital resources (Van Galen, 2010). The horticulturists have thus always been dependent on others with respect to their financial resources. As innovation is a risky business, external financiers have especially invested in relatively safe process innovations for which they can easier assess the pay-back return on investment periods (Alkemade et al., 2010: *in press*).

Human resources

With respect to human resources, the literature distinguishes low and high qualified personnel and the education level of the horticulturists themselves.

First, the sector depends on low skilled and routine labour (De Bakker et al., 2004). The need for this type of labour differs across the sector and during the year. However, the sector experiences problems with finding sufficient personnel, especially during the harvest periods (De Bakker et al., 2004; Vermeulen et al., 2004). This is especially a problem for the horticulture as they employ almost 80% of all agricultural personnel (Silvis et al., 2009). This problem is often solved by hiring labour from new EU members. However, there is uncertainty about the availability of labour migrants from new EU members as it is hard to predict the development of their labour markets.

Next to this, the use of illegal labour is high in the Netherlands (De Bakker et al., 2004; Boone et al., 2007; Van Galen, 2010). This is also done from a cost perspective (De Bakker et al., 2004). Many researchers claim that the rising labour costs negatively influence the Dutch greenhouse horticulture (e.g. De Boon, 2005; De Rooij, 2008; Van Henten & Pekerriet, 2008). Figure 11 shows that labour costs have considerably increased over the past twenty years (this also includes the costs for high qualified personnel). For the last couple of years this rise has stagnated.

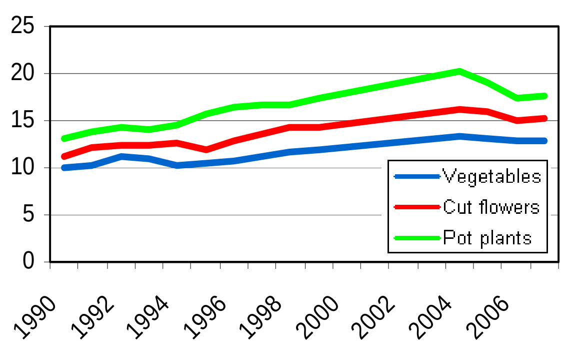

Figure 11: Labour costs in euros/m^2 for Dutch greenhouse horticulturists (data sources: LEI, 2010a; De Bont & Van der Knijff 2006-2007)

Due to the negative position of the Netherlands in its low qualified personnel, horticulturists chose to invest in process innovations. On the one hand, the aim of these process innovations was to save labour costs. On the other hand, these innovations enabled horticulturists to replace labour with technology.

The sector also depends on high qualified personnel for two reasons. First, because of the increasing complexity of process innovations such as the mechanization and automation of production processes in the greenhouse horticulture, there is more demand for personnel with a technical background (Silvis et al., 2009).

Second, the economies of scale (see Annex IV) in the sector lead to an increasing demand for higher qualified personnel (Vermeulen et al., 2004; Van den Ham & Postma, 2007; Van Galen, 2010). In order for a company to remain effective, it is important that the entrepreneur and his employees share responsibility on areas such as product development, marketing and network organization which demands more qualified skills from the personnel (Van der Lans & Vermeulen, 2004; Vermeulen et al., 2004; Van Galen, 2010).

However, compared to the rest of the society, the mean education level of the sector is low (Van Galen, 2010). Almost 60% of the greenhouse horticulturists have problems finding sufficient qualified personnel (Vermeulen et al., 2004). First, there is a lack of students following horticultural related programs (Silvis et al., 2009). This primarily relates to the negative image of the sector (Warmerdam et al., 2003). Reasons for this negative image are that potential students consider greenhouse horticulture as heavy and dirty work and that the media especially discusses sector problems such as transport congestion, chemical crop protection, illegal employees and the negative environmental impact (Warmerdam et al., 2003; Vermeulen et al., 2004; Boone et al., 2009; Silvis et al., 2009).

Second, employees are primarily recruited within the own network or environment of the company (Vermeulen et al., 2004). However, growers complain that the number of potential employees in the direct environment is too small. Third, most employees do not have the motivation to follow extra education or programs to improve their skills although many entrepreneurs are willing to pay for these programs (Van Leth, 2003; Vermeulen et al., 2004). Finally, it is difficult for most growers to keep their personnel. They try to bind their personnel on the basis of work atmosphere and terms of employment, while employees are more interested in career opportunities and work diversity (Warmerdam et al., 2003; Vermeulen et al., 2004).

However, although the sector has problems with finding sufficient high qualified personnel the results of section 4 showed that the amount of process innovations did not drop. However, the same results also showed that the amount of organizational and marketing innovations is low. We can therefore assume that the sector experiences more problems to find high qualified personnel with the aim to share responsibilities on product development, marketing and network organization (marketing and organizational innovations) than for the development of technologies (process innovations). As we see from the education level of horticulturists below, this may relate to the education curricula that mainly favour product and process innovations.

Finally, section 5.1 showed that the role of the horticulturists changed with the breakdown of the OVO-triptych. The greater complexity of today's topics requires horticulturists to do business differently. It is not sufficient anymore to only be a profession expert. Horticulturists now need to develop competencies aimed at strategic entrepreneurship towards market and society. Craftsmanship and operational management remains important however for the short term performance of the company. On the contrary, strategic management is important for forming goals and to guarantee company continuity on the long term. Entrepreneurship in combination with good craftsmanship favours innovation as horticulturists become able to combine the knowledge from the environment with their strong capacities as entrepreneurs.

In order for a horticulturist to develop these entrepreneurial skills we argue that the educational background is important. Table 10 shows the education level of the horticulturists for 1996 and 2005 (CBS Agricultural Countings 1996 and 2005). The table distinguishes people with an agricultural background (e.g. HAS, Wageningen University, College Van Hall Larenstein) and a non-agricultural background. The table shows that the education level of most company leaders is low. There is only a slight increase in the share of leaders with a university or college degree between 1996 and 2005. The largest shift occurred from LBO and other secondary education to MBO. In 1996 still more than 50% had an education level lower than MBO, while in 2005 most entrepreneurs are educated on an MBO level.

	Vegetables under glass		Flowers under glass		Total greenhouse horticultural sector	
	1996	*2005*	*1996*	*2005*	*1996*	*2005*
Agricultural: Finished university or college	3,2 %	4,0%	4,7%	4,7%	4,2%	4,5%
Non-agricultural: Finished university or college	0,8%	1,4%	1,9%	2,0%	1,5%	1,8%
Agricultural. Finished MBO / non-finished HBO	27,4%	42,8%	24,5%	37,0%	25,5%	38,8%
Non-Agricultural. Finished MBO / non-finished HBO	3,1%	6,9%	4,6%	8,4%	4,1%	7,9%
Agricultural. Finished LBO or other secondary education / non-finished MBO	50,5%	34,8%	49,7%	36,8%	50%	36,2%
Non-Agricultural. Finished LBO or other secondary education / non-finished MBO	5,6%	3,7%	5,2%	4,6%	5,4%	4,3%
Only primary education / non-finished LBO or other secondary education	9,3%	6,3%	9,4%	6,4%	9,4%	6,4%

Table 10: Education level of the first company leader (data source: CBS Agricultural Countings, 1996 and 2005).

Compared to universities and colleges, MBO programmes primarily aim at teaching cultivation technical or breeding skills that respectively relate to process and product innovations (e.g. ROC, 2010a-b; Wellant College, 2010a-b).On the contrary, Wageningen University and the Van Hall Larenstein College do teach courses on technology and product development but emphasize that it is important to educate their students on management because of the complex environment in which today's horticultural companies reside (e.g. Hogeschool Van Hall Larenstein, 2010a-b WUR, 2010a-b). So, the background of most horticulturists forces them in the direction of product and process innovations.

Knowledge resources

The Dutch greenhouse horticultural sector has several specialized research institutes (see table 11). Table 11 also indicates to which innovation trajectory the topics relate that are studied by the different research institutes.

Product innovation: • LEI (Agricultural Economic Institute) • PPO (Practice Research Plant and Environment) • PRI (Plant Research International) • WUR Greenhouse Horticulture • TTI-GG (TTI Green Genetics)	**Process innovation:** • LEI (Agricultural Economic Institute) • PPO (Practice Research Plant and Environment) • PRI (Plant Research International) • WUR Greenhouse Horticulture • TNO (Dutch organization for applied scientific research) dep. Greenhouse Horticulture • ISSO (knowledge institute for the installation sector)
Marketing innovation: • LEI (Agricultural Economic Institute) • PPO (Practice Research Plant and Environment) • PBH (Product Board Horticulture) • FCH (Flower Council Holland)	**Organizational innovation:** • LEI (Agricultural Economic Institute) • PPO (Practice Research Plant and Environment) •

Table 11: Overview of the most important knowledge institutes for the Dutch greenhouse horticultural sector including their research specialization (data source: Zandvliet & Sijses, 2007; Cornelis & De Jong, 2010).

LEI, PPO and PRI are all part of the Wageningen University and Research Centre (WUR) (WUR, 2010c) and belong to the top of the world on the area of horticulture, especially with respect to plant breeding (Zandvliet & Sijses, 2007). The LEI is a research organ that supports governments and companies with economic knowledge development in the areas of food, agriculture and green space (LEI, 2010b). The LEI performs studies on areas such as international policy, markets and chains, and sector and entrepreneurship and takes into account the whole supply chain (LEI, 2010b). PPO is more practice directed and based on co-innovation with partners from different disciplines such as agriculture, science, the industry and the government translate management and cultivation related topics into practical solutions. Next, PRI conducts strategic and applicative research on the area of genetics, genomics, crop protection and the like and is thus more directed at product innovations in particular (Zandvliet & Sijses, 2007; PRI, 2010).

Within WUR and TNO there are also special departments aimed at the greenhouse horticulture. Research especially aims at creating practical technical solutions in cooperation with the greenhouse horticultural sector. Examples are the development of fully automated cultivation systems, new crop protection strategies and energy saving measures.

The TTI-GG is a cooperation between the companies active in breeding (seeds, bulbs, tissue and young plants) and knowledge institutes to improve the knowledge infrastructure around plant genetics, physiology and pathology on the basis of research and education (Zandvliet & Sijses, 2007; TTI-GG, 2010). Research aims at (1) the growth and development of plants to optimize adaptation of plants to new production circumstances (2) plant healthiness to increase protection and diseases and plagues and (3) consumer quality to improve the quality (e.g. taste and smell) of products under changed production circumstances (Zandvliet & Sijses, 2007).

