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Bargaining for Risk Reduction: A Political Economy Model on the Specification of Regulations in the Use of GM Crop

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The discussion on the use of Genetically Modified (GM) crops has become a tedious issue. It seems that an amicable settlement of the conflicts between those who object the use of GM crops and want a general ban (more or less) on modification of plant and animal genetic resources on the one side, and those who want to have a generic permit for the application of genetic modifications (to authorize their experiments with nature) on the other side, remains to be a mirage. The conflict is also about the aims of agro-biotechnology as well as the distribution of its costs and benefits. This article seeks to advance towards a solution by suggesting that a property rights assignment may help to realize an agreement that is less risky than the current status quo. We outline a bargaining model referring to government regulations on property rights, which shall encourage mutually respected private agreements for industry and farming. It can be an explicit right to pursue commercial biotechnology or an explicit right to be protected from the exposure to commercial GM crops Specifically we aim at designating interests in a rights exchange to settle the conflict. It is the objective of this contribution (1) to analyze the exchange of rights in a political economy viewpoint instead of proposing a market solution (Harsanyi/Zusman). (2) It attempts to outline the stakeholders' interests and to specify externalities of uncertain effects of GM crops. (3) The article refers to a compromise which could be built on reciprocity where risk is the common denominator. The compromise requires an understanding beyond the exchange of technical details and involves a political bargaining process to find "better" solutions as well as commitments. Solutions are defined as reduced risks from GM crops given current status of a most likely inevitable spread of GM crops.

Keywords: GM crops, political economy, bargaining model

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1. Introduction

Debates on Genetically Modified (GM) crops and their commercial application in agriculture are frequent and continuing. These debates are characterized by limited consensus, political squabbles, and many a times driven by emotions rather than scientific or economic sense. Despite voluminous exchange of arguments on pros and cons of commercialization of GM crops, it seems that no consensus has been reached yet (see the books of Horlick et al. 2007, Wesseler, 2005 and Cook, 2004 for a general overview and, as examples of the discourse, refer Cabinet Office, 2007 for the United Kingdom or BMVEL, 2002 for Germany). Attempts to classify costs and benefits of GM crops as well as assigning political weights to different scenarios of their introduction (Cabinet Office, 2003) seem to have had limited success in reaching a consensus. However, scenario building seems to help establish the understanding on the possible spectrum of consensuses, as shown in the latter case. Nevertheless, real jointness in underlying opinions is still elusive. Mostly opinions and arguments are built on the basis of different natural science perspectives, risk assessments, and even philosophy. However, the current debates show a mix-up of science, economics and moral driven arguments that do not fit together.

In this article a different and alternative position is taken, as it introduces a change in perspectives by arguing that an assignment of property rights is the key for reaching a consensus. It can be an explicit right to pursue commercial biotechnology or an explicit right to be protected from the exposure to commercial GM crops or both of these rights. We will see how this may lead to a scenario of bargaining and exchanges of rights and hence an intermediary solution. Suggestions are made by researchers of institutional economics who want to ground the property rights in the tenets of moral and political economy. So, we can approach the dissent on commercial application of GM crops from the angle of an absence of property rights but also from the angle of limited agreements on moral positions. In this respect a question is: what is the role of an economist? Following the position of Tietenberg 1996, we may think an economist should make suggestions on conflict solving mechanisms and aim at increasing efficiency (for an outline of such an approach in the vein of a nearly classical handling of environmental economic problems, i. e. the interpretation of the Coase Theorem, primarily as pursuit

of efficiency, see again Tietenberg, 1996, p. 58). But the role could be also that of a policy advisor who seeks, finds, and suggests policies (regulations) that improve a situation on the basis of social considerations such as equity and ecology. A matter is how neutral an economist in the GM crop debate is. In the authors' opinion, neutrality can be revealed by clarifying the aims and moral stands in a modeling framework that envisages and anticipates policy outcomes. For instance, the delineation on the economic, social and ecological implications of property right assignments could be of help. This might additionally include tasks such as revealing the interests and power of conflicting parties. In this respect we depart from the Coase theorem, because we see a political economy situation after assigning property rights rather than a market solution (normally, perfect competition is assumed in ordinary applications of Coase).

To describe the consequences of property right assignment, a subsequent bargaining on rights is modeled. As already stated, it can be a right to commercially cultivate GM crops or a right to be free from the exposure of the commercial cultivation of GM crops. But what are the practical implications? In this respect we refer to the institutional arrangements such as property rights for buffer strips around GM crop fields assigned to ecologists (representatives of "nature's interest") and property rights to do business and commercialize genetic modification technologies to the proponents (representatives of GM crop companies' interest). Both rights will be intensively discussed in the following sections. However, such an exercise demands assumptions to be clarified, methods to be outlined and modified, as well as a most rigorous proof (as normally based on modeling), to be envisaged. In this respect the suggested method is political economy bargaining (Zusman 1976).

Anyway, to be moderate on the goals of the paper, the aim of the article is limited to presenting the debate in a political economy mode and to using this theory to structure the bargaining. From that work we can proceed to a more elaborated approach applying the proposed regulations on GM crops to a European country, region or the whole European Union. Based on the article, this research work can, for instance, provide political power coefficients and throw light on interest and positions of conflicting parties. From an analytical point, it is a positive approach. Though, additionally, the approach has a normative component as it is supposed to persuade policy makers to take action in assigning rights,

as they can foresee the effects from the trading of rights. In the case of trading of rights, the private sector should be at minimal transactions costs compared to a public setup. It also satisfies the intention of Coase (1960), i.e. to bargain privately agreed actions (regulations) to which parties commit each other.

The article introduces political economy aspects of the discourses on commercialization of GM crops in agriculture into the debate, presents the current status of ideas for regulation (co-existence, liabilities, etc.) and touches on the moral background (reciprocity). The discourse is discussed briefly but sufficiently enough to get some background knowledge. However, the focus of the article is on the modeling of the property right assignment, and the political economy bargaining on these rights. The article follows the conceptual organization viz.: (1) discourses on commercialization of GM crops and their results are presented, (2) a background for bargaining on property rights is explained and (3) the theoretical concept of political economy modeling is given, (4) a full model is outlined and (5) arguments are summarized and interpreted.

