Foreign Direct Investment and Spillovers in Seed Sector Development - Towards an Assessment of the Impact of Intellectual Property Rights

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The role of foreign direct investment and intellectual property rights in economic development is discussed widely in the literature. However, an integrating framework is missing to assess the role of FDI and IPR for agricultural development. This paper establishes a framework to assess the role of FDI and IPR for seed sector development in developing countries. The impact assessment is carried out with a System Dynamics model that shows local capacity development to develop new seed varieties in the scenario of a multinational company penetrating the market and spillovers occurring. Simulation runs reveal the impact of IPR on the quantity technology transferred by multinational companies and on spillovers. The development path of the local industry depends crucially on the capacity of the local seed sector when the multinational company enters. A pattern for seed sector development is derived.

1 Introduction

The yields of cereals in Sub Saharan Africa (SSA) have been stagnating in the past decades and the yield gap between SSA and the rest of the world has been widened (World Development Report 2008). Yields per ha in Asia on average have increased almost to the level of developed countries whereas yields in Sub-Sahara African countries have stagnated. One reason for this development is the missing investment into the seed business. Considering the majority of African agriculture is subsistence agriculture and that Sub-Saharan Africa is experiencing the largest urban growth in the world, increasing productivity of cultivated areas and turning subsistence agriculture into commercial agriculture is crucial for food security.

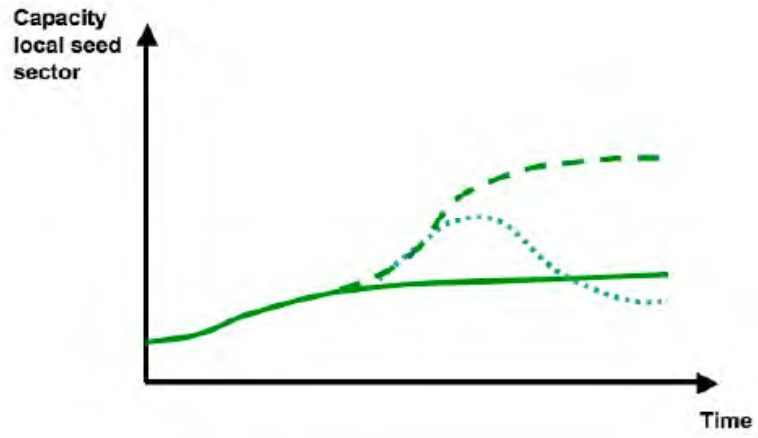
With the exception of a few countries like e.g. South Africa, there is very little evidence of successful commercial seed sector development (Tripp, Rohrbach 2000). Also the public sector has reduced its investments over time so that sustainable seed supply could not be achieved. Most farmers in SSA still use seed they have saved from the last harvest saved instead of higher yielding commercially bred varieties like hybrids. But recent initiatives are

about to change that picture. Initiatives like the Alliance for a Green Revolution for Africa (AGRA) or the West African Seed Alliance (WASA) aim for a green revolution in Africa. One component of these alliances are Public Private Partnerships to increase investment into the development of new seed varieties.

Investment is in developing countries often foreign direct investment (FDI) as the national capacity to invest is often restricted. There are several forms of FDI. Whether FDI actually encourages growth of developing countries depends, especially in knowledge intensive industries like plant breeding, on the scope of knowledge spillovers. The scope of knowledge spillovers depends in turn on the entry mode of companies in foreign markets. For example Joint Ventures result in much higher spillover then export or Greenfield entries. But the entry mode depends in part also on Intellectual Property Rights (IPR) since foreign companies put their knowledge assets at risk when they partner with other companies. Thus, spillover depend on IPR´s since IPR´s play a role for the entry mode that is chosen and for how, once knowledge got transferred, the use of this knowledge is restricted and therefore how it can diffuse.

Especially for a R&D intensive sector like plant breeding the protection of intangible assets embodied in seeds represents an incentive to invest in further R&D activity. Empirical work emphasizes the positive effect that IPR have on FDI (Lee, Mansfield 1996). Most West African countries do not yet have implemented IPR frameworks but in order to comply with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) regulations will have to implement protection of intellectual property for biotechnological products like new plant varieties. Little empirical evidence exists on the impact of IPR on developing country agricultural markets. IPR have only been implemented recently in some developing countries. Thus, statements about the impact of IPR on the capacity development of the seed sector in developing countries are controversial and concerns are strong. For instance farmers associations in developing countries claim that IPRs will lead to monopolies that will increase seed prices and that will lead to a reduction in the amount of attention paid to the needs of farmers who will not be able to benefit from foreign bred materials (Louwaars, 2007). And also FDI can have different impacts on local economies. Foreign firms could overinvest, at the expense of domestic producers. There is a possibility that only the most solid firms will be financed through FDI, leaving domestic investors stuck with low-productivity firms. (Razin et al. 1999) The question we want to address is what impact will future developments in investment have on the SSA seed sector. How will local capacity to breed new seed varieties in West Africa develop under the influence of foreign investors like multinational companies. How will the largely underdeveloped seed markets in West Africa respond to FDI and IPR protection and what are the interactions between increased FDI and IPR. Following Saeed (1998) we constructed the reference mode by making projections based on observed behaviours in other regions of the world. Possible developments paths of local capacity of Sub Saharan countries to develop new seed varieties is sketched out in figure 1. The continuous line represents a scenario of seed sector development without any foreign intervention. This is similar to a scenario which we find for example in Mali, where overall investment into seed production has been low with public plant breeding as the primary source of new variety technology. The dotted lines represent scenarios of foreign direct investment, whereas one scenario is not sustainable, leading to an increase in capacity which is followed by a decrease of capacity of the seed sector and the other one is sustainable leading to an overall increased capacity of the seed sector. The former scenario can be compared with the situation found in Ghana where e.g. Pioneer Hi Bred made an attempt to invest in the 80´s and pulled out because of unmet demand expectations, whereas the latter one can be considered the ideal situation in which it was possible for the local industry to reach a higher level of productivity. The case of India can be considered to be such an example where due to investment into plant breeding and an appropriate technology transfer policy the development of national seed companies was successful. In this paper we will try to map the structure that lead to these behaviour patterns.

Figure 1: The behaviour of local seed sector capacity under the influence of foreign direct investment



What the future development of these markets will be depends also on how these markets have developed so far and how policy makers will be able to adapt to the changing requirements of international investors. Most African countries have strict policies on variety release, multiplication and trade, which are controlled by statal agencies. Though competition is now being allowed with government seed enterprises, and some of the public companies are being privatised, wholesale and retail traders in most countries must still obtain special licenses to sell seed. Thus, regulations ostensibly meant to restrict sales of inappropriate seed severely limit the extent of participation in seed trade. (Tripp, Rohrbach 2000) Coupled with the absence of intellectual property laws that are especially for the research intensive foreign biotechnology companies a major incentive so set up local plants, FDI has been consequently missing. The resulting research questions here are therefore for the seed market in SSA

- How will local capacity develop in the future with and without FDI
- Which role plays FDI in contributing to the development of a private sector in SSA
- How doe IPR affect this developments

There is a large body of literature examining the impact of FDI on productivity, the influence of IPR on FDI, the influence that IPR has on the quality and quantity of technology that is transferred from multinational companies to their local affiliates and how FDI affects the development of the local economy via spillovers. But largely missing are models that integrate the existing body of literature and captures the dynamics in the system (Novoselova et al. 2007).