The ISSO aims at the identification, development and transfer of knowledge on installation disciplines, mechanics, electro technique and ICT (Zandvliet & Sijses, 2007). Popular themes are safety, health, environment, energy and quality.

Finally Product Board Horticulture and Flower Council Holland specifically aim at developing market related knowledge. PBH is a corporate company organization that consists of different commissions for cut flowers, fruit and vegetables, tree cultivation and the like (Zandvliet & Sijses, 2007). The mission of PBH is to improve the competitive position of the Dutch horticulture. Together with employers' and employees' organizations, they invest in promotion of the sector and research. The main research focus is on market research for the (greenhouse) horticultural sector on how to promote products among consumers and testing the effectiveness of promotion campaigns on the basis of consumer panels (Cornelis & De Jong, 2010). This is done for both the Dutch as well as foreign markets because many products are exported.

Flower Council Holland has much knowledge about the floricultural market in particular. It is the sector wide promotion organization of the floricultural sector that provides for all the commercials and advertisement of Dutch cut flowers and pot plants. Their aim is to increase sales in the Netherlands as well as abroad and to professionalize the marketing of Dutch products. One of their departments – the Project Bureau – places this knowledge at the disposal of horticulturists. This bureau is specialized in advising horticulturists on how to promote their products or on how to achieve higher sales by adding value to the product.

In sum, the Dutch greenhouse horticultural sector has an advanced and specialized knowledge infrastructure that pursues research that relates to all four innovation trajectories. In other words, the availability of knowledge is not an issue for the sector. However, in section 6.1 we discuss who determines which knowledge is developed and whether horticulturists are able to gain access to this knowledge institutes.

5.3 Demand conditions

Although the Dutch horticultural market is only small, Dutch horticulturists have been able to increase their export demand substantially. With respect to vegetables, there was an early foreign demand for Dutch products. When countries such as Germany, Great-Britain and France industrialized at the beginning of the 19th century, there was an increasing demand for vegetables (Poppe et al., 2009). Dutch horticulturists could easily profit from this development because the Netherlands industrialized much later (around 1890) and thus still depended on their agriculture and horticulture (Poppe et al., 2009). Furthermore, the Dutch horticulturists benefited from their geographical position, decreasing transport costs and their export mindedness build up in the 1850s (Van Doesburg et al., 1999; Poppe et al., 2009).

Next to that, there was also an early international demand for Dutch floricultural products. The sector stimulated this demand for floricultural products by arranging exhibitions in both the Netherlands and abroad (Van Winden & Bakker, 1999). Because of exhibitions in Gent, Berlin and London at the beginning of the 20th century, foreign demand for Dutch floricultural products grew.

The literature does not indicate whether foreign demand qualitatively differed from that of the Dutch at that time. However, important is that the demand for Dutch horticultural products steadily increased from around the end of the 19th century onwards. Because of this increasing demand, Dutch horticulturists invested in process innovations aimed at production improvement in order to satisfy this large foreign demand for the horticultural products.

With respect to the quantity of demand, greenhouse horticulturist still export almost 70-90% of all products to countries such as Germany, Great-Britain and France (De Bakker et al., 2004; Van Galen, 2010). Table 12 and 13 show export statistics for the vegetable and floricultural industry respectively (Boone et al., 2007). Table 12 shows that the export of Dutch vegetables is relatively stable. The export value of the floricultural products has increased more for the same period (table 13). In 2006, this is partly explained by a higher price for both cut flowers and pot plants (Boone et al., 2007). Next to that, export increased thanks to a higher quality assortment and more added value. The export of floricultural products thus also increased in terms of volume.

	2000	2001	2002	2003	2004	2005	2006
Eggplant	26,7	25,1	25,9	31,3	33,5	32,2	31,3
Cucumber	302,6	317,1	331,9	324	338	344,1	345,5
Pepper	245,7	264,4	270	272,3	282,7	312,1	286,4
Tomato	465	495	503,9	541,3	606,6	608	624,5
Total a)	-	-	2.464,30	2.655,30	2.722,50	2.677,60	2.666,60

Table 12: Exported amount of fresh vegetables (inclusive re-export) in the period of 2000-2006 (in million kg) (data source: Boone et al., 2007). a) Glass and open ground vegetables.

	1990	1995	2000	2004	2005	2006
Cut flowers	1.600	2.027	2.847	3.052	3.144	3.237
Pot plants	669	808	1.175	1.611	1.715	1.779
Total floriculture	2.269	2.835	4.022	4.663	4.859	5.017

Table 13: Export value of the floriculture in the period of 2000-2006 (million euro) (data source: Boone et al., 2007).

Next to the quantity of demand, Bijman & Hendrikse (2001) claim that the quality of demand for vegetables is high for consumers in North Western Europe. Food needs to be safe, healthy, and convenient and also variation is important. They are prepared to pay a higher price for these products. Based on Haegens (2010) we can also expect that the quality of demand for floricultural products is high as the industry is sensitive to trends.

In sum, the quantity of demand favours process innovations as firms needed to satisfy large foreign demand. Next, the quality of demand stimulates product-, marketing and process innovations (aimed at increasing product quality).

5.4 Related & supporting industries

The Netherlands belong to the top of the world in greenhouse technology (Vermeulen & Poot, 2008; AVAG, 2004). Dutch installation companies and greenhouse builders played the most prominent role in this technology development (AVAG, 2004). This market leadership is expressed in a number of ways:

- Dutch greenhouse builders export to other countries on a large scale. Only Israelian and Spanish greenhouse builders and installation companies do this on a certain scale, dependent of region and climate.

- Dutch companies have a lead in applying technologies that are necessary for moderate (climate) regions, especially in regions where factor costs are high
- Dutch companies succeed in establishing profitable large projects also in remote regions.
- Dutch greenhouse builders and the installation companies built up a good reputation and therefore a high credibility.

Another strength of the suppliers is that they easily adopt technologies from outside the sector and translate these into solutions for Dutch greenhouse horticulture. This is because most of these companies have a branch outside the horticulture (AVAG, 2004). This enables them to see opportunities outside the sector that can be applied for horticultural purposes.

Furthermore, they profit from interactions with research institutes (knowledge resources) and horticulturists. On the basis of scientific knowledge created by research institutes, Dutch greenhouse suppliers innovate in two phases: a pre-competitive and a competitive phase (Van Galen, 2010). In the pre-competitive phase, the suppliers and the research institutes together translate fundamental research into new technologies. Horticulturists are furthermore involved to act as a test site for the innovation. Then, in the competitive phase the suppliers further develop and sophisticate the technology in cooperation with the horticulturists, and eventually commercialize the technology.

The sector often uses this construction for process innovations as they are capital intensive (Alkemade et al., 2010: *in press*; Van Galen, 2010). Both the supplier and the horticulturist invest in the development of the technology. The supplier profits from obtaining the technology patent, while the grower receives the technology under feasible conditions.

Finally, the suppliers profit from Dutch greenhouse horticulturists for three more reasons. First, in line with Porter, Van Galen (2010) and Vermeulen & Poot (2008) add that suppliers especially prefer the interaction with Dutch growers because of cultural and physical proximity. Second, AVAG (2004) concludes that many horticulturists invest in new concepts of which the performance not necessarily has been proved in practice yet. This creates stimuli for suppliers to invest in new technological concepts. Third, Both Porter (1998) and Van Meijl et al. (1999) emphasize the importance of exigent demand for innovation and product development. This is primarily caused by increasing foreign competition which puts pressures on the Dutch grower to lower energy and labour costs that are much higher than in countries such as Spain and Morocco (Van Meijl et al., 1999; AVAG, 2004).

In sum, the Dutch greenhouse horticultural sector contains strong technological suppliers because of an early specialization and division of activities. The presence of strong suppliers and strong connections between research, suppliers and horticulturists especially favour process innovations.

5.5 Chance

Probably the most important chance event within the history of the Dutch greenhouse horticulture was the agricultural crisis at the end of the nineteenth century. At the basis of this crisis were the improved transport facilities from the United States to Europe, and the increased production of cheap grain produced by the United States (Van der Meer et al., 1991). On the basis of this crisis, the government reacted by studying how they could improve the competitive position of the horticultural sector

(Van Winden & Bakker, 1999a). This eventually led to the rapid modernization of the greenhouse horticulture as we know it today.

However, an important condition for this rapid development of the sector was the discovery of the greenhouse (Van Winden & Bakker, 1999a). This was a major technological breakthrough, that enabled Dutch horticulturists to advance and extent their cultivation season to a large extent.

Finally, there was an important role for the energy crisis of 1973 related to the Jom Kipoer War (Vonk Noordegraaf & Van Winden, 1999; Vijverberg, 2007). Until then, energy had never been a problem. Cheap energy was an important development factor for the Dutch greenhouse horticultural sector. Now, the sector needed to focus on energy saving technological solutions. In 1979, there was a second oil crisis.

In sum, the chance events especially pushed the direction of innovation of the sector towards process innovations.

5.6 Government

An important characteristic of the horticultural sector is that the influence of the national government is limited. Currently, about eighty percent of all legislation created by the Ministry of Agriculture, Nature and Food Quality is based upon EU directives (Ministry of ANF, 2010b). Furthermore, the Dutch greenhouse horticultural sector creates many rules and legislation themselves. The Product Board Horticulture is responsible for this. In cooperation with employers and employees it has the power to create so called ordinances to which all sectoral players need to comply. The task of the Ministry of ANF is only to monitor these activities.

According to Van Galen (2010) one of the most important influences of the EU on the sector has been in the creation of so called ‘growers’ unions’. Compared to former study clubs, these unions are not noncommittal. Growers’ unions are real companies with statutes and quality standards to which the members must comply. For the establishment of these growers’ unions horticulturists receive a subsidy. The advantages according to the EU are first of all that innovation on the basis of cooperation is much better and faster. Second, growers need to be protected against the power of supermarkets for example. The prices of greenhouse horticultural products could decrease to such an extent that many smaller growers could collapse. A cooperation of growers thus creates more mass to compete in the sector. Finally, horticulturists can use the investments more efficiently as it is shared by more growers and the smaller firms can now profit from highly sophisticated technologies. In a time where machines become more complex and more expensive, most companies do not have sufficient financial resources to buy these installations.