2. Selected Political Arguments and Need for a Political Economy Approach: Setting the Agenda

The authors think that it would be wrong to see the discussions on GM crops only in the vein of costs and benefits, ecology and good governance. We argue that political economy matters in the case of commercial use of GM crops. To support this position, documented discourses such as the German GM crop discourse under the green/social democratic government (BMVEL 2002) and the UK discourse (Office of the Cabinet 2003) are used to articulate the arguments. We may further see that the dispute and particularly its unsettlement can be attributed to the conflicting parties' unwillingness to accept property rights and regulations. This is perceivable if we separate moral positions and emotions on the conflict on commercial cropping of GM crops and conduct a factual analysis. Such an unwillingness to accept rights of each side is perceived to weaken the conflicting groups' political will for a compro-

mise. In contrast, property rights and regulations can mediate bargains to compromises on GM cropping, given a proper institutional frame. In this article it will be clarified how an assignment of property rights and its acceptance by parties can result in a cooperative solution.

Evidently, the right to be free from the exposure to commercial GM crops requires the devising of risk sharing instruments such as the introduction of buffer zones in GMO fields and added responsibility (more costs) in bio-technology application. The latter can be achieved though minimizing the risk of gene proliferation by advanced technology choice of companies producing GM crop. Other instruments aiming at reducing the spreading of genes from GM crops can be intensive monitoring, documenting of ecological evidence for gene proliferation, etc.; they are not discussed here. We rather limit the discussion to buffer strips and technologies. A major argument of the article is that, though these instruments are secondary to the more primary need of finding a definition and codex of conduct in GM crop development and application, they can help in a bargaining process. Another challenge is the coordination of the conflicting sides' actions. This depends on reciprocity and trust in activities of participants and stakeholders including representatives of "nature's interest". It means that working out the "do ut des" principle is vital in coordinating the interests. The argument is that we must seek hints on "joint objectives".

A joint interest of the conflicting sides can be found in minimizing the risk of genetic modification technologies, to which all parties should agree in principle. So far it seems that most GM crop cases are oriented towards cost minimization for companies, farmers, etc. and do not sufficiently address the need of risk minimization on gene proliferation. Even in the new generation GM crops, which shall improve the nutrition status of the population, an "economic" objective is pursued, not an ecological one. Very few "breeding" efforts explicitly include "ecological" objectives such as risk reduction. The article holds the underlying belief that a joint strategy between "ecological" and "economic" objectives, focusing on risk, could be a point for recognition, contract, and achieving compromises. To elaborate this aspect as an acceptable, mutually agreeable argument, the political economy bargaining model is presented.

The intention is to explore an assignment of rights and model the subsequent bargaining and to show how it can lead to reduced ecological

risk of GM crops. It is important to analyze such interventions to create incentives and build reciprocity that can bring us a step forward to mutual agreements on commercializing GM crops. In contrast, the extreme rhetoric of both sides, such as saving a hungry world by GM crops or destroying the world with them, is taken as part of the game. We see the mentioned rhetoric as reference positions in the political economy of GM cropping, not more.

3. Results of Recent Discourses

The intention of this chapter is to substantiate the political economy modeling approach of the study. So the relevant supportive arguments from recent discourses are briefly presented (for the embeddings of GM crop in an even bigger discourse and meaning of discourse see already: Scandizzo 2009). The authors are aware that the complexity of the issue can not fully be appreciated by such a short presentation like ours. Nevertheless, it supports further understanding. There have been several discourses on biotechnology and GM crops. One of the most acclaimed dialogues is documented in BMVEL (2002). This discourse in Germany tried to bring together conflicting groups, like GM crop proponents and opponents, and reach a compromise. One can conclude that divergence of their political positions in the matter did not subside even after the discourse. For the sake of this article we interpret this as a strategic decision of lobby groups who think that they can still attain a maximum position of their interest through the political process. For instance, concerning matters of discontent such as protection of biodiversity, risk evaluation and co-existence, all parties adhere to their maximum position and no compromise is seen. Especially the notions of risk mitigation (reduction of spread of genes and cross pollination) and co-existence (scaling freedom of choice for farmers) were disputed. Until now, no measure has evolved that can offer a solution for the dispute. It seems that both parties still consider themselves strong enough to avoid relaxing their positions and hence settling the conflict.

Especially GM crops opponents seem to win because they think they present a morally superior argument, i.e. that the environment should not be harmed. Nevertheless, they are in a tricky position as they rely mainly on public opinion and campaigning. In contrast, many EU coun-

tries have legal procedures to let farmers grow GM crops and it could be expected that refinements of laws will open the way for the GM crops in Europe. The current ruling of the EU Commission (International Herald Tribune 2009/03/02, 2009) that Austria and Hungary can maintain their ban on GM crops (other countries do not) does not show the opposite. The chance of GM crop opponents winning a generic stand is remote (for background information see: Devos, 2008). The ruling only shows that bans are confined to some countries and that the EU currently follows the subsidiary rule that decision making should take place at the lowest level political unit. Across-the-board decisions are becoming rare and more and more decisions are left to the individual countries. Similar observations can be made from political proceedings, such as the UK cabinet report on "Weighting up costs and benefits from GM crops" (Cabinet Office 2003). Requests for bans are confronted with a multitude of arguments, however, centering on business freedom and minimal ecological risk. The arguments on the importance of GM crop industries' contribution to the competitiveness of the United Kingdom (Cabinet Office 2003, p. 48) are especially appealing. Citizens can be informed and formation of public opinion on GM cropping can be influenced. So the current popular support for anti-GM groups does not warrant unilateral decisions against GM cropping, such as bans.

In addition to the public opinion, assessment of the science community on the impacts of GM crops and the need for regulations also plays a prime role in the discourse. It can be seen that impacts (ecological, econoic, agronomic, landscapes, etc) are strongly disputed among the scientific fraternity as well. (see for example Pemsl et al. 2008 and Batie, 2003). Nonetheless, no negative absolute consensus has been reached, yet; rather, suggestions for regulatory interventions dominate. In the case of regulations, discussion on a broader basis already exists (Just et al. 2006) and deliberations with a regional perspective are currently emerging. This trend is evident in recent literature, such as the one looking at spatially disaggregated impacts and regulations on GM crops (for instance, Munro, 2008). It seems that a section of science prefers segregated governance and the notion of co-existence. Approaches to deal with the issue of co-existence (segregation) have been practically emerging (see a recent study by Beckmann and Weseller 2007) for quite a while. These proposed approaches (also designed as solution for conflict) are based on instruments such as liabilities, insur-

ances, government regulations on trade, etc. The idea is basically to try to create a platform of regulations which allow restricted application of GM crops at national levels. These regulations have to accommodate the rights of non-GM crop users and the ecological points of view as much as possible. However, compromises are still needed. Nevertheless, the quoted studies refer to a strong impetus to find regional solutions beyond bans.