With this in mind we take an approach quite different from those present in the existing literature. The principal contribution of this effort is to derive new insights from established variables and relationships. The central premise here is that the missing piece to the puzzle is a research methodology appropriate to the dynamic nature of the development of the seed market. Several authors have documented the dynamic nature of the development process (Saggi 2000) of the advent of a seed sector. Therefore, supported by the body of literature that examines the relations between FDI, technology transfer, spillover and capacity, productivity and innovations in local industries we establish a simulation model to characterize the outcomes that these processes generate. Thus we will be able to determine the impact of FDI and IPR on the seed sector in developing countries. Recommendations on how much regulation the seed sector needs so that local capacity development with spillovers is possible will be derived. The paper is structured as follows. In the second part we develop an integrative framework that captures the dynamics processes presented by previous authors. In the third part we specify the conceptual model that has been developed with the literature with empirical data. In the fourth part we analyze the model of the seed market that has been developed. In the fifth part we present conclusions that result from the model and in the sixth part we show implications for future research and practice are discussed.

2 Theory: Seed sector development, FDI and IPR

2.1. Methodology

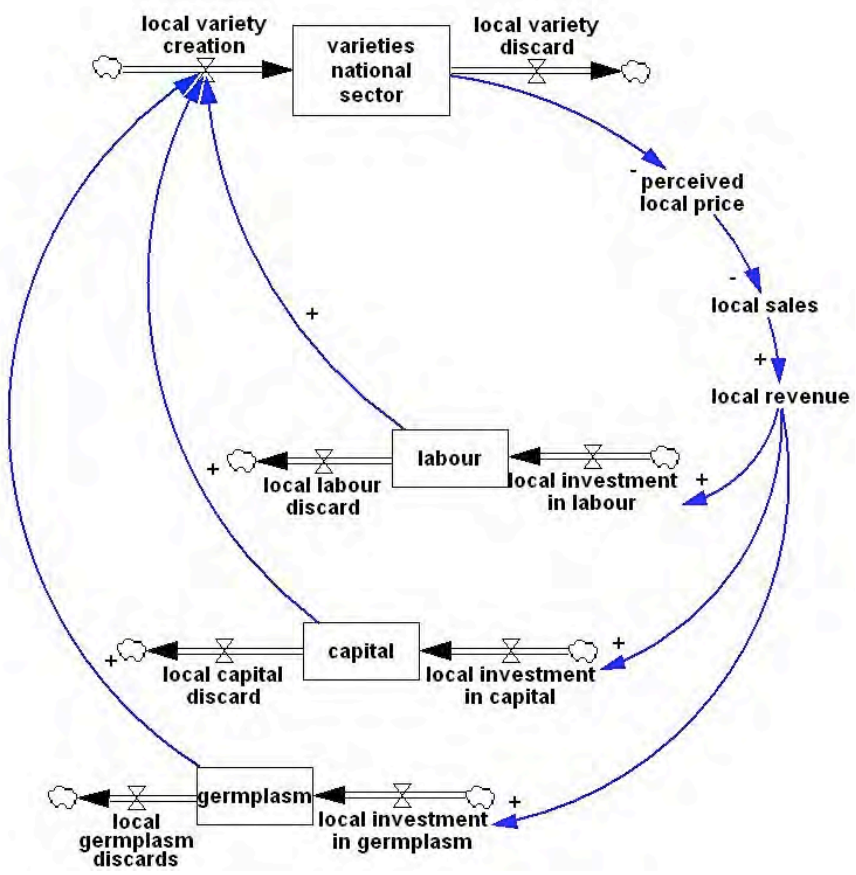
Most studies capture static equilibria instead of dynamic choices resulting from interactions over time thus missing out the fact that there exist important dynamics over time (Saggi, 2000). But the decision of how much resources a company will devote to penetrate a new market is a dynamic one. Investors may increase or decrease their resources over time and these dynamics result from interactions like a firms R&D expenditure relative to others in an industry and the aggregate R&D expenditure of the industry relative to other industries. Such dynamics may interact in subtle ways to influence the choice between alternative market entry modes. Nevertheless, most studies address the problem with static models. In this study we are therefore using System Dynamics to be able to capture dynamic decisions over time and the feedback loops that lead to these decisions. System dynamics is a method for policy analysis and design in complex dynamic systems, i.e. in systems characterised by delays, feedback mechanisms and non-linear relationships (Sterman 2000). The model presents a case in which a multinational company is investing in the development of new seed varieties in a developing country with a largely underdeveloped seed market where there is only public sector investment involved in the development of new seed varieties. The two sectors, the national private sector and the international private sector compete for market share, which is represented by the farmers demand for new seed. The model we developed is work in progress and although we tried to work as close as possible on the circumstances in West Africa, the model aims to capture general trends instead of replicating exact figures. In the following the model structure is presented in detail. National seed sector development is important because the several components of a seed sector, the informal as well as the local formal and multinational formal sector play important roles in meeting the demand for seed. For example the international private sector focus on research, production and marketing of seed for hybrids and commercial food whereas the national commercial sector focus on fiber crops specialty crops, or vegetable crops. The model tries to capture the transformation process of a traditional seed system where farmers save mostly seed from their harvest to a commercial seed system where commercial seed production and marketing is common. This transformation is considered to go in line with an increased investment in variety development, higher yield and thus an increase in agricultural productivity. (Maredia et al, 1999)

2.2 Development of R&D capacity of the seed sector

2.2.1 Resources of the seed industry

Plant breeding can be differentiated between classical and modern plant breeding. In classical plant breeding, which is practiced nowadays mostly by subsistence farmers, plants are crossbred to introduce traits encoded in genes from one variety into a new genetic background. Modern plant breeding uses techniques of molecular biology to select, or in the case of genetic modification insert, desirable traits into plants. A range of technologies is therefore applied to breed new varieties, which requires a large variety of input factors. For the purpose of this analysis we aggregate these input factors into three stocks: capital, labour, germplasm. We assume that the production for R&D output is determined by capital, labour and germplasm. As shown in figure 2, in our model, the level of a resource can influence the overall amount of output of a seed sector in a country, which in turn can generate an increase in the investment in such resource. This creates a positive, or reinforcing, feedback loop. That loop drives growth and development through the accumulation of resources. The interaction between the necessary resources for plant breeding, the research capacity and the increase in production of new seed varieties form the reinforcing feedback loops that drive the growth of the seed sector. An increase in the level of capacity for varietal R&D increases production, which increases investment in capital, labour stocks and germplasm stocks.

