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**ECONOMIE ET SOCIOLOGIE
RURALES**

About the Organization of Agrarian Innovations

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Abstract

The principles of transaction cost minimizing can be adapted to agrarian innovation and help to determine the effective boundaries of market, private, public and hybrid organizations with regard to agrarian innovation. A theoretical framework is developed for setting-up an effective public agrarian policy, agrobusiness strategy and institutional design. A matrix of effective forms of organization of knowledge supply, labor supply, input supply, capital supply and marketing transactions in agrarian innovation is presented.

Key-words : Organization. Innovation. Agricultural sector.
Transaction costs. Agro-business strategy.

Résumé

Les principes de minimisation des coûts de transaction peuvent être adaptés à l'innovation dans le secteur agricole et aider à déterminer les frontières effectives du marché et des organisations publiques, privées ou hybrides concernées. Un cadre théorique est développé pour établir une politique agricole effective, une stratégie agro-industrielle et leur conception institutionnelle. Une matrice présente les formes effectives d'organisation de l'offre de savoir, de travail, d'intrants et de capital, ainsi que les transactions concernant la commercialisation, liées à l'innovation dans le secteur agricole.

Mots-clés : Organisation. Innovation. Secteur agricole
Coûts de transaction. Stratégie agro-industrielle.

ABOUT THE ORGANIZATION OF AGRARIAN
INNOVATIONS

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ABOUT THE ORGANIZATION OF AGRARIAN INNOVATIONS

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Introduction

There has been a fundamental institutional modernization of agrarian research and technological development during the last two or three decades, with a privatization policy in public research and development organizations and the decentralization of the management of innovation activities. New intellectual property rights concerning agrarian innovations¹ have been introduced and new modes of cooperation in the innovation area have been used extensively. New forms of coordination of research and development at national and transnational scales have come into existence. All these changes have been broadly discussed in the specialized literature among agents and managers for innovations and among policy makers and the general public.

¹ Agrarian innovation involves various activities in fundamental and pre-technological research, applied research, technological and product development, input supply, farming, agro-processing and marketing. Ultimately, the products or services of these activities are associated with some kind of innovation (product, technology, method of organization etc.) in the agricultural sector.

Newly-emerging Transaction Cost Economics provides a powerful framework for understanding the development of governance structures and institutions in the contemporary world. With few exceptions, this new concept has not been applied to the large sphere of transactions in agrarian innovation. Broadly applied traditional analysis in this area has not been able either to explain the origin and character of new evolving forms or to predict the real prospects for their development. As a result, designed research and development policy has not always been consistent with the 'logic of development' of agrarian innovations. All this has delayed or substantially deformed the development of research and innovation potential in most developing and transitional countries.

We set out here to adapt the principles of transaction cost minimizing to agrarian innovations and to determine the effective boundaries of market, private, public, and hybrid organizations with regard to agrarian innovations. The ultimate goal of the paper is the setting-up of a theoretical framework for an effective public agrarian policy and agro-business strategy and institutional design. Coverage of the transaction cost economics of agrarian innovations is followed by discussion of the behavioral, attributive, and environmental factors of transaction costs in agrarian innovations and presentation of a matrix of effective forms of organization of knowledge supply, labor supply, input supply, capital supply, and marketing transactions in agrarian innovations

In order to simplify our approach, we assume that a constant outcome can be reached, given a range of transaction modes, and that a set of property rights pre-exists and stays unchanged during a certain time.

'Market or hierarchy'

Agrarian innovation was an indissociable part of production activity (farming) for thousands of years. The separation of innovation as a specialized economic activity in society started in the nineteenth century when the first agricultural experimental stations were established. Since then, specialization and division of labor in agrarian innovation have increased enormously. A number of different branches have evolved in agrarian research and technological development and various kinds of farming extension have come into existence as specialized activities.

In a system with developed specialization and division of labor, individual operators need to exchange the products of their work and resources or, to put it another way, they have to do business with each other. For instance, when a farmer buys a new seed variety he uses the autonomous market mode for the organization of his transaction with a seed producer. When a researcher is ordered by the Director of the Experimental Station to move from one project (department) to another, this is a hierarchical mode of transaction.