From a broader perspective, moratoriums, bans, co-existence, etc. can be perceived as a part of national and international disputes and we have to appreciate the fact that many countries like Germany are looking for compromises (BMELV 2008). In this scenario, it can be predicted that regulations giving more room for commercial interests may be framed. There are strong hints that measures to minimize the ecological risk, such as the use of buffer strips around GM croplands, are at the core of the regulations' refinement (Demont et al. 2008).

However, active ecological risk reduction initiatives for biotech companies do not exist. It is a frightening observation that GM crops are allowed to remain risky and only minor attempts are made to reduce the ecological risk of biotechnology arising from unintended transfer of gene sequences through markers, promoters, etc. Another factor which increases the risk of unintended effects is that insertion of the foreign gene into the host genome is not controlled by the genetic engineers but is rather a random process under current technology. It is possible that risk mitigation could increase research and development costs and seed fees. Another fact is the absence of trust that GM crop companies will minimize ecological risk. The authors think that it is important to move towards more actions in the direction of risk reduction, i.e. to decrease risk in biotechnology and hence increase responsibility to make GM crops safer. The tenet of ecological risk minimization can be appreciated by both pro and anti GM groups and can be seen as a middle ground for the convergence of the extreme positions of both parties.

4. Background of Rights and Translation into Political Economy

4.1 Property Rights Assignment and Bargaining: General

Basically, we presume that no corner solution such as a ban or an unlimited freedom on GM cropping can exist in the long run. It means that no interest group has power enough to realize their maximum position. Rather, the possibility is that the political discourse will continue. Then it would be naive to think decisions will be based on pure science or moral arguments. The likelihood of lobbying by interest groups and the involvement of political power exist. When power is involved, decisions become vaguely determined. In this light, it matters how the assignment of relevant property rights (see section 1) can lead to an interrelated decision process under different constellations of power.

So how can one model the assignment of rights and subsequent decision making through exchanging rights under different scenarios of power? Normally a bargaining situation, instead of a market solution, exists if the property rights are not fully set. This is a typical state of affairs for many public goods. We consider the effects of GM crops, such as the risk of gene proliferation and health hazards (such as developing allergic reactions), as public goods. GM crops are liable for damages if the environment, businesses such as organic farming, and public health are affected by them. So gene proliferation and health risks of GM crops are negative public goods. Since probabilities of spreading genes are at the heart of the GM organism discussion, a real question is how probabilities can be communicated and become part of a bargain on efforts to reduce probabilities (risk) of spreading genes. However, under specific regulations we see a potential for structuring the discussion on gene proliferation as a bargain on rights impacting on probabilities. This bargain should reduce risk. This implies that some property rights have to be legally set up and we have to outline the bargain. The basic idea of political economy bargain is that both sides of a bargain become interested in establishing a dialogue leading to a solution. In our case it is the reduced risk of gene proliferation and giving up of both extreme positions. We suggest looking at two measures for reducing the

probability of gene proliferation (risk) that are widely talked about: (1) having buffers strips in GM cropped lands or (2) employing higher effort (costs) on developing safer genetic transfer technologies and bio-technology screening for unintended effects in laboratories.

This new suggestion of assigning property rights (on the above two aspects) to conflicting partners shall help to reduce risk. Assignment is a tricky thing. Economists normally shy away from rights distribution. But eventually we can justify assignments with moral and philosophical arguments. The idea is to ground assignments of property rights in a discourse knowing the consequences. According to the Coase theorem, economists are neutral and assignments do not matter for results of bargains. But it is seldom correct in reality. A consensus on right assignments is more likely if a supportive public opinion can be formed (moral arguments are behind assignments: Bromley 2001). Moral philosophy (Rawls 2000) can prove helpful in the case of rights allocation. The moral argument here is that it is justifiable to give a right to do business with genes to GM proponents and a right to buffers to the GM opponents, if minimal risk can be achieved on mutual considerations. A matter is, of course, how severe the ecological risk of GM crops is. For GM opponents or ecological promoters (as we call them), we presume that there is a good reason to get a property right for a maximum of buffer strips around GM cropped lands (science based). The assignment, however, has to be understood in the political economy framework of property rights trade.

Then, still in the vein of Coase, we see a property right assignment as a tool for solving resource management conflicts through increasing the efficiency of the resource use by exchanging rights (Tietenberg 1996). Resource management is understood as a broader term that is also applicable to the modes of introducing and managing GM crops. The mode of right exchange can result in different levels of risk. The intention is that a right owner gives up (offers) some elements of his right in return for a reduced execution of a right of another person (receives). We assume that hereby an ingenious assignment of property rights will encourage agents to change their behavior. But another assumption is that (in contrast to Coase 1960) the assignment does not provide a social optimum which is independent of the power of lobbying groups. Rather, we take reality into account and will model both, a change in behavior subject to right assignments and the outcome of a power

struggle. This modeling is considered more appropriate than a "naive" perception that a perfect market can come into existence on which rights are exchanged (Coase 1960). But, still the selected mode of GM crop management should reflect a socially agreeable type of right assignment. The proposed setup is supposed to settle the dispute on GM cropping to a greater extent than currently observable. Hence the contribution has a normative and a positive aspect.

We will soon spell out how the proposed property rights regime can be used for a more efficient risk reduction than the current one. This reduction in risk of GM crop cultivation shall prove beneficial for groups lobbying for GM cropping as well as for those who stand for nature's interest. The society is considered to be a mix of both groups. In addition to risk mitigation, the issue of power distribution to lobbying groups by the assignment of property rights will be part of the bargaining model (it reveals the parameters of such a bargaining).