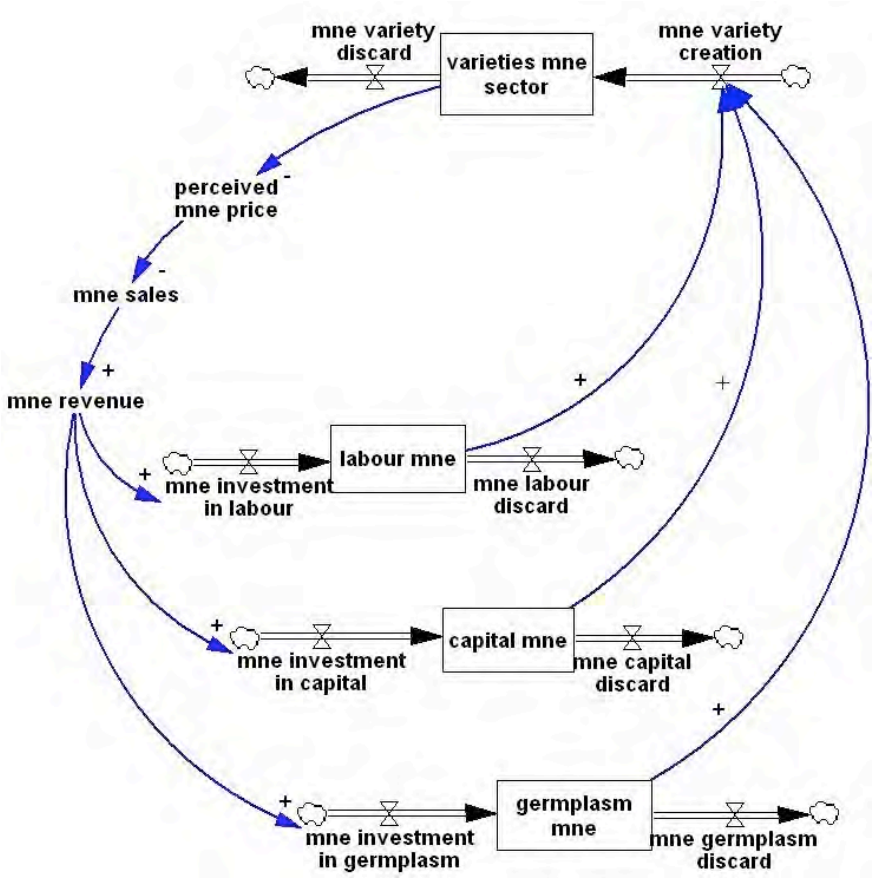
Figure 2: The reinforcing loops of national capacity creation



2.2.1 FDI in seed industry

Generally, FDI flows to Africa have increased only marginally and are still at levels behind those of other developing country regions. The region accounted for less than one percent of the global total FDI inflows in the late part of the 1990s (Odenthal, L. 2001). While inflows to developing countries as a group increased from US$ 20 billion to US$ 75 billion between 1981 and 1985, Africa's share of that inflow dropped (UNCTAD). Multinational firms concentrate in sectors that exhibit a high ratio of R&D relative to sales (Markusen 1995). Saggi point out that FDI happens in sectors where multinational companies can rely heavily on their intangible assets such as superior technology to compete with national firms who are better acquainted with local conditions (Saggi 2000). The seed sector is such a research-intensive industry, which relies on the protection and control of intangible assets. The Indian vegetable industry for example has experienced an increased FDI inflow after in 1988 trade barriers were removed and the seed sector was liberalized. Joint ventures were set up and there was an import of germplasm. We assume that for a multinational company investing in a developing country the same input factors apply for FDI investment as they apply for national capacity. Also the same loops will drive the investment into FDI R&D capacity. It can however be assumed that due to the technological advantage of the multinational company the delay times for breeding new varieties are shorter for multinational companies.

Figure 3: The reinforcing loops of capacity creation of Multinational Companies

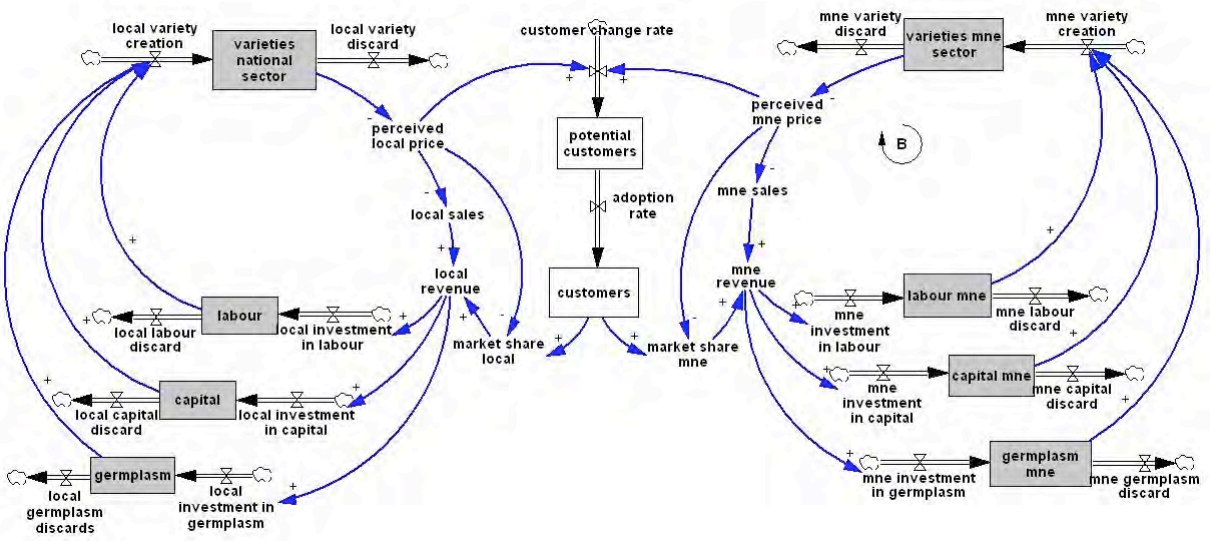


2.2.2 FDI and the national private seed sector

FDI can have positive as well as negative effects. In effect, national seed companies and foreign seed companies of seed compete on the same market for sales. Aitken and Harrison (1999) point out that this competition can have the effect of attracting away demand from domestic competitors. Such a development may lead, after an initial increase of the overall R&D capacity of the seed sector, to a decrease of national research capacity since the national private sector cant compete with the multinational companies anymore. The reason for such a development could be that the capacity with which the multinational company enters the market is under certain circumstances much higher then the current capacity of the national private seed sector. Since positive feedback loops drive the growth of the industry, a pattern of path dependency would arise. More sales of one group acting on the market leads to increased sales of this group and decreased sales of the other group, resulting in more capacity to invest in further variety development of the one actor and even less R&D capacity of the other actor. The result would be a concentration of MNEs in the Sub Saharan African markets. In the causal loop diagram this relationship is represented by the variable “market share MNE”. The consequences of this process for the small scale farmer could be a reduced availability of varieties that are adapted to extremer environments as well as a price increase as a result of oligopolistic or monopolistic market structures. Market share is calculated in the model based on the market structure set out by Kampmann (1992) Actors set their prices on the market. Decisions on the market are made based on the perceived price, which is the price weighted by the relative quality of the product. The perceived prices of the national and international actors make up the aggregated price level. This has an influence on aggregated demand represented by an elasticity of demand. The products of the two sectors have some degree of differentiation, which is represented by the elasticity of substitution. Aggregated demand is split by the elasticity of substitution and determines the market for the national and the international actors. The market share is