The importance of the 'invisible hand of the market' for the coordination of economic activities and for effective allocation of social resources has been part of the fundamentals of political economics for more than 200 years. The idea of that 'there are costs in using the price mechanism' is a new insight in the recent development of economic theory. In the words of Coase, 'if production is regulated by price movement, production could be carried out without any organization, well might we ask: Why is there any organization?' (Coase 1937). Would not it be possible for all transactions and coordination between factors of production to be carried out by the market? Why are there organizations for agricultural research, extension services, technological development etc.? Why do experimental stations,

cooperatives, corporations and contract research exist in agriculture? Why are technologically separable stages of innovation activities linked with each other rather to all others (market)?

The answer is that it is sometimes cheaper or possible to organize a transaction using the **internal mode** rather than the market. The difficulties of technology transfer across market interfaces have been well recognized in economic theory. The 'fundamental paradox' of information is that 'its value for the purchaser is not known until he has the information, but when he has in effect acquired it without costs' (Arrow 1962). In addition, consumption of new knowledge does not involve rivalry and it is very frequently associated with high positive externalities (spillovers) and high exclusion costs. It is prohibitively expensive for sellers to control market exchange and to appropriate the benefit of transactions, to exclude non-payers, to use invention and to verify cheating, etc. There are also considerable opportunities for consumers to 'free ride' using non price modes for innovation supply (informal, pirating etc.) without great risk of punishment. This is why the market 'fails' to organize a considerable proportion of agrarian innovation transactions.

If there are costs involved in using a price system, it is not surprising that individuals set up different private organizational and contractual devices to minimize transacting costs. It is very often more profitable to coordinate the division of labor in innovation activities in an organization either through **group decision-making** or by the '**visible hand of a manager**'.

When for instance a seed producer (company) hires a researcher to develop new varieties, he replaces a set of market transactions for new variety supply with another form for organization of previous transactions such as an employment contract. Initially, labor is hired on the market and this involves the costs of looking for good researcher, negotiating working conditions, salary, etc. However, once this transaction has been

completed, the employee agrees to follow the orders of the owner (to be directed) throughout the contract period. As a result, coordination of economic activities between these agents is not by market price movements but in a centralized manner by **authority**. The internalizing of transactions gives the seed producer an opportunity (power) to control the innovation process more effectively, to reduce market risk and uncertainty and to increase his adaptive capacity. This new form of transacting allows both parties to save repeated costs of contracting research (or trading new varieties), of the negotiation of conditions of exchange, of renegotiation during the execution stage and of the settling of disputes by a third party (e.g. a court). The benefits of this new way of transacting take the form of better **governance** rather than production cost savings.

However, one might wonder why all agricultural innovations are not carried out by one large company. As Williamson puts it: 'Why cannot a large firm do everything that a collection of smaller firms do and more?' (Williamson 1992). Why are there individual research departments, laboratories, consortiums, and other organizations of different sizes in agrarian innovation? What determines the limits of research institutes and innovation organizations in agriculture?

The answer might be that the advantages of internal organization do not come without costs and namely transaction costs for the coordination and stimulation of innovation through group decision-making or in a hierarchy. Internal organization has great advantages in transaction control in comparison with the autonomous market. However, it does not enjoy high-powered, self-enforcing market incentives. Thus the basic trade-off must be between increased control potential and loss of incentives in the integrative mode.

Alternative forms of governing transactions

Market and organization are not opposites but two extremes in the **continuum** of alternative governance modes for transaction (Williamson 1975). Transacting forms range from spot markets through various short and long term bilateral and multilateral contractual arrangements to unified (ownership) integration. Whether a transaction is to be executed in the market or within an organization depends also on **differential** transaction costs. A transaction will be carried out within an organization if the costs are lower than those of same transaction in the market or in other organizations. Hence, an organization becomes bigger if it includes (internalizes) additional transactions which were previously performed on the market or by another organization. The organization becomes smaller if an internal transaction is left to the market or to another organization. Economic structures in agrarian innovation and the distribution of economic activities between different organizational forms can therefore be explained on the basis of **the comparative efficiency** of these transactional modes, in terms of transferring costs and capturing benefits.