Since this article is primarily concerned with the outline of a bargaining concept (modeling of it), a detailed outline of the legal aspects is avoided. The authors are aware that a detailed prescription of regulations is crucial and necessary if one specifies practical policies. Nevertheless, detailed prescriptions bring in another dimension of negotiations which would make the basic argument unperceivable. However, legal aspects are considered beyond the scope of this contribution. We refer to land use rights (buffer strips) and technologies rights (techniques for reducing risk of gene proliferation) of GM cultivation as broad categories of regulation only. A stylized version of the analysis on assignment of rights intended to settle disputes on GM crops is presented here. We discuss the assignment as a policy tool to provide opportunities of bargaining between conflicting groups and to influence the behavior of actors, not more. The key feature of this modeling exercise is the explicit consideration of the issue of power distribution among the groups along with the bargaining for risk mitigation.

4.2 Property Rights Assignment and Bargaining: Detailed Specification

(1) We assume (and will argue for this) that a lobby group promoting "ecological interests" has a right to a buffer strip on GM cropped lands

(land use right). A buffer strip separates GM crop fields from neighboring conventional fields. (2) We argue that the crop biotechnology companies have a right on techniques for reducing risk of gene proliferation. We assume that higher costs in the process of crop design exist, which are associated with more carefulness, diligence, etc. in biotechnology practices, and this will decrease risks of ecological impacts. The focus is not on the pure outcome of producing a genetically modified crop, but rather the whole process. The further underlying assumption is that it requires more effort in terms of labor, better equipment and hence can prove more costly. However, companies seek to minimize these costs.

The right to a buffer strip means that farm-business using GM crops has to initially assure the use of a "maximum" strip if they want GM crops on their field (restricted private property). This will reduce the farm area allocated to crops. We assume that science based analysis can establish a reference of a "maximum" strip (van de Wiel et al 2005). Nevertheless, the focus of the article will be on a bargaining for the size of the buffer strip in exchange for the use of safer (reduced risk of gene proliferation) GM crops in the field, not strip size.

For final justification on moral grounds in this article: The assignments could also and still have a moral background. One moral criterion in assignments is that rights should not harm any parties or at least should confine harms to a minimum. (As no one wants to be harmed by others concerning his business, he agrees to a restriction of his behavior and business to an extent that is least harmful to others.) The reference here is the mutuality, reciprocity and common sense in moral philosophy as formulated by Kant (see Rawls 2009). Wattles (1993, p. 37) states: "According to Diogenes Laertius, when asked how to behave toward friends, Aristotle replied, `As we would wish friends should behave to us". This reasoning forms the base for acceptance of rights as a basis of minimal mutual harm, i. e. the environmental risks and commercial interests. The conclusion is that a moral pressure could help to arrive at an agreement on rights, i.e. if a party seriously recognizes the right of the other party (by mutual respect). The rights can be established by assignment (legally) but also through voluntary action (accepted moral position). And it is not pure moral or legal; the position is even supported by practical economic studies on the grounding of reciprocity and acceptance (Gintis et al. 2005).

4.3 Political Economy and Bargaining

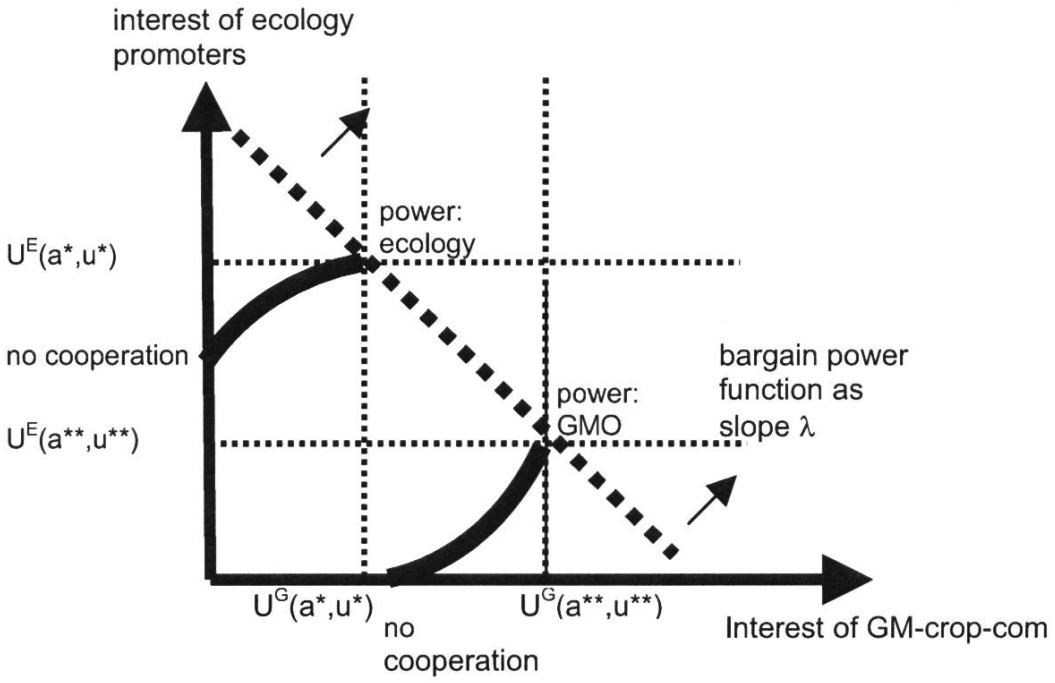
To further frame the political economy arguments and detail the bargaining process for modeling, one has to clearly define actors on both sides. Here, sides are represented by a conglomerate of actors rather than a single actor. We call one actor "GM-crop-company (-ies)" and the other "ecology-promoter (-s)". Under the heading of "GM-crop-company" we summarize the interest of the companies themselves, conventional farmers, research laboratories of GM crops, etc. Under the heading of "ecology-promoter" we summarize ecologists concerned about (afraid of) gene proliferation, ecological farmers, non-governmental organizations, etc. The idea of modeling the bargaining is that these two representative lobby groups will find a compromise that suits their clients.

For the GM-crop-companies, we attribute (that they can claim) general reasons for economic freedom (self determination and ownership) to pursue business (including job creation and right of innovation). The companies seek to minimize their unit costs. Minimized cost does not mean the lowest possible costs if the low costs mean external effects. If low costs imply that costs are negatively related to the safety of biotechnology, there should be a will or societal demand to reduce risk! In addition, there can be moral thrust on the company to be careful with the use of technology to minimize ecological risk of their products. This can be done by testing their own products (precautionary principle), etc. The "ecology promoter" is mostly concerned about the ecological risk of GM crops; but there are also economic risks involved, such as the danger of ecological farms losing a revenue margin. The objective will be discussed in the next chapter. In the next chapters, we will discuss the implications of assigning property rights and how bargaining may improve (likely reduce) GMO effects.