Then, the national government does have created a list of agreements together with the sector on topics such as energy, crop protection and manure use and which are translated to individual company norms (Boone et al., 2007). Furthermore, the local governments influence the spatial planning that may influence greenhouse horticulturists. According to Van Galen (2010) the norms for using chemicals are much tighter than those for energy. Although the greenhouse horticultural sector accounts for 85% of total agricultural energy use (Boone et al., 2007), they are still allowed to use as much energy as they want.

This relates to the strong lobby of incumbent actors in the sector (Alkemade et al., 2010: *in press*). Many incumbents with large interests are often well organized and have a large influence on sector policies. Many incumbents thus profit from the current system conditions and do not profit from sustainability changes. This may lead to higher costs or threat their market share and market position.

Furthermore, the national government provides a set of subsidies that specifically relate to energy related innovations (Alkemade et al., 2010: *in press*): Market introduction Energy Innovations (MEI), Investment Regulation Energy savings (IRE), the demo regulation energy, Energy Investment Deduction (EIA), fiscal deduction regulation MIA/VAMIL and the Energy Research Subsidies (EOS). The projects within the boundaries of these subsidies especially relate to process innovation.

Finally, the sector ordinances created by the Product Board Horticulture mainly relate to limiting chemical use or guaranteeing a certain product quality (Product Board Horticulture, 2010b).

In sum, policies stimulate firms to engage in process innovations via the growers' unions subsidies, energy subsidies and policies on the use of chemicals. So, also government legislation favoured the direction of innovation of the sector towards process innovation.

6. Malerba analysis

This section discusses the determinants that have influenced the direction of innovation in the Dutch greenhouse horticultural sector from the perspective of Malerba's SSIP.

6.1 Knowledge and learning processes

This section discusses the internal and external accessibility of knowledge, opportunity and the cumulativeness of knowledge of the knowledge and learning processes building block.

Internal accessibility of knowledge

From section 5.1 it became clear that right after the Second World War, consensus and collectiveness characterized the sector. This positively influenced the internal accessibility of knowledge (ability to adopt and imitate products and processes of competitors). First, unions and study clubs bought inputs collectively and discussed mutual cultivation and management related problems (Van Winden & Bakker, 1999a; Vijverberg, 2007). In principle, horticulturists shared all types of knowledge within these study clubs. However, the reason for the establishment of these clubs mainly related to the rapid technological development. Because the parents of horticulturists did not have any knowledge on most of the new technologies, horticulturists needed other ways to develop the competencies to deal with these new technologies (Vijverberg, 2007). The study club thus favoured the development of process innovations.

Second, auctions played an important role in this respect as they functioned as meeting places, where growers learned that together they would have a much stronger market position (Van Winden & Bakker, 1999a). During the cultivation season excursions were planned to practice experiments, interesting developments at colleagues' firms and developments abroad. On the basis of these excursions, the horticulturists especially shared cultivation related and technological knowledge (De Man, 2009). Also the excursions thus favoured the development of process innovations.

However, internal accessibility decreased when rivalry shifted to competition on price as described by section 5.1. Based on Alkemade et al. (2010: *in press*), you would thus expect that horticulturists will share less knowledge with each other as the possibilities for process innovations are limited for mature industries and because advantages are only temporary. Rutten & Van Oosten (1999) confirm that there is a growing notion that the vitality of a company and the company branch falls and stands with knowledge, and therefore knowledge is now seen as a more scarce good that should not be shared

Today, the internal accessibility of knowledge remains therefore limited to sharing knowledge with the horticulturists that are member of the same growers' union (Kooistra & Weststeijn, 1999; Hoeve & Drost, 2002). These horticulturists share primarily knowledge on cultivation technologies and the creation of new brands and thus favour process and marketing innovations (Bijman & Hendrikse, 2001; De Man, 2006). Furthermore, Kooistra & Weststeijn (1999) and De Man (2009) claim that horticulturists started to cooperate more on a vertical level rather than on the horizontal level with other horticulturists. Here, you would expect that cooperation with downstream actors (e.g. retail and consumers) would lead to the development of marketing innovations and cooperation with upstream actors (e.g. breeders and technological suppliers).would lead to product and process innovations.

In sum, the rate of knowledge sharing between horticulturists thus decreased which negatively influenced the internal accessibility of knowledge. However, the types of knowledge shared between horticulturists extended, as small groups of horticulturists started to share technological as well as marketing related knowledge within growers' unions.

External accessibility of knowledge

In section 5.2 we described that for the Dutch greenhouse horticultural sector there is an extensive network of specialized and advanced knowledge institutes available, that study topics on all four types of innovation. However, as we saw from section 4, the amount of marketing and organizational innovations is low for the sector. This could imply that horticulturists have troubles to really access the available knowledge.

The external accessibility of knowledge in times of the OVO-triptych was high. Education and extension (advisors) had the function to disseminate the knowledge developed by research institutes among horticulturists. These advisors thus visited the horticulturists with information on the newest developed technologies (Van Doesburg et al., 1999). Furthermore, they helped horticulturists with the implementation of these new technologies in their company. In line with the aim of increasing production and product quality, there was thus a high external accessibility of process related knowledge.

However, over the years the accessibility of external knowledge decreased for two reasons (Klerkx & Leeuwis, 2008). First, as for the same reasons that caused the OVO-triptych to breakdown, the accessibility of external knowledge decreased as firms differentiated on products and technologies over the years. The one-size-fits-all solutions created by the OVO-triptych did thus not qualitatively satisfy most knowledge questions by horticulturists. Second, horticulturists became self responsible for collecting the knowledge they needed when knowledge institutes privatized in the 1980s. Acquiring knowledge from external actors thus became an important entrepreneurial routine for horticulturists as there were no advisors anymore that connected the research institutes with the horticulturists (Van Doesburg et al., 1999). (Klerkx & Leeuwis, 2008). However, in section 5.2 we saw that the education level of horticulturists remains low which restricts them from acquiring these entrepreneurial skills.

These two developments negatively influenced especially the accessibility of marketing related knowledge. The technological knowledge resources still show characteristics of a supply driven knowledge system. As we explained in section 5.4, research institutes search for suppliers in order to transform their developed knowledge into new technologies who themselves search for horticulturists that function as test sights (Van Galen, 2010).

On the contrary, horticulturists have more problems with finding marketing knowledge residing at the Product Board Horticulture and the Flower Council Holland as they have to look for this knowledge themselves. According to Cornelis & De Jong (2010) these two organizations possess much market related knowledge, but it is the responsibility of the horticulturists to do something with this knowledge.

So, although the quality and amount of knowledge resources available to the Dutch greenhouse horticultural sector did not change that much, the accessibility of the knowledge created by this institutions drastically changed. Horticulturists became responsible for finding their own external knowledge but lacked the competencies to achieve this. This especially hampers marketing innovations, as the marketing related knowledge resources handle a more reactive strategy. On the contrary, since the technological knowledge institutions proactively look for potential development partners, the sector has been able to remain active on the field of process innovations.

Opportunity

In times of the OVO-triptych, the major sources of opportunities were the research institutes (see section 5.1). They developed the knowledge at the basis of the process innovations (Van Galen, 2010). There was not much attention for marketing innovation since the aim of the sector was especially to increase production and lower costs. Also, organizational innovations did not play a large role because the system aimed at the development of uniform firms and the strategy of firms mostly depended on the goals of the top (e.g. Van Galen, 2010; Van den Ham & Postma, 2007).

After the breakdown of the OVO-triptych, the research institutes remained an important innovator within the sector. Still 80% of the most radical innovations are based on fundamental and practice research (see section 6.2) (Van Galen, 2010). However, the role of suppliers became more important for process innovations in the sector as we discussed in section 5.1 and 5.4. Today, innovation occurs on the basis of strong interactions between research institutes, suppliers and horticulturists. All data sources only name the suppliers as the innovators for process innovations which relates to the fact that they are the ones who receive the patent (Alkemade et al., 2010: *in press*; Van Galen, 2010).

For process innovations, the suppliers refer especially to greenhouse builders and installation and machine companies (based on patents). Not all installation and machine builders are specifically aimed towards the greenhouse horticulture as was already explained by section 5.4. However, the sector profits from this as these suppliers are able translate knowledge from other sectors in innovations for the greenhouse horticultural sector.

Product innovations are especially pursuit by breeders. Based on the breeders' rights Horti Fair Innovation Award database we can also conclude that not all breeders are pure breeders but can also be active in growth and cultivation.

Then, on the basis of the trade journals we see that especially horticulturists and the retail are responsible for marketing innovations. However, section 4 showed that the amount of marketing innovations is low. The literature claims that these actors do not put much effort in this type of innovation which implies that they do not see much opportunity in marketing innovations. De Man (2009) claims that for horticulturists this relates to the lack of competencies on this area. According to the Vakblad voor de Bloemisterij supermarket manager do not give much attention to flowers and plants for example as they think that this does not result in significant higher profits (e.g. 2005: 43, 2006: 2, 2007: 13).

In sum, the sector seems to see more opportunities in product and process innovations rather than in marketing innovations.

Cumulativeness of knowledge

It is difficult to draw conclusions on the influence of the cumulativeness of knowledge on the direction of innovation of the sector based on the literature. We expect that the cumulativeness of all four types of innovation is low. First, knowledge related to product and process innovations is mainly in the form of crops and technologies which could thus easily be obtained by buying these crops or technologies. Second, for marketing innovations you do not have to have much knowledge on how the market was a couple of years ago. It satisfies to collect marketing knowledge on today's market characteristics.

However, cumulativeness may be high with respect to the "success-breeds-success" principle. Malerba (2002: 252) states that "innovative success yields profits that can be reinvested in R&D, thereby increasing the probability to innovate again". As the success of the Dutch greenhouse horticultural sector mainly depended on process innovations, there are numerous examples of successful process innovations (see section 6.2). However, according to Riezebos & Zimmermann (2005) there are only a couple of successful marketing innovations (e.g. brand names as Zespri and Chiquita). In this respect the cumulativeness of knowledge probably favoured process innovations. As became clear from section 5.4, AVAG (2004) even concludes that many horticulturists invest in new technologies of which the success has not necessarily been proved in practice yet.

6.2 Basic technologies with key links and dynamic complementarities

This section elaborates on the process innovations mentioned in section 5. These process innovations mainly related to saving (energy and labour) costs and partly aimed at improving yield and product quality improvement. This section discusses the technologies in more detail that were important for the development of the Dutch greenhouse horticultural sector.