calculated by dividing the number of farmers that demand a product from whether the national or international sector by the overall customers. The number of customers in turn is calculated in an adoption structure to represent the fact that changes in demand due to a change in product quality or product price do not happen instantaneously. Revenue is then calculated out of the market share, seed bought per customer and price per kg seed. There is a positive relationship between this variable and the investment of a multinational company. In contrast there is a negative relationship between the market share of MNE and the investment of national companies, since their sales and their revenue are decreased by increasing sales of multinational companies.

Figure 4: Interaction of national R&D capacity and capacity of multinational companies



2.2.3 Mode of investment – the effect of the investment type on technology transfer

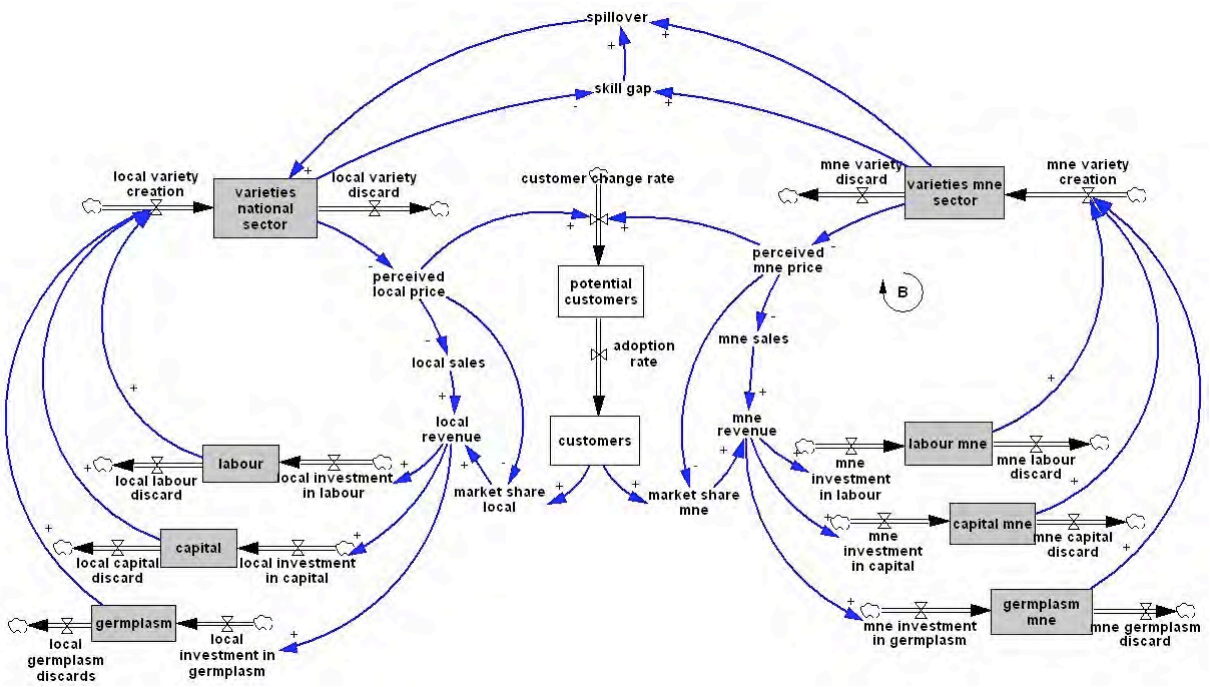
Foreign direct investment can have the form of capital as well as technology that is transferred into the host country. The quantity of capital and the type of technology transferred depends on mode of investment. The various modes for a company to invest in a foreign country include setting up a wholly owned subsidiary, building a new factory, called Greenfield, entering a joint venture, called Brownfield or licensing out technologies to be produced by other companies. Revenues, control over production and the risk of loosing capital and intellectual property are factors that change with the degree of ownership that a company has on the local affiliate. A wholly owned subsidiary can be effectively controlled so that the risk of loss of IP is minimized. Thus, Javorcik et al. (2008) argue that more and newer technology is transferred to wholly owned subsidiaries. However, this form of investment might not be feasible due to regulated markets or undesired due to risk aversion of the company. Therefore, the incentive to prevent the dissipation of knowledge based assets is reflected in the fact that multinationals prefer to license or transfer their older technologies via joint ventures (Mansfield, Romeo 1980). Corresponding with Blomstrom and Sjöholm (1999) we therefore conclude that there is a positive relationship between the share a foreign company holds on a national plant and the quality and quantity of resources it transfers. In the model ownership share is represented by initial investment of the international actor. Depending on the sophistication of the national private sector and the legal frameworks that are in place, a multinational company would decide to enter the market with more or less resources.

2.2.4 FDI and spillovers

Spillovers can have an effect on knowledge, productivity and quality of the national industry. Blomström and Sjöholm (1999) found that for Indonesia foreign ownership increases productivity of the national affiliates. But what are spillovers in the seed sector context? As

primary channels for spillovers Saggi (2000) mentions demonstration effects, labor turnover and vertical linkages. Demonstration effects might happen in the seed industry only in the case that the sophistication of the national private sector is advanced enough so that imitation or even inventing around is an option. Here also the strength of intellectual property rights is of importance. The effect of labour turnover depends on the activities an international private company actually carries out. Vertical linkages again depend on the skill level of the national industry and to what extend cooperation between the national and the international industries is possible. Thus it turns out that one very important variable that decides on whether the national industry is able to internalize the knowledge that has been transferred from investors is the skill gap between the investing part and the national industry. Horizontal spillover take place only in the presence of a moderate technological gap between foreign and national firms (Kokko et al. 1996). Greater technological sophistication of wholly owned foreign subsidiaries may impede knowledge diffusion to national firms operating in the same sector, which may lack sufficient absorptive capacity (Smarzynska et al. 2008). However, it has also been argued that a larger technology gap may present a greater potential for knowledge transfer and thus lead to more knowledge diffusion (Blalock, Gertler 2005). We conclude that there is a negative relationship between the size of the skill difference between the investing company and the host countries industry and the spillover that will be realized. If greater investment of multinational companies will therefore result in a greater capacity of the national private sector depends on the size of the skill gap between these two parties. Another question regarding spillovers from FDI is to what extend the share a company holds on a national affiliate influences the spillovers realized. Smarzynska et al. (2008) find that projects with joint domestic and foreign ownership may result in greater knowledge dissipation due to their lower technological sophistication and the involvement of the national partner. Thus, they expect that greater knowledge diffusion is associated with partially owned foreign affiliates. But