Our further understanding of developing a compromise among the actors draws on a political economy bargaining model of Zusman (1976). The introduction of a bargaining model is a first and theoretical step to simulating the potential for a compromise. For that, we briefly reiterate the theoretical background of a bargaining model. As can be shown in Diagram 1, a bargaining model starts from the limited allocation of property rights (as opposed to a market solution of full rights) and depicts achievements of individual objectives of collaborating units in a power game (Harsanyi 1993).

In particular we need corner solutions. For the envisaged problem we assume that rights are either with GMO proponents (GM-crop-company) or opponents (ecology-promoter). For the moment the objectives are roughly: (1) "Maximizing net gains of industry" (having highest return from bio-technology and taking no risk as industry) or (2) "Minimizing risk of the GM crops but ensuring the maximum of survival of humans as part of global food security" for opponents (net compromise of accepting some GMO types: see below in detail).

In Diagram 1, there are four corner solutions: (1) "no cooperation" of the GM-crop-company and (2) no cooperation of the ecology-promoter group (3) supreme power of the GM-crop-company, $U^G(a^{**},u^{**})\wedge U^{E-}(a^{**},u^{**})$ and (4) supreme power of ecology-promoter, $U^G(a^{*},u^{*})\wedge U^{E-}(a^{*},u^{*})$ are depicted. This power situation serves as a reference point for the final situation explained at a later stage. The crucial point is that a political bargaining model works along the concept of exchange and one has to specify the interest function and criteria to be exchanged. In our case we refer to risk imposed on the ecology by GM crops. However, it is assumed that cooperation (in a game theoretical context) shall reduce the risk. We have to think about measures of exchange. Diagram 1 only supplies the structure.



Source: Authors' own elaboration, according to Harsanyi, 1993

Fig. 1: Political Bargain Model and Power Measurement.

5. Risk Communication and Objective Functions

Our matter for communication is the risk posed by GM crops (Pemsl et al. 2007). There are three strains of risk: (1) of health problems with food consumptions (such as developing allergic reactions), (2) of the environment (such as genes spreading to natural varieties by cross pollination), and (3) of economic damages to organic farming (such as contamination of seeds and loss of sales). A major problem for the society is to find a way for risk sharing. Again, let us presume that there are no ultimate solutions as having no GM crops or no regulations and vice versa (this position may be pessimistic, though it is realistic). Then the question at hand is how one may achieve a solution which fits as a compromise and at the same time minimizes risk. The compromise has to be balanced (bargained) to accommodate benefits for both sides.

Now, if we want to adopt the bargaining model presented in the previous section, defining the positive interests in GMO risk mitigation has to be carried out. However, there is a double sided problem of property rights. For the ecology-promoter group, a starting point for bargaining can be the definition of bearable risk for society. If that is decided, any subsequent bargain on this risk may improve the situation. The same problem applies to GMO companies; here we can refer to extra costs of screening of products for ecological risk. However, what is the quantitative risk and what measure can help to reduce it? As already stated, we consider that two measures can be taken to facilitate the negotiations: (1) There can be buffer strips around GM crop fields. They are already now part of the discussion, but we want to make it a part of the bargain. (2) Additionally, the use of biotechnological safeguards, such as care in the selection of genes, avoiding unintended small or large changes in the modified genes and applying techniques to reduce the risk of unnecessary gene transfer, are to be followed. All these particular measures are to be taken from the side of GM companies. It will increase their unit costs but the escalating costs reflect measures.

A third aspect is who offers what. Normally an exchange is a mutual action and setting of property rights shall create an interest in bargaining. This creation of interest is a prerequisite for cooperation instead of non-cooperation or defection (notions of game theory, which can also be see as part of institutional economics deliberations: Richter and Furubotn 1998). Co-operation should actually be the superior strategy but the non-cooperative outcomes serve as reference points (Zusman 1976). In our case, we presume (set) that the ecologists have the right to request large buffers strips. As a reference we assume a maximum of risk neutralization in fields (large strips) as requested by the ecology-promoter. Then, as already stated, bargaining can concentrate on the size of buffer strips in exchange for the use of safer (reduced risk of gene proliferation) GM crops. (The ecology promoter gives up rights on the size of the strip in exchange for safer GM crop). The right on the use of safer biotechnology that can limit the spread of genes is vested in the GMO companies and we assume that safety measures are reflected in their higher unit costs. Now the bargain can start. The GM-company offers to make its products more ecologically safe (to reduce buffer strips) but this implies higher costs. The cost escalation may be reflected by higher seeds prices that companies charge as price transmis-

sion to end users occur (farmers' interests can be included: Johnson et al. 2005). In the bargain, a GM-crop-company (representing industries and GM farmers' interest) receives larger fields because buffer strips are reduced in return to ecologically safer products.

Now we can construct or simulate the bargaining and then receive potential outcomes. Towards obtaining the interest function, (1) the elements of exchange in the bargain have to be translated into the objective functions (costs and benefits). Then the exchange can impact on costs and benefits. (2) In our case, the revenue of GM companies shall depend on the size of land seeded with GM crops and farmers' willingness to pay for cost increases as fees. If the cost escalation due to biotechnological screening for risks is borne by the company (internalization of the cost), the increased size of GM cropped land mirrors the increased revenue of the company. (3) We extend this to a change in per-unit margin (change in costs included) multiplied by an expected market volume for the GM crops. (4) Two variables specify the interest function of the GM-crop-company: (4a) cost escalation due to bargaining on the buffer strips (negative) and (4b) more land under GM crop (positive).

(5) We then can construct the objective function of ecology promoters. Hereby we portray ecology promoters, as represented by a lobby group of ecological farmers who are facing income losses accrued by a probability of spreading of genetic material of GMO plants. (6) Technically it is assumed that the probability can be regressed on the variables, such as size of buffer strips (6a) and type of technologies used to ensure ecological safety of GMOs. The type of technologies is further correlated to the costs (6b) of supplying the technologies: High per-unit costs mean "better" technologies. We outline this in a mathematical form.