First of all, the greenhouse itself forms the basis of the success of the greenhouse horticultural sector. Greenhouses made it possible to extend the cultivation season and cultivate crops that would not have survived our climate (Van Winden & Bakker, 1999a). Around 1900 glass entered the sector in the form of so called flat glass. Ever since, many new forms of glass were introduced such as one-lighters, conservatories and head greenhouses.

The ancestor of the greenhouses as we know them today was introduced in 1906 (warehouses) (Vijverberg, 2007). Within a decade also heated greenhouses started to increase. This greenhouse suffered from a limited light transmission and chinks which were a source of heat loss and diseases. The development of the Venlo greenhouse in 1928 solved these problems (Vijverberg & Van Doesburg, 1999). This greenhouse enabled the cultivation of both vegetable and floricultural crops and was therefore the first universal greenhouse. More recently, initiatives relate to the creation of sustainable and energy producing greenhouses (Vijverberg, 2007)

Not only the greenhouses themselves but also the technology and greenhouse regulating systems became ever more advanced over the years. From 1951 onwards there was increased attention for the regulation of the greenhouse climate (Vijverberg, 2007). Probably the first innovation on this area was the mechanization of the greenhouse ventilation. Many have followed in the past decades, of which we will now discuss a number of important ones.

The tube rail system was an important labour saving technology in the 70s (De Bakker et al. (2004). From the 90s onwards this technology became a standard in most greenhouse companies. Rails of tubes are placed in every path so that crops can be easily collected in barrows and transported. In imitation of this technology more technologies have been designed to facilitate the transport of products from the greenhouses to the sorting hall. Another important labour saving technology was the sorting machine (De Bakker et al. (2004). This machine can sort crops on length, colour, quality, etc. and are sometimes even more accurate than the human eye.

The tube rail system also enabled the development of a high fibre cultivation system which is thus a dynamic complementarity (Van den Berg, 1999). For example, this has led to a revolutionary change of tomato cultivation. The top of the blossoming bunches are now maximal lighted while the fruits remained in the shadow. The result was more tomatoes per plant and a better quality product. Because of the electric tube rail system that could automatically be adapted to different heights it became possible to treat the plants even on high levels. Also pepper and cucumber production have profited from this technology.

With respect to saving energy costs, the introduction of the more efficient heat power combination was important (Van den Berg, 1999). This energy delivering system produces electricity, heat and CO2. CO2 is an important input for the growth of crops. The electricity was mainly used to provide the greenhouses with extra light, since extra light leads to a higher production. Electricity was thus a positive by-product which also led to the stimulation of assimilation lighting because of lower electricity costs (dynamic complementarity). Assimilation lighting refers to lighting with a certain wave length that is most optimal for photosynthesis. Another important energy saving technology is aquifers that store heat or water in the bottom (Boone et al., 2007).

Substrate cultivation has been another important innovation for the sector (De Lauwere et al., 2006). Intensive plant cultivation often leads to problems with the structure and fertility of the soil and to plant diseases. From the 80s onwards the spread of substrate among Dutch greenhouse horticulturists is fast. Substrate cultivation led to higher yields, better quality products and circumvented strict chemical regulation.

Finally, the development of the computer had a major impact on the greenhouse horticulture from the 80s onwards (Van den Berg, 1999). The introduction of the computer was a logical consequence of the shift from labour by hand to mechanization to automation. With the development of the recent walking-plant system, the cultivation of plants is fully automated and plants move through the greenhouse as they grow and as they require other growth conditions. This is thus a dynamic complementarity in the sense that it has enabled the automation of the whole production process. Before, it was still necessary to apply human labour to transport the plants from one machine to the other. Also, the computer has made it possible to collect data on plant cultivation. Computers record data with respect to temperature, food, CO2-concentration, humidity and the like. By comparing these data with each other, horticulturists have become more aware of the optimal cultivation conditions.

In sum, as technologies already intrinsically refer to process innovations, this building block has especially stimulated process innovation.

6.3 Types and structure of interactions among heterogeneous firms and non-firm organizations

We already discussed many interactions between firms and non-firm organizations in the previous sections. Figure 12 presents an overview of all interactions as they are nowadays. The main supply chain (blue box) consists of all actors that are responsible for getting the greenhouse horticultural products to the end-consumer (Alkemade et al., 2010: *in press)*. For all other actors, figure 12 shows how they relate to this main supply chain.

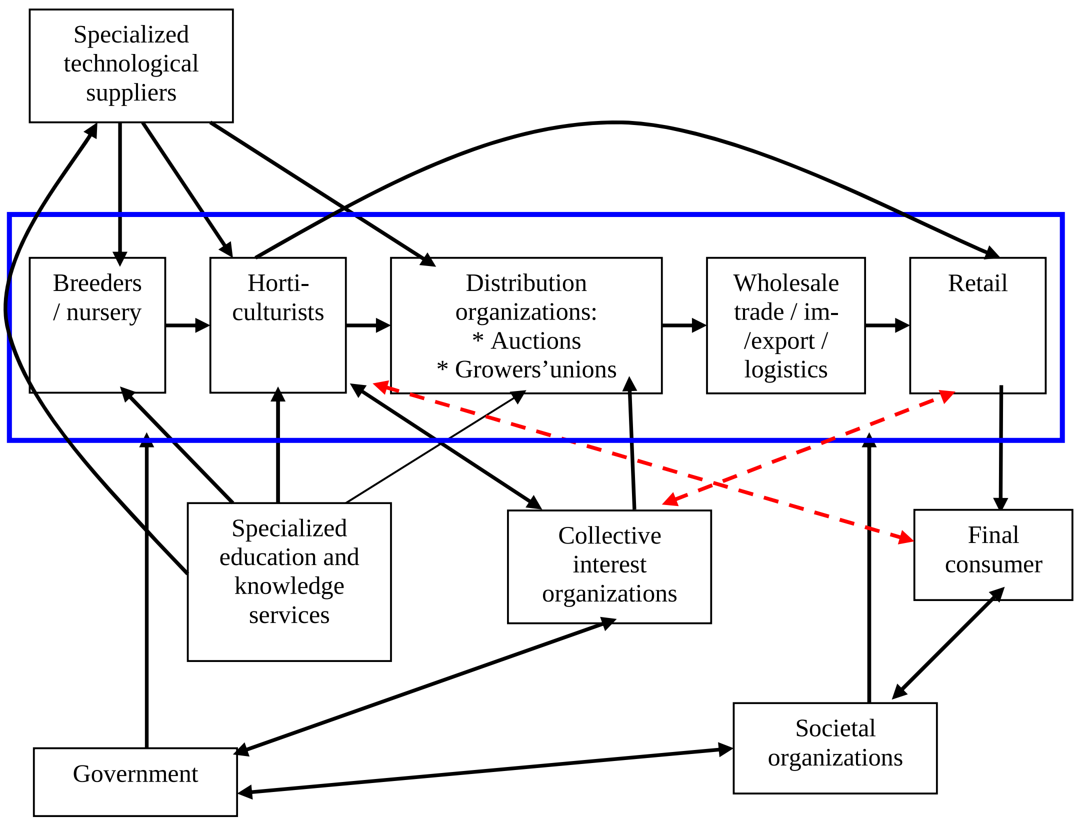

Figure 12: Supply chain of the Dutch greenhouse horticulture (based on LEI & Dialogic, 2001).

As became clear from section 5.1, rivalry shifted from competition on quality to competition on price and product differentiation when international competition increased (Van Galen, 2010). Dutch greenhouse horticulturists could easily adapt to this change as the specialized technological suppliers and breeders had already developed many new technologies and crops respectively. Furthermore, on the basis figure 12 we see that the lines are short between horticulturists and these two actors which probably further facilitated the change process. These interactions thus further stimulated product and process innovations.

Furthermore, the link with specialized technological suppliers is beneficial for the Dutch greenhouse horticulturists as we could say that these suppliers have substituted the extension (advisors) of the former OVO-triptych (see section 5.4 and 6.1). Former advisors had the function to transfer knowledge developed by knowledge institutes to horticulturists. When the OVO-triptych broke down and knowledge institutes privatized, this function disappeared. This was problematic as horticulturists still lack the skills to proactively seek for external knowledge. However, as technological knowledge is still supply driven, horticulturists do not need knowledge acquiring competencies and thus easily obtain new technologies which stimulate process innovation.

This supply chain also indicates why horticulturists have troubles to engage in marketing innovation and successful product innovation (see red dashed arrow). First of all, distribution organizations, wholesale trade and retailers separate the growers from the consumer. Because of this distance, growers often lack market information on consumer demands. Also because of this distance it is difficult for the horticulturists to create successful brands. As a producer, it is hard to guarantee the freshness of horticultural products as other actors are involved in the transportation and selling of these products. Furthermore, according to Van Galen (2010) horticulturists consider it the task of the retail to pass on market knowledge. However, much market knowledge is residing at the collective interest organizations (e.g. the Product Board Horticulture and the Flower Council Holland). This supports the statement of section 6.1 that horticulturists have troubles to find their way to these collective interest organizations (Cornelis & De Jong, 2010).

Also the supply chain lacks a link between retail and collective interest organizations that would stimulate supermarkets for example to engage more in marketing innovation. For example, Flower Council Holland is an organization which aims at further professionalizing the marketing processes within the floricultural sector and promoting floricultural products in the Netherlands and abroad (Cornelis & De Jong, 2010). By means of commercials, advertisement and the like the organization tries to trigger consumers to buy flowers and plants (Cornelis & De Jong, 2010). After that, it is the task of the supermarket, florist or garden centre to make the consumer buy the products. This is problematic as According to the Vakblad voor de Bloemisterij supermarket manager give too less attention to the presentation of flowers and plants in their store (e.g. 2005: 43, 2006: 2, 2007: 13).

Finally, also the link between horticulturists and retailers negatively affect marketing innovation. Lately, growers started to put up contracts with fixed buyers instead of selling the products via the auction to guarantee selling of the products (Van Galen, 2010). This led to an increasing power of the supermarkets that grew as they were able to play the growers off against each other on price (Cornelis & De Jong, 2010; Van Galen, 2010). This development negatively influences the required increase in marketing innovations as proposed by Van Galen (2010). Since supermarkets want to remain able to switch among suppliers when there is a considerable cost difference, they do not accept branding for example (Cornelis & De Jong, 2010; Van Galen, 2010). Branding could cause the lock-in of products.

In sum, the interactions within the Dutch greenhouse horticultural sector leading to process and product innovations are particularly strong. On the contrary, the interactions that stimulate marketing innovations are very weak.