An innovation transaction—for example the supply of extension services for beef cattle farming—could be organized in quite different ways: a farmer can do it himself (ownership mode), he can buy an extension service on the market for a fee (free market transaction) or contract extension supply with a university (long term contract mode). A big farmer may hire an extension expert (employment contract), he can lease his stock to another farmer practicing new methods (share tenancy or fixed rent lease contract), several farmers may buy extension services (joint ownership), a farmer can join a cooperative that provides an extension service (non-profit organization), a farmer may sell extension services to other farmers (profit-making organization), a farmer can join forces with a processing company and have

extension services supplied by the industry (interlinked contracts), a farmer can be hired by a processing company to work on his farm with all the inputs supplied by industry (labor providing contract), a farmer can lobby for public extension supply and get it free (public mode), a farmers' extension organization can obtain public or private subsidies (hybrid mode), supply of extension services can be obtained from another farmer or an extension officer over a drink (informal mode) or extension services provided for a neighbor can be copied on his own farm (pirating). All these alternative forms of transacting have quite different costs and incentive advantages. The choice of mode will depend on the costs and benefits involved in carrying out this transaction in alternative governance forms. This is why we assume that organizational design is comparative and predominantly a transaction cost saving undertaking, with the proviso that there is a constant outcome, consistent across all transactional modes, during a certain time.

When a transaction is considered as the **basic unit** of economic analysis, innovation organization is a method of governing transactions—a nexus for the organization of internal and external transacting. There is no internal transacting on an individual (one-person) farm. The level of external transactions depends on the degree of self-sufficiency of the farm and this may be close to zero². When a farmer hires a worker, the level of internal transactions increases. Accordingly, the costs associated with internal transactions grow and it must be decided whether it is more economical to buy on the spot market (e.g. new seed variety), to use internal sources (employment) or an outside contract. The latter also provides different cost minimizing alternatives such as whether to contract service work (contract research) or to join an innovation organization (e.g. a

² For instance, outside transactions are very limited in traditional self-sufficient agriculture and farmers occasionally spend time studying the progressive practices of his neighbors or exchange goods and services.

cooperative or joint-venture operation). The resulting economic description of innovation organization is that of a device (mode) for the organization of **internal** and **external** transactions at minimum cost.

Transaction cost economics overcomes the zero transaction cost assumption of Neoclassical economics. It puts the 'costs of running the economic system' alongside production costs when defining effective boundaries of different governance modes for the organization of economic activities. As Arrow states, 'Market failure is not absolute. It is better to consider a broader category, that of transaction costs which in general impede and in particular cases block the formation of markets' (Arrow 1969). As specialization and the diversification of economic activity increase, exchange between economic agents becomes complex. Consequently, the costs of the coordination and motivation of activities of specialized agents form an increasing share of all social expenditure.

The concept of 'market failure' is not a new one in economic theory. For example, traditional institutional economics describes cases of market failure in order to justify government intervention. However, it does not mention all the varieties of effective private governance organizations which can effectively substitute the market. There is also a strong possibility of 'government failure' as government bureaucrats cannot define real public demand and allocate resources effectively. Notorious extreme examples of permanent Government failures have been the organization of all agrarian transactions by means of a central plan in the former Communist countries.

When a big dairy farmer hires a veterinarian instead of relying on the market for veterinarian services or when a farmer signs a long term contract with a university professor or a processing company for direct innovation supply and when an agrofirm or cooperative sets up a technology division or a research laboratory instead of buying innovations on the market,

this means that economic agents are replacing a price system with different forms of non-market organization of agrarian transactions (such as employment contracts, long term contracts, strategic alliances or vertical integration). Thus the structure of activities in the agrarian sphere is defined not only by prices on the free market but also by negotiations between partners and by bilateral or multilateral arrangements or by authority in a hierarchy.