Figure 5: Investment of multinational companies and spillovers



2.3 Model Data

The model was set up based on information gathered in field trips to West Africa and calibrated with data from a study on breeding costs in Mexico (CIMMYT, 2000). The size of the stocks was measured in varieties, so the number of varieties a sector is able to produce over time. Capacity consists of three stocks: capital, labour and germplasm. The variety

production is the average of the availability of these three resources. The national and the MNE sector compete for market share which is influenced by the capacity of the sectors – the higher the capacity, the stronger the signal for consumers that the seed sector produces innovative products and the stronger the incentive to buy commercial seed. Spillovers are measured as an absolute amount of varieties that multinationals are able to produce that the national private sector will also be able to produce. The skill difference between the national and the multinational sector is represented in the skill ratio (national capacity / MNE capacity) and affects the spillovers realized. The number of customers is assumed to be low in the beginning. Most farmers will in a typical SSA scenario use farm saved seed. An adoption model structure is used to model the process of additional customers getting interested in commercial seed. Table 1 describes the terminology and the start values.

3 Analysis - Resulting patterns

The model structure was calibrated to analyse under what circumstances the three possible developments of the national seed sector in interaction with a foreign company would result. What follows is an analysis of how the structure creates the observed behaviour, what likely variations of the structure could happen, what institutions are involved and what measures could be taken to lead the industry to a sustainable growth path.

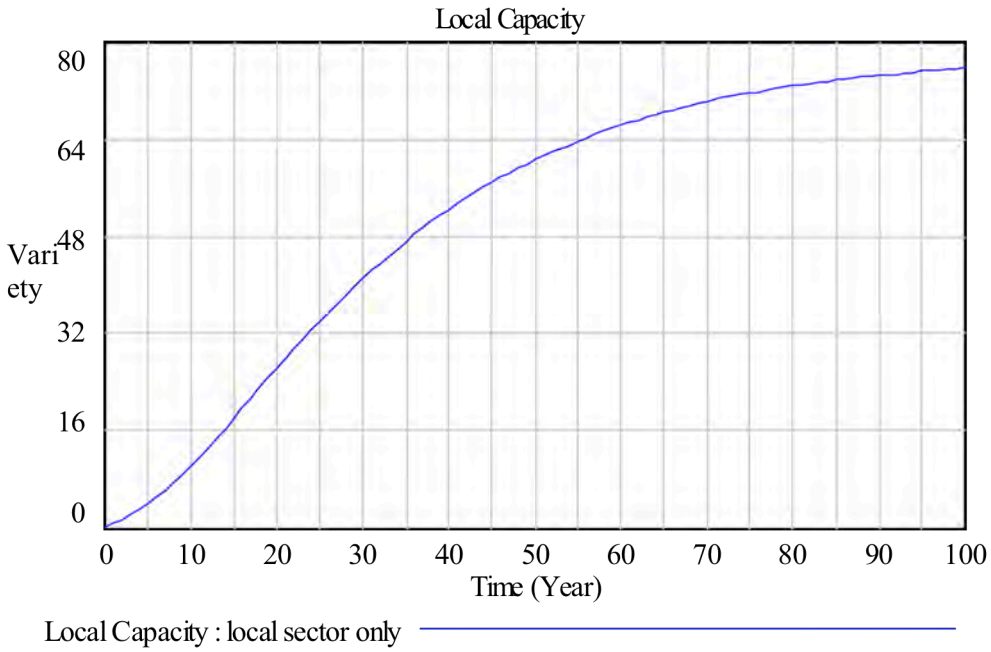
3.1. National Development when no FDI is involved

In the first scenario only the national private sector is assumed to invest into variety development and marketing. There is no foreign direct investment from multinational companies. The reinforcing loops of the national private sector are working but adoption of the commercial seed is low and hence demand and revenues are low. This allows only for little investment into the development and marketing of new varieties. The data that the model was set up with are displayed in table 1. The behaviour of the model is shown in figure 6.

Table 1: Start values for the scenario of national seed sector development without FDI involvement

Variable	***Definition***	***Start Value***
National capacity for variety development	*The ability to produce varieties of the national seed sector*	*0.2 (variety)*
Multinational capacity	*The ability to produce varieties of the multinational seed sector*	*10 (variety)*
Capital national	*Represents physical capital such as production facilities*	*1M (USD)*
Labour national	*Represents skilled and unskilled workers*	*1M (USD)*
Germplasm national	*Represents knowledge about breeding embodied in genetic material*	*1M (USD)*
Elasticity of Substitution	*Substitutability of the products of the national and multinational sector when price changes*	*0.35 (dmnl)*
Elasticity of Demand	*Responsiveness in the quantity demanded for a commodity as a result of change in price*	*0.8 (dmnl)*
Skill ratio	*The difference between the skill level in production between the national and multinational sector*	*0.9 (dmnl)*
Potential Customer	*Farmers that have not yet adopted commercial seed*	*12M (farmer)*
Customer	*Farmers that have adopted commercial seed*	*2.2M (farmer)*
Time to create variety national private	*Time it takes the national industry to develop one new variety*	*5 (year)*
Time to create variety multinational	*Time it takes the multinational industry to develop one new variety*	*2 (year)*

Figure 6: National capacity creation in absence of foreign direct investment



What can be observed is that there is a slow development of a private sector since the growth processes are working but at a slow pace. Considering that it takes time to educate breeders to develop new germplasm and thus to build up the necessary stocks for variety development, the stock of the national capacity is growing only gradually and is almost outweighed by the discard of resources. Thus the availability of improved seed is low and farmers cant get into contact with the new product. Agrodealers can not get acquainted with the technology and therefore can not build trust into the properties of the new product at the farmers side. Consequently demand is missing, which results in low adoption and low sales, which is again stalling the reinforcing loops. Missing investment of multinational companies, as we assumed it in this scenario, can have various reasons. Important incentives for multinational companies to invest are the potential market size and, especially in knowledge intensive industries, the existence of legal frameworks that protect intellectual assets and provide for clear ownership and codes of conduct. To support the development of the national private sector, an increase in investment in plant breeding and production of seed could result in a higher supply, thus giving a push to demand. That could trigger, if sustained, higher revenues, which could be reinvested in inputs for variety development. Rising demand would attract foreign investors, which would then invest in more variety production whether in the form of Greenfield entries or joint ventures. Additionally higher growth of national capacity could result in a lower skill gap, which would attract more investors that could effectively cooperate with local companies, given that IPR are enforced.