6.4 Processes of selection and variety generation

On the basis of section 4 we saw that variation in innovation has been primarily restricted to variation within rather than between the four different innovation trajectories. In other words, the sector does not show alternating periods in which the amount of product-, process- and marketing innovations vary. Rather, variation was expressed in terms of process innovations for improving quality, saving labour costs or saving energy costs for example.

Because processes of variation are mainly limited to process and product innovations, we therefore do not expect that the current system stimulates variation in marketing innovations. On the one hand, we state that this is caused by the selection mechanism in the form of competition on price (see section 5.1). Because rivalry shifted to competition on price, firms especially focus on saving costs and thus on process innovations. On the other hand, an important selection mechanism is the auctions that ask for bulk uniform products. This stimulates process and product innovations to create bulk and uniform products.

Furthermore, Porter (1998) and Malerba (2002) stated that variety generation in the form of new businesses is most important for the innovation process. New organizations bring in new knowledge, ideas and skills which may cause a shift towards marketing innovation. Furthermore, as more firms enter the sector, competition increases which pressures firms' profits and which may stimulate marketing innovation.

However, as was mentioned along this paper, the sector has faced economies of scale (Annex IV). Over the years, the number of greenhouse horticulturists therefore decreased. Also, not many new horticulturists have entered this sector for a couple of reasons (Van Galen, 2010). There is limited space for greenhouse horticulture because of destination plans. Land prices are high in the Netherlands. Installations and machines have become more complex and advanced and therefore require considerable investment costs. To enter the sector, much knowledge is required on the sector, technologies, the market and the like. Finally, it requires large investments to create networks that are necessary to obtain knowledge and form a block against your competitors. Because of these challenges, also many horticulturists have left the sector.

Finally, more firms are becoming member of a growers' union. According to De Man (2009) and Hoeve & Drost (2001) this may lead to a situation where growers do not have an outward look anymore and that they more and more become each others look a like. Again, a lack of variation does not create stimuli to change plans and to pursue marketing innovations.

In sum, variation processes have been primarily restricted to product and process innovations. The main reasons for this are selection mechanisms such as competition on price and the auctions.

7. Concluding remarks

Statistics showed a negative trend in the financial performance of the Dutch greenhouse horticultural sector. As innovation has played an important role in the history of the Dutch greenhouse horticulture, we therefore studied whether the rate and direction of innovation still suit the challenges the sector is currently facing. This led us to the following research question:

How can we evaluate and assess the chosen rate and direction of innovation of the Dutch greenhouse horticultural sector and what does this imply for the sector?

Innovation theory distinguishes four types of innovation: product-, process-, marketing- and organizational innovation. The importance of each type varies during the life cycle of an industry. As the Dutch greenhouse horticulture consists of a set of mature industries, we expected to find marketing-, product- and process innovations.

In order to evaluate the chosen rate and direction of innovation, we studied two important bodies of innovation literature. First, the 'Sectoral System of Innovation and Production' (SSIP) approach of Malerba (2002) contributed to understanding how sectors operate and evolve and the role of innovation processes in this. Second, the diamond framework of Porter (1998) provided insights in the determinants that based on innovation influence the performance of industries. Both frameworks relate as we claimed that sectors consist of a set of interrelated industries. On the basis of these two theories we created a new conceptual.

We claimed that both theories are complementary for two reasons. First, Porter mainly focuses on the static quality of his determinants while Malerba is more specifically interested in the dynamics of his system. For example, Porter asks for the presence of high quality knowledge institutes while Malerba considers how firms learn from these knowledge institutes. Second, while Malerba applies a more internal focus for understanding the performance of sectoral systems, Porter is more interested in an industry's environment. However, be aware that what can be the environment according to Porter, can be within the system of Malerba. While Porter separates the industry from its environment, Malerba considers all links and interdependencies between related industries and services that together form the boundaries of his sectoral system. Integrating both models thus leads to a more complete view of the determinants that influence the rate and innovation of sectors.

On the basis of a set of frequently used innovation indicators – among which patents, breeders' rights, LNV subsidy, product announcements and the Horti Fair Innovation Award – we first studied the rate of innovation for the sector. The results showed that despite the decreasing profits in the sector, the rate of process innovation still increased. Furthermore, the rate of product innovation remained relatively stable. And, the rate of marketing innovation showed a negative trend. However, data on this latter innovation type was limited. We therefore concluded that there is no relation between the rate of innovation and the decreasing profits in the sector.

We used these same data sources to measure the direction of innovation for the sector. The data showed that the Dutch greenhouse horticultural sector especially engages in product and process innovations and that marketing and organizational are underrepresented. These results were contradictory to what we expected on the basis of life cycle theory. First, life cycle theory claims that mature industries also engage in marketing innovation next to product and process innovation. Second, product innovations especially aim at quality improvement for vegetables and adaptations in colour, shape and the like for floricultural products rather than at starting new life cycles. We therefore claimed that we had to seek the causes of the negative trend for the performance of the sector in the determinants that influence the direction of innovation.

On the basis of a literature study, we first analyzed the determinants presented by Porter (see table 14). The '+' indicates which determinants positively influenced the type of innovation and the '-' indicates the opposite.

Product innovation:	**Process innovation:**
+ • Firm strategy, structure & rivalry (*firm strategy and structure, structure of rivalry*) • Factor conditions (*human and knowledge resources*) • Demand conditions (*quality of demand*) - • Factor conditions (*capital resources*)	+ • Firm strategy, structure & rivalry (*firm strategy and structure, structure of rivalry*) • Factor conditions (*physical, capital, human and knowledge resources)* • Demand conditions (*size and quality of demand*) • Related and supporting industries • Chance • Government
Marketing innovation: + • Factor conditions (*knowledge resources*) • Demand conditions (*quality of demand*) - • Firm strategy, structure & rivalry (*firm strategy and structure, structure of rivalry*) • Factor conditions (*human and capital resources*)	**Organizational innovation:** + • Factor conditions (*knowledge resources*) - • Firm strategy, structure & rivalry (*firm strategy and structure*) • Factor conditions (*human resources*)

Table 34: The influence of the determinants of Porter's diamond on the direction of innovation.

On the basis of this table it becomes clear that most of Porter's determinants favour the development of product and process innovations and undermine marketing and organizational innovation. First, the sector favours product and process innovations because of the education level of most horticulturists. Most horticulturists followed MBO programmes from which they especially learned about breeding and production technologies, which imply that they develop skills on the area of product and process innovations respectively. On the contrary, universities and colleges also teach courses with respect to management and marketing skills as they acknowledge that these are necessary in today's complex environment. The education level of most horticulturists thus negatively affects the sector's marketing and organizational innovations.

Second, capital resources especially favour process innovation. Dutch greenhouse horticulturists are for most of their capital resources dependent on external financiers. As innovation is a risky business, external financiers have especially invested in relatively safe process innovations for which they can easier assess the pay-back return on investment periods. Apparently, it is more difficult to assess this pay-back return on investment for marketing innovations and therefore these external financiers do not take the risk to invest in these innovations.

Finally, on the basis of this research we cannot explain an important contradiction within the results. On the hand, on the basis of demand conditions we find that North West European consumers show a high quality of demand for both vegetables and floricultural products, for which they are prepared to pay more money. On the other hand, supermarkets seem to be interested in price and change suppliers if this results in cost advantages. Future research should therefore focus on how retailers determine their strategies and how they involve consumers in this process.

In sum, on the basis of Porter we can conclude that most determinants aim at the development of product and process innovations. For marketing innovations the determinants show differentiation in how they influence this innovation trajectory. However, based on Porter, we cannot explain why the influence of the negative determinants probably dominates the influence of the positive determinants as section 4 showed that the amount of marketing innovations is low for the Dutch greenhouse horticultural sector. This relates to the fact that Porter especially considers the static quality of the determinants. Insights provided by Malerba's SSIP provided an answer to this question.

Table 15 again presents a matrix that shows how the SSIP's building blocks influenced the four innovation trajectories.

Product innovation: + • Knowledge and learning processes (*sources of opportunity*) • Types and structure of interactions • Processes of generation of variety and selection	**Process innovation:** + • Knowledge and learning processes (*internal and external accessibility of knowledge, sources of opportunity, cumulativeness of knowledge*) • Basic technologies • Types and structure of interactions • Processes of generation of variety and selection
Marketing innovation: + • Knowledge and learning processes (*internal accessibility of knowledge*) - • Knowledge and learning processes (*external accessibility of knowledge, sources of opportunity, cumulativeness of knowledge*) • Types and structure of interactions • Processes of generation of variety and selection	**Organizational innovation:** - • Knowledge and learning processes (*external accessibility of knowledge, cumulativeness of knowledge*)

Table 45: The influence of the determinants of Porter's diamond on the direction of innovation.

This table shows similarities with the matrix of Porter presented in table 14. Malerba's building blocks stimulate the development of product and process innovations and undermine the marketing and organizational innovations. However, compared to Porter, Malerba shows that his building blocks show a more clearly negative influence on the marketing innovations within the Dutch greenhouse horticultural sector. With respect to Porter, he thus gives an answer to the question: What explains why a high quality of demand for Dutch greenhouse horticultural products does not translate into marketing innovations or successful product innovations? This question intrinsically also studies why the sector chose to be production oriented rather than market oriented for which they have been criticized (e.g. Van Dijk en Van der Ploeg, 1995; Hoeve & Drost, 2002; Riezebos & Zimmermann, 2005; ING, 2009).

A similar question with respect to section 4 is why the large amount of product innovations do not translate into higher profits? According to the literature for example for floricultural products horticulturists have to adhere to trends to be successful. The question is thus whether horticulturists notice these trends or react on the wrong trends for example. Let us now consider possible answers to these questions.

First, the matrix shows that the external accessibility of knowledge especially favours process innovation but negatively influences marketing innovation. When knowledge institutes privatized, the knowledge infrastructure changed from a supply driven to a demand driven knowledge market. This meant that horticulturists became self responsible for collecting the external knowledge they needed. However, because most horticulturists lack this type of skills, they experienced problems with this data collection. The accessibility of technological knowledge remained high as this market still shows characteristics of a supply driven market where knowledge institutes look for potential suppliers to translate fundamental knowledge into technologies. Then, suppliers often search for horticulturists that can act as test sites and so horticulturists still have much knowledge on process innovations. On the contrary, horticulturists have more problems with finding marketing knowledge residing at the Product Board Horticulture and the Flower Council Holland as they have to look for this knowledge themselves. These two organizations possess much market related knowledge, but take a more reactive stance and state that it is the responsibility of the horticulturists to do something with this knowledge.