The role of the Government

Third-party involvement in individual transacting is necessary to make it possible or more efficient. This is very frequently a result of a private third party involvement in transactions. For instance, a private consultancy or development firm mediates innovation supply between public research institutes and farming. It is also common when effective third-party involvement occurs as a result of community efforts performed by a local authority (e.g. extension and development organization).

The failure of all types of private sector economic and legal organization to work satisfactorily is a necessary condition for Government intervention or third-party Government involvement in agrarian transactions. The organization and provision of basic and pre-technology agricultural research is a typical example of the inefficiency of market transacting. Those activities might be carried out by private organizations for supplying goods on a collective basis. However, the transaction costs of organizing thousands of farmers would be very high. It may take a long time to build up such an organization and it would probably not be very stable because of the tenuous relations between individual contributions and benefits (free-riding problem). In

addition, costs of efforts to develop a special private mode would not be justified, because of the low frequency of transacting between the same parties (innovator-individual farmer). This is why the Government intervenes in these transactions to make them more cost-effective or possible at all. This is the case, for instance, when mandatory levies (parafiscal taxes) on agricultural output are introduced in order to facilitate organization of collective supply (e.g. supply of applied research and extension services).

The greatest problem here is that when market or private sectors seem to work ineffectively it does not mean that Government intervention is always more effective. Bureaucrats are likely to have great difficulty in identifying cases of suboptimality and in devising the appropriate corrective policy. There might also be problems in monitoring the agents to whom the execution of legislative power is delegated. Last but not least, the Government may be influenced by special interest groups and fail to organize transactions in the most effective way for all parties.

The benefits should therefore be judged in relation to costs (including transacting costs) for any Government involvement in agrarian transactions. This covers the general case of public intervention in the agrarian sphere as well as the selection of specific modes for its organization (direct financing or in-house production of public goods, various regulations etc.) in such a way as to minimize comparative transaction costs. For example, sustainable agrarian development is currently in great demand in all developed countries. Market mechanisms would not seem to serve this public demand effectively. Interested individuals might develop different kind of private organizations to meet their demand for safe food, animal welfare, and protection of environmental resources, etc. However, it would be very time-consuming and expensive because of poor appropriability and high externalities. Government involvement in these transactions

could be more cost-effective. However, there would be very different ways (modes) of organizing such trilateral transactions. The Government could organize in-house research in state institutions; it could finance research projects in autonomous public institutes on a 'pork barrel' or competitive basis. The Government can invite tenders from the private sector and foreign institutions. It could introduce agrarian intellectual property rights for national (and multinational) investors and set up institutions to enforce these new rights. It can introduce regulations and standards for the protection of environmental resources. It may promote projects and award subsidies, tax preferences, etc. for agents involved in innovation activities etc. These different modes of governing the transaction would have different control, decision making, adaptive and incentive features and therefore quite different costs for participants and general taxpayers. Each represents a different set of property rights, hence a different set of winners and losers.

Thus, in the **market-based economy**, individual agents need and develop non-market forms of organization of their transactions, and the real agrarian economy consists of many coordinated subsections. Given the competitive setting, the trend will be for the adapting of the organizational modes that best save transaction costs for the same benefits. This means that there is no single form for the organization of all kinds of agrarian transactions and universal governance modes do not last forever. Economic agents will choose and improve forms of organization of their transactions along with development of technology³ and changes in the conditions of exchange (e.g. improvement of contract enforcement systems, introduction of new property rights, etc.). Governance modes will emerge and evolve as long as any transaction economizing potential exists

³ For example, the introduction of new scientific methods (e.g. hybridization) and the improvement of communication technologies, etc. usually require new forms for organization as well.

and they will eventually die when more effective forms for organization arise. In the long run, the transaction costs minimizing the organization required for each individual transaction will prevail (efficiency principle).