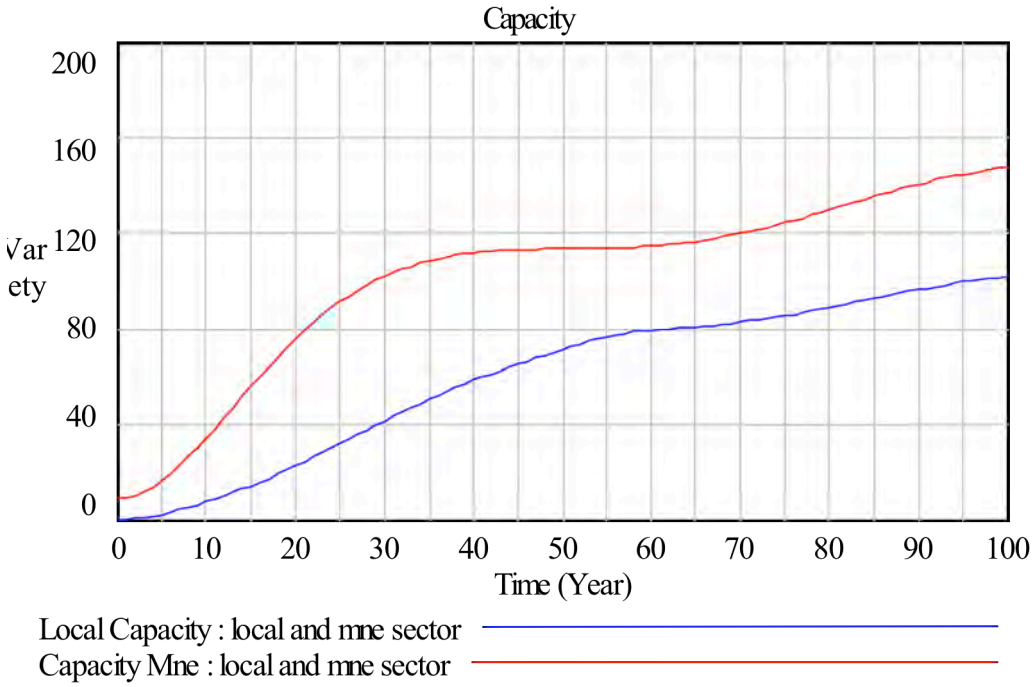
3.2. Local Development when FDI is sustained

In the second scenario it was assumed that besides a national private sector also multinational companies are investing in the industry. Since the multinational company is assumed to dispose of better technologies, a higher initial stock of varieties and a lower delay time for breeding new varieties was assumed. Adoption of commercial seed is high in this scenario since the supply of commercial seed is much higher and thus the contact rate is increasing over time. The reinforcing loops of both sectors work stronger since there is a higher demand that allows for higher revenues and higher investment in new variety development. The data that the model was set up with are displayed in table 2. The behaviour of the model is shown in figure 7.

Table 2: Start values for the scenario of national seed sector development without FDI involvement

Variable	Definition	Start Value
National capacity for variety development	*The ability to produce varieties of the national seed sector*	*0.2 (variety)*
Multinational capacity	*The ability to produce varieties of the multinational seed sector*	*10 (variety)*
Capital national	*Represents physical capital such as production facilities*	*1M*
Labour national	*Represents skilled and unskilled workers*	*1M*
Germplasm national	*Represents knowledge about breeding embodied in genetic material*	*1M*
Elasticity of Substitution	*Substitutability of the products of the national and multinational sector when price changes*	*0.35*
Elasticity of Demand	*Responsiveness in the quantity demanded for a commodity as a result of change in price*	*0.8*
Skill ratio	*The difference between the skill level in production between the national and multinational sector*	*0.9*
Potential Customer	*Farmers that have not yet adopted commercial seed*	*12M*
Customer	*Farmers that have adopted commercial seed*	*2.2M*
Time to create variety national private	*Time it takes the national industry to develop one new variety*	*5 (year)*
Time to create variety multinational	*Time it takes the multinational industry to develop one new variety*	*2 (year)*

Figure 7: National and Multinational capacity creation



What can be observed from the graph is that there is an increasing private sector development for both, the national and the international private sector. The reinforcing loops that drive capacity growth are working at a much faster pace for both sectors since the supply push from the one also impacts on the demand of the other. The decay rate of the resources is thus by far outweighed. An accumulation of resources occurs and the sector

experiences growth. A higher supply implies more contact of farmers with the new product, which stimulates trust building. Consequently demand is stimulated, which results in high adoption rates and high sales, which in turn stimulates the reinforcing loops of capacity creation. There are several reasons for the sustained growth path of the national and international private sector. IPR legislations stimulate investment of multinational companies. They also stimulate business models like joint ventures where the local industry benefits from knowledge spillover and consequently is able to follow the growth path of the MNE. Regarding the development of the national private sector, more investment in plant breeding and production of seed results in a higher supply, thus giving a push to demand that triggers higher revenues, which are reinvested in inputs for variety development. Rising demand attracts foreign investors, which then invest in more variety production.

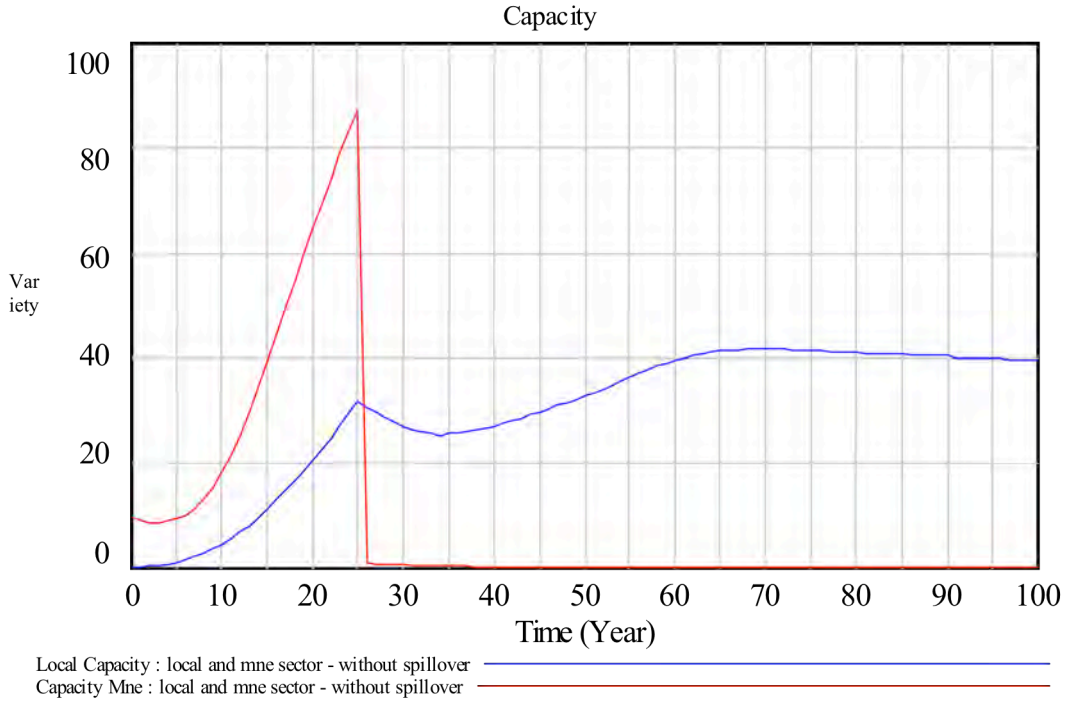
3.3. Local development when FDI is not sustainable