Second, the types and structure of interaction clarify why the sector has problems to engage in marketing innovations. For example, marketing innovation by horticulturists is problematic as distribution organizations, wholesale trade and retail separate the producer from the consumer. As a result, the growers do not have a clear view of markets and market demand. Furthermore, also the retail (e.g. supermarkets) engages to a minimal extent in marketing innovation as there are no organizations that convince or help them to pursue these types of innovations. Most managers give too less attention to the presentation of flowers and plants in their store because these products only cover a small part of the supermarket's profits. The literature however indicates that marketing innovation in retail would result in significantly increasing profits. On the contrary, the links with breeders and technological suppliers are short so that they have a more complete view on the development of product and process innovations respectively.

In sum, the building blocks of Malerba favour the development of product and process innovations and undermine organizational and marketing innovations. Marketing innovation is mainly undermined because horticulturists do not have a clear idea of the characteristics of demand. On the contrary, there are strong interactions with actors such as technological suppliers and breeders that make them aware of product and process innovations.

So, based on these results we formulate a set of recommendations that should help the sector to increase its profits again. The main recommendation is that marketing innovation should be stimulated in the sector because this type of innovations enables horticulturists to ask for higher prices which increase profits again. Also, the direction of product and process innovations should be changed in line with the quality of demand. On the one hand, process innovations are too much aimed at saving costs while consumers ask for higher quality products. On the other hand, product innovations should become more aligned with the demands by consumers. At this moment, the product innovations do not translate in higher profits. Let us now consider a more specific set of recommendations.

In line with the conclusions on Porter above, we first recommend to reconsider the curricula of MBO programmes. These programmes are now too much aimed at breeding and production technologies, which favour product and process innovations. In line with the accessibility of knowledge, explained by Porter, we can also recommend to increase the contact between knowledge institutes and students, so that they develop the competencies to find this knowledge and apply this in their advantage.

Second, the sector should provide more risk capital for marketing innovations. Capital is now too much focussed on process innovations as these investments are less risky.

Third, based on Malerba, we recommend increasing the accessibility of knowledge from institutions such as Product Board Horticulture and Flower Council Holland. One way to achieve this is to establish knowledge intermediaries that help firms with answering their knowledge questions on the area of marketing innovation.

Fourth, the interactions between horticulturists and consumers should be increased by applying chain inversion. This means that horticulturists should ask themselves who their customers are and where their products are sold. It may be helpful to arrange excursions to the retailers that sell the horticulturists products. So, also the interactions between horticulturists and retailers should be improved.

Finally, we also consider a more methodological recommendation. We have experienced problems with finding innovation data for some types of innovation. Studies such as the ‘Innovation Monitor’ are thus feasible to gather data on the developments of the sector on the area of innovation. However, as became also clear from the interview with Van Galen (2010), the ‘Innovation Monitor’ still often lacks much data on marketing and organizational innovations. More efforts should thus be directed on mapping measuring all four innovation trajectories for the Dutch greenhouse horticulture.

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Annex I: Amount of horticulturists in the Dutch greenhouse horticultural sector

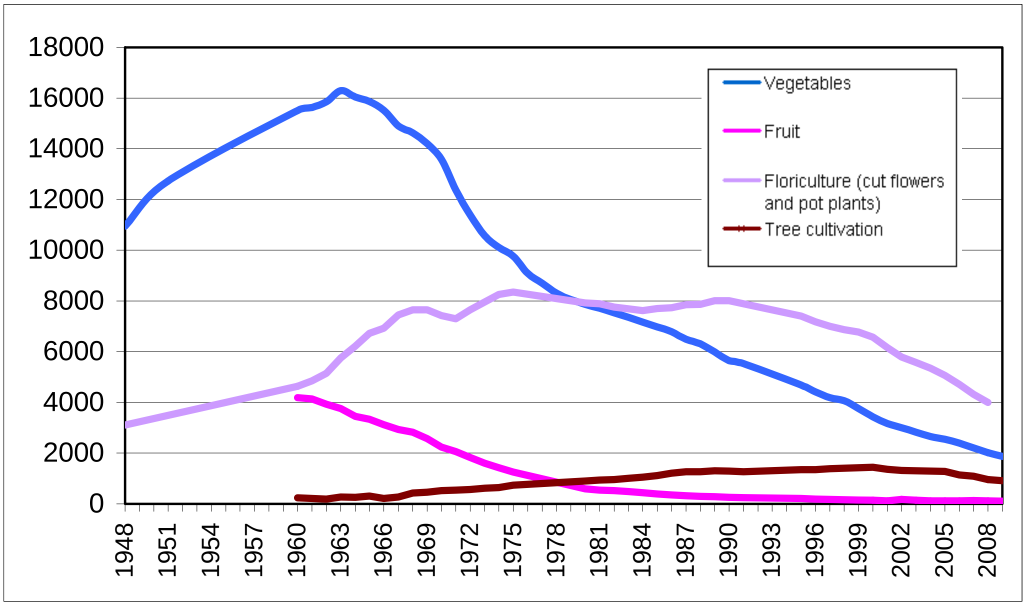

Figure 13: Amount of Dutch greenhouse horticulturists in the period of 1948-2009 (data sources: LEI & CBS, 1951-1953; LEI, 1961-1967; LEI, 1968-1976; PGF, 1976-1991; PVS, 1984-1991; PT, 2010)

Annex II: Greenhouse horticultural patent groups

In this study we use the Espacenet patent database. Based on this patent database the first step was to select a classification system: IPC or ECLA. We selected the ECLA classification system because it contains patents for a longer time period and it covers more sub classes, which is helpful for finding *greenhouse* horticulture related patents in particular.

Then, we created a list of patents that was specifically aimed towards the greenhouse horticultural sector. The ECLA system already contained a specific subclass for horticulture in general, A01G (see table 14).

A01G1) Horticulture; Cultivation of vegetables (labels or name-plates G09F3/00 , G09F7/00)
A01G3) Cutting implements specially adapted for horticultural purposes; Delimbing standing trees (felling trees A01G23/08 ; hand-held cutting tools suitable for other use B26B)
A01G5) Floral handling
A01G7) Botany in general (cultivation without soil A01G31/00)
A01G9) Cultivation of flowers, vegetables or rice in receptacles, forcing-frames, or greenhouses (cultivation without soil A01G31/00 ; [N: turfing of roofs E04D11/00B])
A01G11) Sterilising soil by steam (soil-conditioning or soil-stabilising materials C09K17/00)
A01G13) Protecting plants (apparatus for the destruction of vermin or noxious animals A01M ; use of chemical materials therefor, composition of protective materials, e.g. grafting wax, A01N ; [N: coverings around trees forming part of a road E01C9/00D2])
A01G15) Devices or methods for influencing weather conditions (dispersing fog in general E01H13/00)
A01G16) Cultivation of rice (A01G9/00 takes precedence)
A01G17) Cultivation of hops, vines, fruit trees, or like trees
A01G21) [N: IPC2] Devices for hanging-up harvested fruit
A01G23) Forestry
A01G25) Watering gardens, fields, sports grounds, or the like (special apparatus or adaptations for fertilising-liquids A01C23/00 ; nozzles or outlets, spraying apparatus B05B ; gravity flow, open channel irrigation ditch systems E02B13/00)
A01G27) Self-acting watering devices, e.g. for flower-pots
A01G29) Root feeders; Injecting fertilisers into the roots
A01G31) Hydroponics; Cultivation without soil (A01G33/00 takes precedence)
A01G33) Cultivation of seaweed [N: or algae]

Table 16: Classification codes of horticulture related patents (dat source: Espacenet).

However as not all patent groups refer to the *greenhouse* horticulture or to one of the three industries (vegetables, pot plants or cut flowers), we needed to filter out a set of . patents (see the tables below). We only take those patent classes into account that are coloured in green

[N: Growing turf]	A01G1/00C
Cultivation of asparagus	A01G1/02
Cultivation of mushrooms (composts or fertilisers for cultivating mushrooms C05)	A01G1/04
[N: Growing rooms with treatment apparatus; Cultivation racks or trays]	A01G1/04B
[N: Apparatus for treating mushroom compost]	A01G1/04C
[N: Cultivation bags or bottles]	A01G1/04D
[N: Mycorrhiza]	A01G1/04F
Grafting (grafting-wax A01N3/04)	A01G1/06
Edging for beds, lawns, or the like, e.g. using tiles	A01G1/08
Tools for cultivating turf; Sweeping apparatus for lawns; Garden rollers (machines for treating meadows or lawns A01B45/00 ; lawn-mowers A01D34/00)	A01G1/12
[N: Machines for sweeping lawns and for collecting or disintegrating lawn debris]	A01G1/12B

Table 17: A01G1) Horticulture; Cultivation of vegetables (labels or name-plates G09F3/00 , G09F7/00).

[N: for comminuting plant waste (comminuting by cutting implements in general B02C18/00)]	A01G3/00B
Secateurs; Flower or fruit shears	A01G3/02
having elongated or extended handles	A01G3/025
having motor-driven blades	A01G3/033
the driving means being an electric motor	A01G3/037
Apparatus for trimming hedges, e.g. hedge shears	A01G3/04
portable	A01G3/047
motor-driven	A01G3/053
[N: with rotatable knives]	A01G3/053B
Hand-held edge trimmers or shears for lawns [N: (with a flexible rotating cutter A01D34/00C4)]	A01G3/06
[N: Motor-driven edge trimmers]	A01G3/06B
[N: Hand operated shears for lawns]	A01G3/06C
[N: Motor-driven shears for lawns]	A01G3/06D
Other tools for pruning, branching or delimbing standing trees	A01G3/08

Table 18: A01G3) Cutting implements specially adapted for horticultural purposes; Delimbing standing trees (felling trees A01G23/08 ; hand-held cutting tools suitable for other use B26B).

Apparatus for binding bouquets or wreaths	A01G5/02
Mountings for wreaths, or the like; Racks or holders for flowers	A01G5/04
Devices for preserving flowers (chemical substances A01N3/02 ; flower vases A47G7/06)	A01G5/06

Table 19: A01G5) Floral handling.