Finally, a continuum of alternative modes of agrarian transactions is available for the individuals and based on the **dominant legal system**. For instance, if agrarian intellectual property rights are not introduced and properly enforced, then trade secrets and/or technology imports will be used in the private sector and there will be strong pressure for the development of public innovation supply as an alternative—although not the most efficient form—for the organization of transactions.

Current long term costs of transacting

So far we have examined the current transaction economics of innovative agrarian activities. Each society must also bear the **long term** transaction costs for setting up one or another organizational form. These are a high level of preliminary entrepreneurial costs in the private sector and political entrepreneurship costs for public goods supply or institutional development. They differ from current transaction costs for using the existing alternative modes and thus form long term investments with a return from the transaction economizing potential of the new forms. Let us suppose that a transaction requires a high level of specific investment for a particular partner but is occasional. Trade with intellectual agrarian products (e.g. patents) can be included in this class of transactions. Market mediation would not be effective because of the low appropriability, divisibility and measurability and the high uncertainty of the innovation activity. At the same time, the set

up costs for a special bilateral private structure to secure effective transacting may not be covered since the frequency of transacting between the same parties is low. Consequently, the agents would not invest in transacting specific assets and the transaction would fail to occur. Hence, third party involvement (e.g. assistance, arbitration, enforcement etc.) is required for effective organization of such transactions. In this case the Government would play a crucial role in the development and enforcement of new property rights.

There are two types of transaction costs: those for establishing 'institutions of governance like firms, hybrids, bureaux' and those for changing the 'institutional environment of which property rights are part' (North). Factors and mechanisms for 'induced' institutional innovation in the agrarian sphere have been well described in the literature on public choice (Hayami and Ruttan 1985). Moreover, the efficiency of the mobilization of the factors for institutional modernization depends on tradition, cultural endowments etc., and these are quite specific to each country (North remarks that it is not possible to import institutions). Besides, public preferences at any stage of development and the admissible social costs for institutional modernization are quite specific to each society. They are very important economic parameters but come to the economic system **from the political system** of society. Economic analysis can contribute less to defining these levels since this is the political decision-making sphere⁴. The basic role for economists here would be to evaluate the alternative ways (forms) and to identify the most effective (transacting minimizing) modes for achieving the social goals.

⁴ If this is not so, it would be very difficult to explain why the level of return on public agricultural research has been so high since the nineteenth century and there has been a large under-investment in public agricultural research and development in all countries.

Behavioral characteristics of the agents in agrarian innovations

What determines the boundaries of innovation organizations and what determines the boundaries of innovation markets? In order to understand when agrarian agents mediate their transactions through the market and when they manage them through private modes, we must first start to make more realistic assumptions about the behavioral attributes of individuals involved in transacting. We must next define the character of transactions in agrarian innovation. Thirdly, we must determine the microeconomic factors (critical dimensions) in differences in transaction costs. Finally, we must match the attributes of transactions (different in each transaction) with alternative governance structures (whose transaction cost minimizing capacity differs) in a discriminant manner.

Transaction cost saving is based on two behavioral assumptions concerning economic agents: bounded rationality and opportunism. The first concerns cognitive assumptions in which human agents are assumed to be 'intendedly rational' but they experience 'limits in formulating and solving complex problems, and in processing information' (Simon). Because of the high level of 'natural' uncertainty or asymmetry of information between transacting parties, it is impossible or extremely expensive to formulate the novelty of innovations in written language, to predict all future circumstances of development of transacting and to specify consecutive actions of parties, to monitor and measure performance of counterparts, to recognize possible applications of innovations, to exclude pirating of innovations and to enforce appropriate payments etc. The economic ramification of this assumption is that practically all forms of contracting of complex transactions are incomplete.

Most of the innovation transactions would therefore seem to be governed by implicit or rational rather than elaborate contracts. Even when competitive grant funding is applied it is usually accompanied only by general statements that some advance in knowledge in a particular area is to be attained. Restricted rationality also makes it difficult for a third party to be efficiently involved in innovation transactions. Chronic 'under-investment' in public agrarian research (government failure) is a classic example. Widespread practicing of the 'excuse doctrine' is another instance since no failed innovation contract has ever been brought before the courts.