In the third scenario it was assumed that after an initial market entry the international private sector stops operating at the national market after 25 years. Until the year 25 the two sectors are evolving together, caused by the previously described growth processes. In the year 25 the withdrawal of the resources of the multinational company is simulated. As a consequence also the growth process of the national private sector are breaking up. After an initial decrease the national private sector recovers and is able to pursue a path of reduced growth. The data that the model was set up with are displayed in table 3. The behaviour of the model is shown in figure 8.

Table 3: Start values for the scenario of national seed sector development without FDI involvement

Variable	***Definition***	***Start Value***
National capacity for variety development	*The ability to produce varieties of the national seed sector*	*0.2 (variety)*
Multinational capacity	*The ability to produce varieties of the multinational seed sector*	*10 (variety)*
Capital national	*Represents physical capital such as production facilities*	*1M*
Labour national	*Represents skilled and unskilled workers*	*1M*
Germplasm national	*Represents knowledge about breeding embodied in genetic material*	*1M*
Elasticity of Substitution	*Substitutability of the products of the national and multinational sector when price changes*	*0.35*
Elasticity of Demand	*Responsiveness in the quantity demanded for a commodity as a result of change in price*	*0.8*
Skill ratio	*The difference between the skill level in production between the national and multinational sector*	*0.9*
Potential Customer	*Farmers that have not yet adopted commercial seed*	*12M*
Customer	*Farmers that have adopted commercial seed*	*2.2M*
Time to create variety national private	*Time it takes the national industry to develop one new variety*	*5 (year)*
Time to create variety multinational	*Time it takes the multinational industry to develop one new variety*	*2 (year)*

Figure 8: National and Multinational capacity creation with the mutinational actor pulling out of the market after 25 years



The behaviour that was simulated was intended to represent a situation in which after an initial growth of the seed sector the multinational company pulls out due to problems of unmatched e.g. revenue expectations or intellectual property infringement. Initially the reinforcing loops that trigger growth are working until the multinational company pulls out resources. The reinforcing loops are still working for the local sector but at a much slower pace since the availability of commercial seed is reduced and thus awareness of the product decreases, the contact rate is reduced and demand drops. This is stalling the reinforcing feedback loops until the national sector has adapted to the new situation, decreased its capacity stocks and start working profitable again. A way of keeping the national seed sector on a growth path also without the resources of the international seed sector obviously by raising awareness of the commercial seed and thus keeping the contact rate high. This could for example be achieved by agrodealer training.

4 The optimal seed sector development

From the way FDI affects the local capacity development we derive recommendations for seed sector development. We have seen that productivity gains from FDI are an important stimulus. But the way they impact the seed sector depends on the initial national capacity when FDI occurs. Therefore we can derive recommendations for a sound pattern of seed sector development. Seed sector development in terms of liberalization of the seed market with the participation of multinational companies and IPR as an incentive for foreign investment could ideally happen in a succession of three stages:

1. In the first stage the market exists without IPR and is only partially liberalized. FDI can happen e.g. only through the involvement of local companies. The national industry is thus protected from aggressive investors and the process of rapid market concentration and grows, supported by the stimulus on productivity by the technology provided by foreign companies. Foreign companies will surely not transfer their newest technology but this might even favour spillover as the technology gap will be lower. There is still the effect that multinational companies investing take market shares from national companies but the national sector is compensated by productivity gains via spillover. As an overall result

national and multinational industries grow slowly. Due to the little investment of multinational companies the tendency of the industry to consolidate wont be very strong. Thus the market price wont change. Due to existing competition also supply will be good. Availability and diversity of seeds as well as yields will rise due to increased investment.
2. In the second stage the market is liberalized but IPR are still not in place. Foreign companies can invest without restrictions but the local industry is still able to enjoy full spillovers and can grow. Missing IPR impact the local seed sector development here like a reduced fee on technology since copying of foreign technologies is legal. The increased investment in the industry will enhance the supply of commercial seed further, increasing the contact rate of farmers with commercial seed and stimulating adoption. Multinational companies might start forming joint ventures or buying national companies, thus increasing industry concentration and restricting access of breeding inputs for other actors in the industry.
3. In the third stage the market is liberalized and IPR are in place and effectively enforced. The local industry has been growing in capacity so that also local companies make use of the IPR system now and start to file. Thus the local sector will also gain managerial capacity in dealing with the IPR system, which will enhance the process of the national capacity development versus the multinational investors. As market concentration increase, oligpolistic structures are likely to arise, thus increasing the price of commercial seed. The pattern developed here could serve as a policy recommendation for a succession of efforts. However, for considering a succession of efforts in policy implementation such as liberalization of an industry and implementation of IPR, surrounding factors like the size of the market need to be considered. These factors will decide e.g. if foreign companies are attracted enough by potential revenues so that even missing IPR and investment restrictions are accepted or if investment will simply not happen due to these restrictions.