Treatment of plants with carbon dioxide (greenhouses therefor A01G9/18)	A01G7/02
Electric or magnetic treatment of plants for promoting growth	A01G7/04
[N: with electric lighting]	A01G7/04B
Treatment of growing trees or plants, e.g. for preventing decay of wood, for tingeing flowers or wood, for prolonging the life of plants	A01G7/06

Table 20: A01G7) Botany in general (cultivation without soil A01G31/00).

Receptacles, e.g. flower-pots or boxes (hanging flower baskets, holders or containers for flower-pots A47G7/00); Glasses for cultivating flowers	A01G9/02
[N: Pots formed in one piece; Materials used therefor]	A01G9/02B
[N: Pots for vertical horticulture; Multi-tiered planters]	A01G9/02C
[N: Foldable pots]	A01G9/02D
[N: Pots connected in horizontal rows]	A01G9/02F

[N: Multi-compartmented pots]	A01G9/02G
Flower-pot saucers	A01G9/04
[N: Combinations of a saucer and a flower pot attached together] [N0705]	A01G9/04B
[N: Trays for receiving multiple pots] [N0705]	A01G9/04C
[N: Channels or gutters, e.g. for hydroponics] [N0705]	A01G9/04D
Devices for cleaning flower-pots	A01G9/06
Devices for filling-up flower-pots [N: or pots for seedlings]; Devices for setting plants [N: or seeds] in pots [C0705]	A01G9/08
[N: Devices for filling-up pots] [N0705]	A01G9/08B
[N: Devices for setting plants in pots] [N0705]	A01G9/08C
[N: Devices for setting seeds in pots] [N0705]	A01G9/08D
[N: Devices for repotting] [N0705]	A01G9/08E
[N: Handling or transferring pots] [N0705]	A01G9/08F
Pots [N: (or other receptacles)] for seedlings, [N: saplings, cuttings or other young plants (foldable pots)] ; Soil [N: (or like)] blocks for seedlings; [N: Plant substrate bodies] ; Means for forming soil-blocks [C0711]	A01G9/10
[N: Tools, machines and methods for forming soil blocks or compressed pots, e.g. from peat] [C0711]	A01G9/10B
[N: soil blocks or compressed pots] [C0711]	A01G9/10C
[N: Planting receptacles specially adapted for remaining in the soil after planting] [C0711]	A01G9/10D
[N: Seed or shoot receptacles] [N0711]	A01G9/10E
[N: Sterile receptacles, e.g. for tissue culture] [C0711]	A01G9/10F
[N: Units comprising two or more connected receptacles] [C0711]	A01G9/10G
[N: Grids for supporting several receptacles] [N0711]	A01G9/10H
[N: Receptacles specially adapted for air layering] [N0711]	A01G9/10I
[N: Handling or transporting of soil blocks or seedlings] [N0711]	A01G9/10J
[N: Composition of plant substrate bodies (plant growth regulators A01N; fertilizers C05; soil conditionning or soil stabilizing materials C09K17/00)] [N0711]	A01G9/10K
Supports for plants; Trellis for strawberries or the like ([N: trellis-work for vines A01G17/06] ; stays for trees, props for vines A01G17/14)	A01G9/12
[N: Stakes]	A01G9/12B
[N: Means for holding stakes upright in, on, or beside pots]	A01G9/12B1
[N: Wirespool supports]	A01G9/12C
[N: Fixing of plants to supports, e.g. by means of clips]	A01G9/12D
Greenhouses (cloches A01G13/04 ; [N: glazing bars, glazing clips therefor E04D3/06])	A01G9/14
[N: of flexible synthetic material]	A01G9/14B
[N: with double or multiple walls]	A01G9/14B1
[N: Greenhouse bench structures]	A01G9/14C
[N: Equipment for handling produce in greenhouses]	A01G9/14D
[N: Covering materials therefor; Materials for protective coverings used for soil and plants, e.g. films, canopies, tunnels or cloches] [C0605]	A01G9/14E
[N: with double or multiple walls]	A01G9/14F
[N: Greenhouse gutters (gutters in general E04D13/064)] [C0103]	A01G9/14G
Dismountable or portable greenhouses; [N: Greenhouses with sliding roofs]	A01G9/16
Greenhouses for treating plants with carbon dioxide or the like	A01G9/18
Forcing-frames; Lights	A01G9/20
Shades or blinds for greenhouses, or the like [N: (canopies A01G13/02B)] [C0605]	A01G9/22
[N: Lamellar or like blinds (in general E06B9/26)]	A01G9/22B
[N: Inflatable structures]	A01G9/22C
[N: rolled up during non-use (in general E06B9/08)]	A01G9/22D
Devices [N: or systems] for heating, ventilating, regulating temperature, or watering, in greenhouses, forcing-frames, or the like	A01G9/24
[N: Arrangement of opening or closing systems for windows and ventilation panels]	A01G9/24B

[N: for greenhouses with flexible coverings]	A01G9/24B1
[N: Collecting solar energy (in general F24J)]	A01G9/24C
[N: Conduits for heating by means of liquids, e.g. used as frame members or for soil heating]	A01G9/24D
[N: Air-conditioning systems]	A01G9/24E
[N: Watering arrangements]	A01G9/24F
Electric devices	A01G9/26

Table 21: A01G9) Cultivation of flowers, vegetables or rice in receptacles, forcing-frames, or greenhouses (cultivation without soil A01G31/00 ; [N: turfing of roofs E04D11/00B]).

A01G11) Sterilising soil by steam (soil-conditioning or soil-stabilising materials C09K17/00)

No sub-classification

Protective coverings for plants; [N: Coverings for the ground;] Devices for laying-out [N: or removing] coverings [N: (covering materials A01G9/14E)] [C0605]	A01G13/02
[N: Canopies, i.e. devices providing a roof above the plants] [C0605]	A01G13/02B
[N: for individual plants, e.g. for plants in pots] [N0603]	A01G13/02B1
[N: Wind breakers, i.e. devices providing lateral protection of the plants] [C0605]	A01G13/02C
[N: Tunnels, i.e. protective full coverings for rows of plants (dismountable or portable greenhouses A01G9/16)] [N0603]	A01G13/02D
[N: Devices for protecting a specific part of a plant, e.g. roots, trunk or fruits] [N0603] [C0605]	A01G13/02E
[N: Protective shelters for young plants, e.g. tubular sleeves] [N0603]	A01G13/02F
[N: Devices for laying-out or removing plant coverings (for ground coverings A01G13/02S4)] [N0603]	A01G13/02G
[N: Ground coverings] [N0603]	A01G13/02S
[N: Mulches, i.e. covering material not-pre-formed in mats or sheets (A01G13/00S3 takes precedence; composition of mulches C09K17/52)] [N0603]	A01G13/02S1
[N: Mats or sheets, e.g. nets or fabrics (A01G13/00S3 takes precedence)] [N0603]	A01G13/02S2
[N: Films] [N0603]	A01G13/02S2B
[N: Protective ground coverings for individual plants, e.g. for plants in pots (coverings around trees forming part of a road E01C9/00D2)] [N0603]	A01G13/02S3
[N: Devices for laying-out or removing ground coverings] [N0603]	A01G13/02S4
[N: Anchoring means for ground coverings] [N0603]	A01G13/02S5
Cloches [N: i.e. protective full coverings for individual plants (dismountable or portable greenhouses A01G9/16; individual canopies A01G13/02B1)] [C0605]	A01G13/04
[N: with flexible coverings]	A01G13/04B
Devices for generating heat, smoke, or fog in gardens, orchards, or forests, e.g. to prevent damage by frost ([N: bee-smokers A01K55/00 ; fumigators for destroying insects A01M13/00D ; for destroying rats A01M17/00B2] ; chemical aspects of generating smoke or mist C06D3/00 ; heating devices in general, see the appropriate classes, e.g. F24)	A01G13/06
[N: Frost protection by generating fog or by spraying]	A01G13/06B
Mechanical apparatus for circulating the air	A01G13/08
Devices for affording protection against animals, birds, or other pests [N: (protective shelters for young plants A01G13/02F)] (traps A01M23/00 [N: scaring or repelling devices A01M29/00]; pesticides A01N)[C0605]	A01G13/10
[N: Protective devices against slugs, snails, crawling insects or other climbing animals]	A01G13/10B

Table 22: A01G13) Protecting plants (apparatus for the destruction of vermin or noxious animals A01M ; use of chemical materials therefor, composition of protective materials, e.g. grafting wax, A01N ; [N: coverings around trees forming part of a road E01C9/00D2]).

A01G15) Devices or methods for influencing weather conditions (dispersing fog in general E01H13/00)
No sub-classification

A01G16) Cultivation of rice (A01G9/00 takes precedence)
No sub-classification

Cultivation of hops or vines	A01G17/02
Supports for hops, vines, or trees	A01G17/04
Trellis-work	A01G17/06
Tools for attaching hops, vines, or boughs to trellis-work; Tying devices	A01G17/08
[N: Tying instruments; Espalier machines]	A01G17/08B
Holders for boughs or branches	A01G17/10
Tree-bands	A01G17/12
Props; Stays	A01G17/14
Devices for driving-in or pulling-out props	A01G17/16
Means for filling-up wounds in trees	A01G17/18

Table 23: A01G17) Cultivation of hops, vines, fruit trees, or like trees.

A01G21) [N: IPC2] Devices for hanging-up harvested fruit
No sub-classification

[N: Collecting felled trees]	A01G23/00B
[N: Log skidders]	A01G23/00B1
Transplanting, uprooting, felling or delimbing trees (delimbing standing trees A01G3/00)	A01G23/02
Transplanting trees; Devices for grasping the root ball, e.g. stump forceps; Wrappings or packages for transporting trees	A01G23/04
[N: Transplanting devices for grasping, undercutting or transporting the root ball (A01G23/04B takes precedence)] [N9505]	A01G23/04A
[N: Transplanting devices using elements to be driven into the ground for making a container around the root ball] [N9505]	A01G23/04B
Uprooting or pulling up trees; Extracting or eliminating stumps	A01G23/06
[N: Pulling up trees or stumps]	A01G23/06B
[N: in a substantially vertical plane]	A01G23/06B1
[N: by comminuting the tree stumps]	A01G23/06C
Felling trees (axes B26B23/00 ; saws, sawing machines B27B)	A01G23/08
Feller-bunchers, i.e. with bunching by felling head (A01G23/083 takes precedence)	A01G23/081
Feller-delimbers	A01G23/083
having the shearing head mounted on a first boom and the delimbing head mounted on a second boom	A01G23/085
Shearing apparatus or the like specially adapted for felling trees (A01G23/081 , A01G23/083 , A01G23/093 take precedence)	A01G23/087
having two or more shears	A01G23/089
of the percussion type	A01G23/09
Sawing apparatus specially adapted for felling trees (A01G23/081 , A01G23/083 , A01G23/093 take precedence)	A01G23/091
Combinations of shearing, sawing or milling apparatus specially adapted for felling trees	A01G23/093
Delimbers (A01G23/083 takes precedence; manufacture of wood shavings, chips, powder, or the like, per se B27L11/00)	A01G23/095
[N: Self-propelled along standing trees]	A01G23/095B
having a fixed delimbing head	A01G23/097
Auxiliary devices, e.g. felling wedges	A01G23/099

Tapping of tree-juices, e.g. caoutchouc, gum	A01G23/10
Knives or axes for tapping	A01G23/12
Tapping-spouts; Receptacles for juices	A01G23/14

Table 24: A01G23) Forestry.