6. Model Outline

6.1 Objective Function of GM-crop-company

Working along this concept and description, it is possible to specify objective functions (also named interest functions) related to the bargain-

ing on the property rights. (1) We take a "GM-crop-company" as a lobby group including several companies, conventional farmers, research laboratories working in the field of biotechnology, etc. In contrast (2) we consider a scenario of an "ecology promoter", including ecological farmers, non-governmental organizations and ecologically concerned groups, holding the right of having the maximum buffer strip around a GM cropped farm.

(1) Interest of GM-crop-company: In this case, revenues of the GM company as well as of the conventional farmers are reduced by the property right. A buffer strip reduces the area sown in the farm and hence the revenue of this farmer. The revenue of farmers and company are shared. (In addition, this condition may drive away farmers from cultivating GM crop altogether as it may increase the opportunity cost of GM cropping, hence further reducing the area sown under the GM crop. But we will not consider this aspect now). The reduction in area sown in turn affects the company revenue, as profits depend on the total area sown with GM crop, reflecting the sales volumes. A compromise on the buffer strip can be obtained by a bargain offering additional measures to ensure the ecological safety of the products. This increases the per-unit cost of producing GM crops due to additional efforts, in terms of manpower and capital. The newly adjusted revenue of the "GM-crop company" lobby group is:

$$I^{GMO}(a,u) = R - m \cdot l \cdot (a^0 - a) - (1+u) \cdot l \cdot c_0 \qquad (1)$$

where: variables

a^0: change in the buffer strip (reduces the buffer strip)

u: percentage change in unit costs coefficients given:

a: buffer strip in percent (reduces the land area for GM crop)

R: status revenue as reference of no bargaining

m: revenue margin per unit of land sowed

l: land sowed

c_0: unit cost for technologies per unit of land area

Also, the gross margin is

$$m = p - c_0(1+u) \tag{2}$$

where:

p: price (fee charged on hectare basis)

Then we assume economies of scale, i.e. the cost per unit depends on the size of operation (land sown). Because of this economy of scale we further see a connection between the initial unit costs and the area served.

$$c = \alpha_0 + \alpha_1 1 \Leftrightarrow l = -\alpha_0 + \alpha_1^{-1} c \Leftrightarrow l = -\alpha_0 + \alpha_1^{-1} c_0(1+u) \tag{3}$$

Moreover, we assume that the revenue margin changes by the response in land area sown under GM crop to an increase in its seed costs

$$I^{GMO}(a,u) = R - [p - c_0(1+u)] \cdot l \cdot (a^0 - a) - c_0(l_0 + \alpha_1^{-1}(1+u))(1+u) \tag{4}$$

This function shall be used to describe the bargain in a mathematical expression.

6.2 Objective Function Ecology Promoters

As has been stated above in our stylized version of a bargaining, we take the ecology promoters as a representative group lobbying for the ecologically oriented interests. It represents the interests of ecologists, organic farmers and non-governmental organizations (i.e. we must assume that an internal coordination of interests has occurred for reducing complexity). The group interest can be specified by an ecological criterion, i.e. the probability of unintended gene proliferation from GM crops and economic damage. For the bargaining purpose of economic damage we take into consideration the monetary interest of organic farmers. They face a reduced margin in selling organic produces if their product is highly probable to contain genetic material from GM plants through unintended proliferation. So we represent the probability of gene spread

as a probability for an economic damage. The second aspect is the citizens' interest for a good environment, represented by their willingness to pay, though imbedding problems may be involved.

In the mathematical modeling framework, a revenue margin is specified for GM crop-free organic farming with a probability of (1-p). A reduced margin prevails given the detection of genes from GM crops in the organic crop (p is the probability of unintended proliferation from GM plants). The reduction in revenue margin is due to a reduced willingness to pay (represented by consumer discount D), i.e. the consumers discount organic products that contain GM genes. Note that a buffer strip around the GM crop can substantially reduce the probability of gene transfer. So the consumer trust (mistrust) with regard to organic crops, represented in their willingness to pay a margin (M) for GM-free organic products over the conventional counterparts can be modeled as a buffer strip related parameter (see below for the mathematical specification). To summarize, the interest of the ecology promoter group (bargaining agent) is represented here as an expected value of a margin to organic farmers who grow crops in a GM-free environment. In this respect a short remark on the territorial restrictions of the interest function and bargaining is needed. There could be an EU-wide application but also a European country or regional application. It depends on the relevance of the territorial restriction of the property rights assignment which shall create the basis for bargaining. The design of buffer strips is a secondary topic that is not discussed here. We now define the interest function (5) of the ecology promoter group

$$I^{ECO}(a,u) = M(1-p(a,u)) + (M-D)p(a,u) \qquad (5)$$

Where additionally: given

M: margin earned by organic farmers

D: depreciation (revenue loss if genes are detected)

p: probability

We now specify the margin (M) as a buffer strip related parameter

$$M = M_0 - \xi(a^0 - a) \qquad (6)$$

and inserting it in (5) gives:

$$I^{ECO}(a,u) = (M_0 - \xi a^0 + \xi a)(1 - p(a,u)) + (M_0 - D)p(a,u) \qquad (7)$$

We consider two cases. (a) If no gene proliferation happens though GM crop cultivation, a margin M prevails. (b) If genes are detected, a discount appears. The margin depends on the consumers' willingness to pay a price differential, and consumer trust dependents on buffer strips around GM crops. Remember that measures by the GM company to reduce the risk of gene proliferation can decrease the need of buffer strips but it may increase the unit cost of GM seeds. Furthermore, we can assume that the ecology promoter group observes a correlation between their margin "M" and the "competitive" unit cost pricing (in the GM crop sector). This is due to the fact that increased unit costs of seeds will be reflected in the food price differential. For the moment let us assume that a detailed specification on these interactions can allow us to calculate coefficients directly or they can be retrieved by statistical methods. Here the coefficients M and D give only average deliberations.

Then a linear functional relationship exists between the probability of gene spread and the measures "a and u". Note that the probability is assigned to the negative event of gene spread form GM crops to nature. This means a reduction in buffer strips will increase the probability, whereas an increase in the unit cost will decrease the probability.

$$p(a,u) = \varphi_o - \varphi^*_1 (a^0 - a) - \varphi^*_2 c^* (1+u) \qquad (8)$$

Inserting and rearranging of the probability coefficients gives a reduced form:

$$I^{ECO}(a,u) = M^* - D[\varphi_1 a - \varphi_2 c_0 \cdot u] - M_0 \varphi_3 u \cdot a - M_0 \varphi_4 a^2 \qquad (9)$$

Note that, M* take all constant elements. The reduced form given in equation (9) is the function for the "eco"-interests, I^{ECO}. Having specified both interest functions, a formal outlay of the bargain in terms of a to-be-optimized "joint" welfare function, which includes the individual interests as weighted interests in an additive mode, can be outlined. In order to do that, the reference points or the corner solutions have to be determined. For this, the political economy approach of Zusman (1976) is adapted for defining corner solutions.