5 Outlook

5.1. Model Data

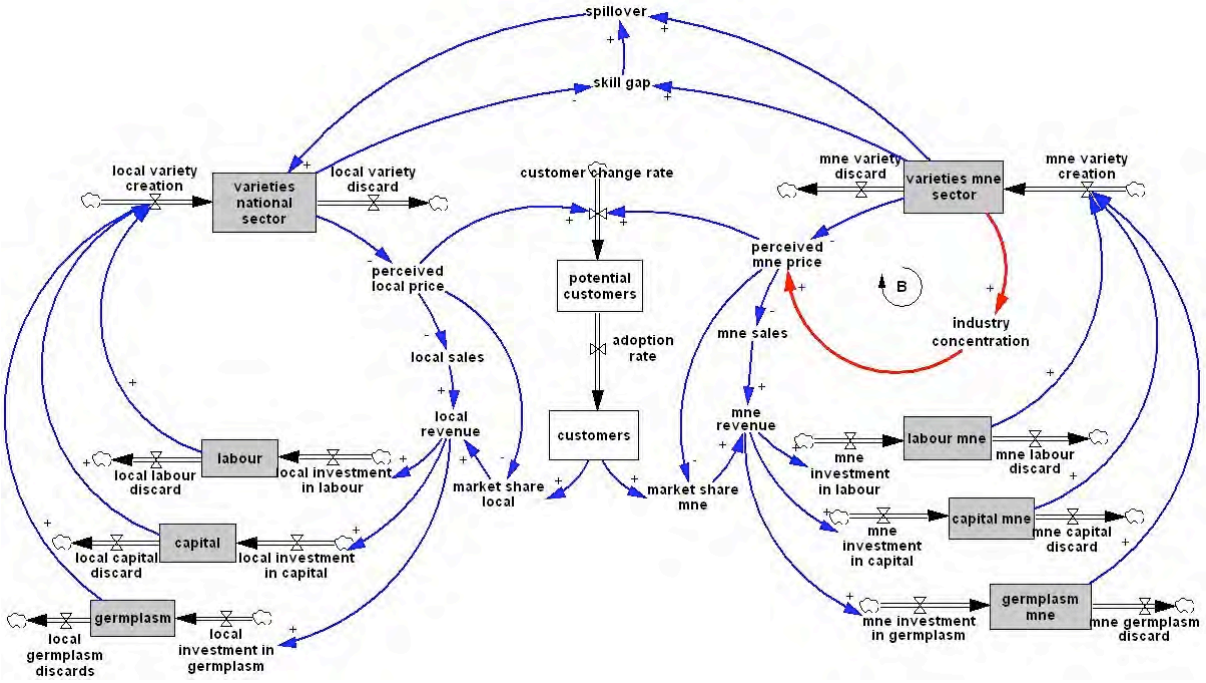
The model is calibrated with dimensionless factors. To achieve realistic outcomes the model needs to be calibrated with empirical data. Gathering data over time on the impact that intellectual property rights have on the development of the agricultural sector, empirically or from literature, is difficult for Sub Saharan Africa since:

- IPR are applied in upstream research and are an upstream instrument – so using impact indicators one mixes the impact of IPR with several other influences that determine an innovation friendly environment and that might even interact with the use of an IPR system
- Current studies are econometric so they treat IPR as a block and try to assess the incentives or disincentives that arise from them, ignoring
    - the dynamics that result from weak or strong enforcement of IPR,
    - that result from the specific form or IPR that is applied
    - that in specific points of the value chains different forms of IPR perform different tasks
- in most developing countries IPR frameworks have been implemented only recently so the data availability is overall low. Comparisons to developed countries need to be handled with care since national companies in variety development are interacting with multinational actors from developed countries, which can change the structure and the development path of national private industries fundamentally.

Also one important loop needs still to be closed: the effect of MNE capacity on concentration, price level and the consequent effect on sales needs to be captured to see if in the long run investment will be sustainable. Industry concentration leads to oligopolies or in the extreme case to monopolies. This has an impact on the prices for seed since the monopolist has at least some degree of price setting power on the market. Higher prices will lead to reduced sales since small scale farmers will not be able to afford increased prices, which in the long

run makes multinationals withdraw their resources again as the market is not profitable to them. (Tripp, Rohrbach 2000) The loop is displayed in figure 17.

Figure 9: The effect of increasing multinational capacity in the seed sector on industry concentration and the price level



5.2. Model testing – sensitive spots

The model needs to be tested further. The following sensitive spots were identified.

- *Elasticity of Substitution:* Given a high elasticity of substitution, the model reacts very sensitive to price changes – if the price of one of the two changes, capacity sinks rapidly since customers prefer the other product. Very slight price changes induce a very strong reaction in the model.
- *Adoption part:* Capacity creation depends very much on how much is sold to how many customers – so changes of contact rate and adoption fraction in the adoption part of the model result in large changes in capacity creation
- *Local capacity smooth:* The smooth determines the period of time that customers perceive changes in capacity and therefore in product quality – the longer the smoothing time, the longer the time horizon that customers have for perceiving a change in quality, the longer they will hesitate to adopt a new product – so the effect is that actual changes in Quality are discounted by the smoothing time and thus actual perceived price does not correspond to the actual price
- *Effect of quality on price table:* The table determines how changes in quality create changes in the perception of the price. The higher the perceived quality, the more will the price be adjusted downwards since the customer gets more value, in this case yield, for his money

5.3. Including policies

More policies need to be included in the model. With this model the seed market development would be analyzed for

- The amount of spillovers occurring
- The speed of market concentration
- The effect on sales and how long, given a raised price level,

Also the way IPR impacts the seed sector development needs to be refined. IPR grant

temporary monopolies on intangible assets. Therefore IPR represent an incentive to invest in research since the inventor will have a comparative advantage to its competitors in offering its technology on the market. IPR interacts with various other parts of the system.

- **IPR and the quantity of FDI:** The sunk or fixed costs of developing an innovation such as herbicide tolerance are often large. However, once developed, the marginal cost of producing additional improved seed is very small. IPR provide a powerful incentive for private-sector innovation, since without monopoly power on their innovation, innovators may not be able to cover their total costs, thus restricting the range of technologies available to farmers (Acquaye, Traxler 2005). Empirical studies highlight the positive effect of increased IPR enforcement on FDI (Lee, Mansfield 1996). IPR is commonly said to create monopoly rights. Such monopoly rights arise since the holder of IPR has the right to exclude others from using the technology. Consequently price levels are higher under monopoly rights. The laws and enforcement of intellectual property rights have provided innovating firms with some monopoly power in the market for seeds (Falck-Zepeda et al. 2000), allowing the innovating firms to set a price higher than marginal cost.
- **IPR and the quality of FDI:** Functioning IPR also affects the quality of technologies that companies transfer to their affiliates. Multinational companies state that without UPOV 1996 they would rather transfer older hybrid varieties to countries and market them there instead of breeding locally adapted varieties. Even when Plant Variety Protection legislation would be in place, initially older material would be used for breeding until there is certainty about effectivity of IPR protection.
- **IPR and the mode of entry of MNE:** IPR also influences the mode of entry of multinational firms. Among other factors companies decide on the mode of investment according to what the risk of loosing capital or intellectual property transferred is. As the seed industry is a highly R&D intensive sector, the potential risk of loosing IP is one of the most important criteria in choosing the mode of investment. Thus, a firm's R&D expenditure is negatively related to the probability of a joint venture and positively related to Greenfield entry (Smarzynska 1999).
- **IPR and industry concentration:** Competitive advantages of companies will be reinforced by IPR as other companies can be excluded from the access to new materials and even procedures, thus making it hard for them to catch up. Furthermore IPR lead to mergers and acquisitions. Powerful companies buy smaller companies to get access to their intellectual property (Srinivasan 2003).
- **IPR and Spillover:** the stronger IPR are enforced, the less spillover will happen because of copying but the more cooperations will possibly be established, so knowledge exchange is inhibited on the one hand but enhanced at the other hand. The importance of the two types of spillover needs to be seen in a time sequence – first allowing copying and then protecting innovative industries. This is represented in the model by the amount of spillover happening

5.4. Disaggregating Spillover

Another problem with the current model is that the way spillover happen is modelled in a very aggregated way. Spillovers are likely to happen in a very different manner for capital, labour and germplasm. In a subsequent and extended version of this model spillovers will be disaggregated for these three stocks.

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