Watering arrangements located above the soil which make use of perforated pipe-lines or pipe-lines with dispensing fittings, e.g. for drip irrigation (perforated pipes per se B05B1/20)	A01G25/02
[N: Dispensing fittings for drip irrigation]	A01G25/02B
Watering arrangements making use of perforated pipe-lines located in the soil (perforated pipes per se B05B1/20 ; similar arrangements for drainage E02B11/00)	A01G25/06
Watering arrangements making use of movable installations on wheels or the like	A01G25/09
[N: movable around a pivot centre]	A01G25/09B
[N: winch-driven (A01G25/09D takes precedence)]	A01G25/09C
[N: guided or propelled along a water supply line with supply line traversing means]	A01G25/09D
Hand watering devices, e.g. watering cans	A01G25/14
[N: with pumps]	A01G25/14B
Control of watering (controlling of spraying devices B05B)	A01G25/16
[N: Sequential operation]	A01G25/16B
[N: Cyclic operations, timing systems, timing valves, impulse operations]	A01G25/16C
[N: Control by humidity of the soil itself or of devices simulating soil or of the atmosphere; Soil humidity sensors]	A01G25/16D

Table 25: A01G25) Watering gardens, fields, sports grounds, or the like (special apparatus or adaptations for fertilising-liquids A01C23/00 ; nozzles or outlets, spraying apparatus B05B ; gravity flow, open channel irrigation ditch systems E02B13/00).

[N: with intermittent watering means]	A01G27/00C
[N: Controls for self-acting watering devices]	A01G27/00D
[N: Reservoirs connected to flower-pots through conduits]	A01G27/00E
[N: Reservoirs, separate from plant-pots, dispensing directly into rooting medium]	A01G27/00F
[N: Component parts, e.g. dispensing fittings, level indicators]	A01G27/00G
having a water reservoir, the main part thereof being located wholly around or directly beside the growth substrate (A01G27/06 takes precedence)	A01G27/02
using wicks or the like	A01G27/04
having a water reservoir, the main part thereof being located wholly around or directly beside the growth substrate	A01G27/06

Table 26: A01G27) Self-acting watering devices, e.g. for flower-pots.

A01G29) Root feeders; Injecting fertilisers into the roots
No sub-classification

[N: Soilless culture substrates]	A01G31/00B
Special apparatus therefor (apparatus for cultivation in receptacles or greenhouses in general A01G9/00 ; self-acting watering devices A01G27/00)	A01G31/02
Hydroponic culture on conveyers	A01G31/04
Hydroponic culture on racks or in stacked containers	A01G31/06

Table 27: A01G31) Hydroponics; Cultivation without soil (A01G33/00 takes precedence).

A01G33) Cultivation of seaweed [N: or algae]
No sub-classification

Annex III: Competitors of Dutch vegetable, cut flower and greenhouse horticulturists

This annex presents three tables that list the competitors for each industry within the Dutch greenhouse horticulture. Whether countries are competitors of the Dutch sector has been based on a literature study. The references have also been listed in the tables.

Competitors on vegetables	**References**
China	• De Bakker et al. (2006) • Wijnands (2004) • Wijnands et al. (2004)
Egypt	• Alleblas & Groot (2000) • Wijnands et al. (2004)
France	• Cantliffe & Vansickle (2009) • Wijnands (2004)
Great-Britain	• Wijnands (2004)
Italy	• Cantliffe & Vansickle (2010) • De Rooij (2008) • Wijnands (2004) • Wijnands et al. (2004)
Mexico	• Cantliffe & Vansickle (2010) • De Bakker et al. (2006)
Morocco	• Alleblas & Groot (2000) • De Bakker et al. (2006) • Wijnands (2004) • Wijnands et al. (2004)
Poland	• De Bakker et al. (2006) • Wijnands (2004)
Spain	• Alleblas & Groot (2000) • Cantliffe & Vansickle (2010) • De Bakker et al. (2006) • De Rooij (2008) • Silvis et al. (2009) • Wijnands (2004) • Wijnands et al. (2004) • Wijnands & Silvis (2000)
Turkey	• Alleblas & Groot (2000) • De Bakker et al. (2006) • Wijnands et al. (2004)
USA	• Cantliffe & Vansickle (2010) • Wijnands et al. (2004)

Table 28: Competitors of the Dutch vegetable greenhouse industry.

Competitors on cur flowers	References
Colombia	• Alleblas & Groot (2000) • De Bakker et al. (2006) • Tavoletti & Te Velde (2007) • Wijnands (2006) • Wijnands & Silvis (2000)
Ecuador	• De Bakker et al. (2006) • Tavoletti & Te Velde (2007) • Wijnands (2006)
Israel	• Alleblas & Groot (2000) • Tavoletti & Te Velde (2007) • Wijnands & Silvis (2000)
Kenya	• Alleblas & Groot (2000) • De Bakker et al. (2006) • Tavoletti & Te Velde (2007) • Wijnands (2006) • Wijnands & Silvis (2000)
Zimbabwe	• Alleblas & Groot (2000) • De Bakker et al. (2006) • Tavoletti & Te Velde (2007) • Wijnands & Silvis (2000)

Table 29: Competitors of the Dutch cut flower greenhouse industry.

Competitors on pot plants	References
Belgium	• Splinter et al. (2006)
Denmark	• Splinter et al. (2006) • Alleblas & Groot (2000) • Wijnands & Silvis (2000)
Germany	• Splinter et al. (2006)
Italy	• Splinter et al. (2006)
Spain	• Splinter et al. (2006)

Table 30: Competitors of the Dutch pot plant greenhouse industry.

Finally, because some countries have even less than 100 patents for the whole A01G (horticulture) patent group, not all competitors of the tables above are taken into account in this study. Figure 14 presents all countries that do satisfy this condition.

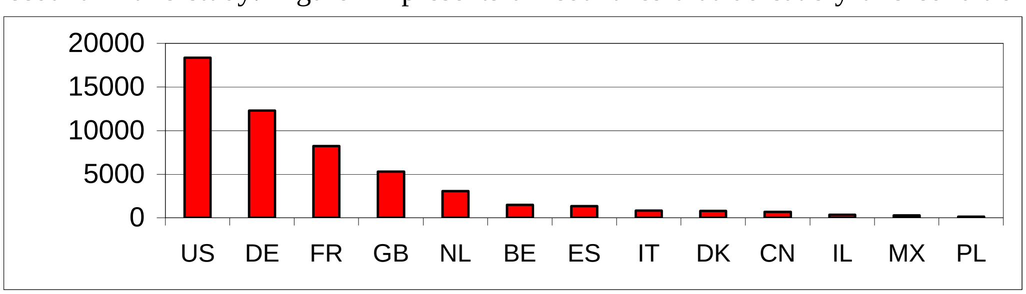

Figure 14: Total amount of horticultural patents for the Netherlands and its competitors (data source: Espacenet).

Annex IV: Dutch greenhouse horticultural acreage separated per industry.

The figure below shows the total acreage of the Dutch greenhouse horticulture for each individual industry. Although the acreage has remained relatively stable over the last years, the amount of horticulturists decreased for the same period (see Annex I). This thus indicates that there are economies of scale in the sector.

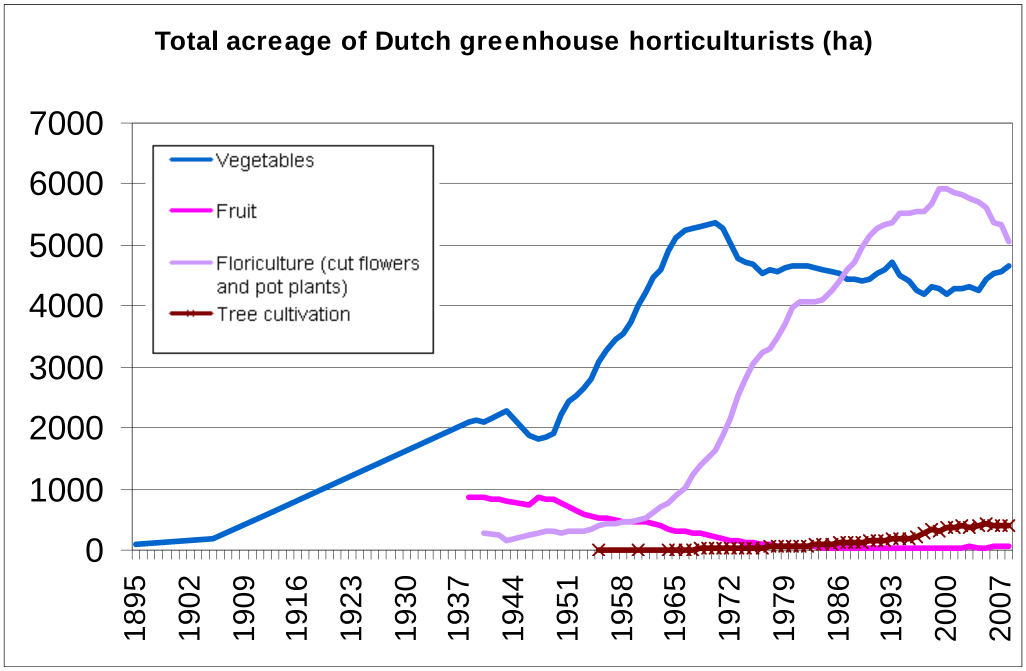

Figure 15: Total acreage of Dutch vegetable, cut flower and pot plant horticulturists (data sources: LEI, 1951-1953; LEI, 1961-1967; LEI, 1968-1996; LEI & CBS, 1997-2009; Van Doesburg et al., 1999).