6.3 Deriving the Power Function

Corner solutions (Diagram 1) serve to get information on the groups' power of bargaining. Corner solutions indicate that the option of defection might be chosen during the bargain. In addition, they represent the threat of non-cooperation (Zusman 1976). Cooperation means that the interaction between the partners (increase) maximizes welfare of conflicting groups (reduces probability in our case). Then bargaining has, at least, two corner solutions as can be seen in Diagram 1. This means that the power is either held solely by the GM-crop-company or by the ecology promoters group. Having sole power on one side means the other side has to just behave according to the incentives offered by the powerful group. The incentives are offered in a process of individual profit maximization by the powerful group. The question is who would be the principal or the agent in an imagined constellation exchange. A principle-agent-constellation means that the power is with the principal and that the agent is reckoned as responding to incentives. Both ways of specification could work for the exchange between the lobbying groups (GM-crop-company and ecology promoters), So we simulate both. Scenarios of different combinations regarding power held by the lobbying groups can also be modeled. But for modeling solutions of such joint and mixed power situations we need the slope of achievable points in the set of possible points. So we start our study with modeling the GM-crop-company lobbyists as principal and the ecology promoters group as agent and vice versa.

GM-crop-company: Principal and Ecology promoter: Agent

We first deliberate the case of the ecology promoters group as agent and the GM-crop-company as principal. A response function of the ecology promoter group (11) is specified as an optimization for the case that the "cost" of a decrease in probability of gene proliferation (using additional efforts by the GM company) is answered by a reduction of the claim in the buffer strip around GM farms. To get that response we have to find the first derivative of the interest function of the eco-group. The response by "a" is given at "u"; it can be considered as compensatory payment. The derivative is

$$\partial I^{ECO}(a,u)/\partial a = D\varphi_1 - M_0\varphi_3 u + M_0\varphi_4 a = 0 \qquad (10)$$

From that partial optimization, a response function (11) offers an "a" if "u" is given in terms of a commitment.

$$a = [M_0\varphi_4]^{-1}[D\varphi_1 + M_0\varphi_3 u] \tag{11}$$

This response is inserted into the objective function of the principal, the GM crop-company, and serves for a secondary optimization:

$$I^{GMO}(a,u) = R - [p - c_0(1+u)] \cdot l \cdot (a^0 - [M_0\varphi_4]^{-1}[D\varphi_1 + M_0\varphi_3 u]) - c_0(l_0 + \alpha_1^{-1}(1+u))(1+u) \tag{12}$$

Function (12) is now solely a function of "u". It can be optimized towards the optimal outcome of the game which now rests with the GM group. It optimizes:

$$\partial I^{GMO}(a,u) \Big/ \partial u = c_0 \cdot l \cdot a^0 - p[M_0\varphi_4]^{-1}[D\varphi_1 + M_0\varphi_3] - c_0(l_0 + \alpha_1^{-1}(1+u)) = 0 \tag{13}$$

from where u** is equated and hence also a** is determined. In this case the GM group was the principal and the opposite case is given below.

Ecology Promoters: Principal and GM-crop-company: Agent

Now we have to start with the GM company which can gain a reduction in the required buffer strips in GM fields if it increases the cost in bio-technologies intended to reduce probability of gene proliferation. Here, the GM company is the agent. Remember that an increase in the area sown under GM crop increases the profit of the company.

$$\partial I^{GMO}(a,u) \Big/ \partial u = c_0 a - c_0(l_0 + \alpha_1^{-1}(1+u)) = 0 \tag{14}$$

Function (14) gives a response of the GM-crop-company lobby group of

$$u = c_0^{-1}\alpha_1 [c_0 a - l_0 + c_0\alpha_1^{-1}] \tag{15}$$

to incentives from the ecology promoter and thus the ecology promoters group has an objective function

$$I^{ECO}(a,u) = M^* - D[\varphi_1 a - \varphi_2 c_0 \cdot c_0^{-1}\alpha_1][c_0 a - l_0 + c_0\alpha_1^{-1}] - M_0\varphi_3[c_0 a - l_0 + c_0\alpha_1^{-1}] \cdot a - M_0\varphi_4 a^2 \tag{16}$$

The ecology promoter (now the principal) optimizes towards the buffer strip a*:

$$\partial I^{ECO}(a,u)/\partial a = -\varphi_2 c_0 \cdot c_0^{-1}\alpha_1 c_0 - M_0\varphi_3[2c_0 a - l_0 + c_0\alpha_1^{-1}] - 2M_0\varphi_4 a = 0 \qquad (17)$$

Having solved for a* the corresponding results for "u" is from inserting a* in (15); it gives u*.

Now we have received the reference points or corner solutions and can continue to find the power function. In the corner solutions, one derives at two sets of “a” and “u”: a* and u* for the GM-crop-company as principal and ecological promoters as agent, as well as u** and a** for ecological promoters as principal and GM-crop-company as agent. These two solutions (feasible corner solutions) allow us to specify the references or power weights as an endogenous problem. In numerical terms $t^{GMO}=U^{GMO}(a^*,u^*)$ and $t^{ECO}=U(a^{**},u^{**})$ are references that are needed for specification of a power coefficient (following Zusman, 1986).

$$\lambda = [I^{GMO}(a^*,u^*) - t^{GMO}(a^{**},u^{**})] / [I^{ECO}(a^{**},u^{**}) - t^{ECO}(a^*,u^*]$$

As already stated, a formal outlay of the bargain in terms of a to-be-optimized “joint” welfare function can be outlined if the corner solutions are already defined. Note that the power coefficient (λ) becomes the slope of a joint welfare function of GM-crop-company and ecological promoters lobby groups (Diagram 2).

7. Solution

In principle, the slope of the tangential function in Diagram 1 and 2 is determined by the reference points. Diagram 1 has to be amended to a new optimum beyond the individual optima (see Diagram 2). Then we get the perspective of bargaining to the extent of reaching a utility frontier curve at the maximum of the tangential equation. The utility frontier curve reveals all possible sets of maximum possible utility of both lobbying groups when they exchange rights. The instrument variables are the measures “a” and “u” for finding a solution (see the diagrammatic expo-

sition). The mathematical exposition uses the objective function and the power slope coefficient "λ". Having obtained the power coefficient, a final optimization of "a" and "u" is possible; let us specify them as a*** and u*** which can be achieved by a joint welfare function.

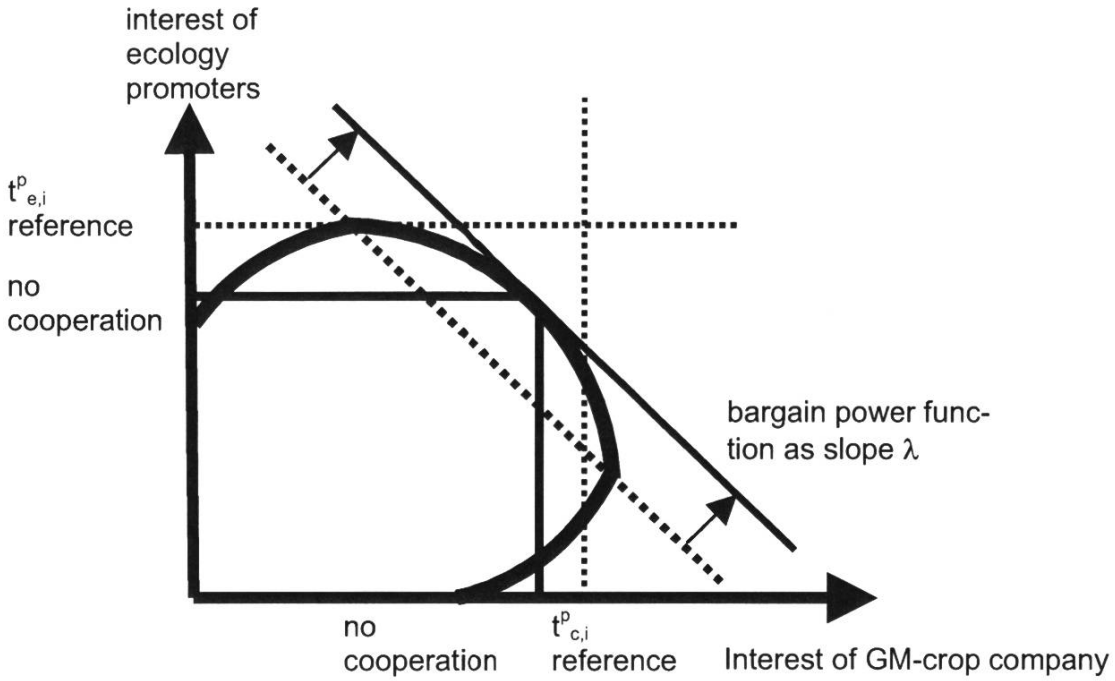
$$W(a,u) = \lambda \cdot ([p - c_0(1+u)] \cdot l \cdot (a^* - a) - c_0(l_0 + \alpha_1^{-1}(1+u))(1+u)) + M^* - D[\varphi_1 a - \varphi_2 c_0 \cdot u] - M_0 \varphi_3 u \cdot a - M_0 \varphi_4 a^2 \quad (18)$$

In this function, "λ" is a weight of the individual strength of lobbying. The optimization of equation (18) gives a representation of the interactive optimization for a*** and u***. Technically it is the first derivatives for "a" and "u":

$$\partial W(a,u) / \partial u = \lambda \cdot (c_0 \cdot l \cdot (a_0 - a^{***}) - c_0(l_0 + \alpha_1^{-1}(1+2u^{***}))) - M_0 \varphi_3 \cdot a^{***} = 0 \quad (19a)$$

$$\partial W(a,u) / \partial a = \lambda \cdot ([p - c_0(1+u^{***})] \cdot l - D\varphi_1 - M_0 \varphi_3 u^{***} - 2M_0 \varphi_4 a^{***} = 0 \quad (19b)$$

Here "a***" and "u***" are considered contractual parameters that are jointly determined through optimization (bargaining). For interpretation, the presented bargaining by joint optimization shows some similarities with the game theoretical approach of Weimann (1995). In fact, it is a game theoretical result that parties find solutions which are socially "optimal" (better) if parties cooperate. The difference is that the bargain documents an artificial agreement where both parties are better off. Nevertheless the solution is given under a certain power relationship which is revealed in optimization. In our case it means gains can be obtained through contracting between the parties on "a" (change in area of the buffer strip) and "u" (percentage change in unit costs coefficients of the GMO company) which go beyond the initial situation of non-cooperation.



Source: Authors' own elaboration (according to Harsanyi, 1993)

Fig. 2: Optimal Bargaining Result.

8. Conclusions

In this paper we discussed a new approach to dealing with conflicting interests in genetically modified (GM) crops and their commercial application in agriculture. The arguments are settled against a bargaining approach on right exchange. The common ground for a bargain between the opposing groups, denoted as GM-crop-company and ecological promoters, is found in the risk in gene proliferation. The basic idea is that a property right assignment can help to establish a bargain on risk reduction. Two instruments are considered for the bargain: (1) The ecological promoter group (GM opponents) may get the right to insist on a "maximum" of buffer strips around GM cropped farms to reduce the probability of gene proliferation. Such large buffer strips can harm the profits of the GM-crop-company. So the latter must find measures to get the buffer strip reduced in exchange for its own right. The bargain on the size of the buffer strip is only possible if the company reduces the risk of

gene proliferation from its products using technically superior measures. So what is the right that the GM company can offer in exchange for reduced buffer strips? (2) A GM company (corporation) may get or have a right on biotechnology measures to improve ecological safety of GM crops. In order to specify objective functions, the additional costs of these measures represented by increased unit costs are used to represent the "quality" of gene transfer technologies. The companies will have a right to minimize such costs. Nevertheless, the paper does not assume a perfect market for the rights and instead a power struggle between the lobbying parties is visualised. Against this background, a political economic approach is followed and the presented mathematical formulation specifies how power coefficients can be introduced into the bargaining process represented by a joint optimisation of interest functions of ecological promoters and the GM-crop-company. It is argued that bargaining delivers a political economy solution, being optimal in solving the GM debate, at least in a model.

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