The second assumption is that economic agents are given to opportunism as a 'deep condition of self-interest seeking with guile' (Williamson 1985). This means that transacting counterparts are less trustworthy and not reliable in actions. Accordingly, if there is an opportunity for one of the transacting sides to obtain extra rent from exchange he will do so. For instance, since uncertainty is high in research and monitoring is difficult (marked bounded rationality of principle), a researcher would devote part of his working time to matters not related to his assigned activities (e.g. for outside 'private' projects). In addition, farmers can hardly be expected to pay royalties for a new variety (or technology) if it is not naturally protected and he can acquire (reproduce) it free. Even for technical innovations where imitation is obvious, 'neighborhood' inventions are widely patented in order to avoid the payment of license fees. Thus, if uncertainty is great and a party may suffer severe losses from opportunism (investments are highly specific to the transaction) he may govern (control) the transaction in internal mode rather than performing transactions in the market place.

These two behavioral assumptions have been broadly used in Agency literature to analyze (inter-) organizational failure. Williamson sets them as the base for solving the problem of any economic organization: '... assess alternative governance

structure in term of their capacity to economize on bounded rationality while simultaneously safeguarding transactions against opportunism' (Williamson 1985). The public good character of agrarian innovations (non-rivalry, non divisibility, and non excludability) would not be important if there were unrestricted cognitive competence and full self-enforcement of transactions. Substantial 'natural' uncertainty surrounding an innovation and asymmetry of information would easily be overcome by transacting parties through current adjustment in their mutual benefits. However, when bounded rationality and opportunism coincides, market transacting (trade with know-how, classic contracting of invention activities etc.) becomes very expensive or impossible. Faceless market transacting is replaced by specially designed private modes (private ordering, brand names) and personal rather than institutional relationships begin to dominate. In addition, a unique feature of the innovation sphere is that cost minimizing forms of transacting are evolving, such as comprehensive (free) public access to scientific information, granting exclusive private rights on invention against public disclosure etc.

The critical dimensions of transactions in agrarian innovations

Under certain circumstances, market prices provide individuals with all the relevant information concerning the economy and powerful incentives to use available resources effectively while maximizing their profit and utility (Milgrom and Roberts). The free market is a perfect mode for organization of agrarian transactions when neither sellers nor buyers can affect prices (agents are price takers and they lack bargaining power), when barriers to exit or entry in different activities are low (no monopoly exists), when information is fully available to the same

degree for all partners (lack of information asymmetry and possibility for opportunism), when products are homogeneous or standardized (minimum costs for finding partners, negotiating, exchange and contract enforcement) and when there are no externalities (the parties bear all the costs and benefits associated with their choices). This is how, for example, a researcher buys (instead of making) all the necessary materials for his experiments on the spot (or specialized) market.

In a world of low (zero) transaction costs, the initial assignment of property rights does not matter and economic agents trade property rights on resources up to the pattern of their effective Neoclassical equilibrium (Coase 1960). However, in a world of real (positive) transaction costs, the initial assignment of the property rights between individuals can substantially deform total outcome efficiency. For example, market transacting would oversupply with intensive chemical innovations and undersupply with environment-friendly technologies. This is because relative price levels do not take the (negative) externalities into account and no third party regulation has been set up.

It is therefore necessary to specify the microeconomic factors in transaction costs and to determine the minimization potential of the transacting costs of the different governing forms, (re-) distribute property rights and initiate other institutional modernization in innovations.

Firstly, agrarian innovation is a result of a broad combination of activities in agricultural research, product (technology) development, agrarian extension and farming. Researchers in different branches and disciplines and a great number of support personal, extension officers, farmers, and consumers of agrarian innovations participate in the process. A typical example is the development of new alfalfa variety with enhanced nitrogen fixation which involved contributions from science-oriented research in biochemistry, genetics, microbiology

and plant physiology together with technology-oriented research in plant breeding and farm management. The efforts took more than 30 years before the marketing stage was reached and relied on both disciplinary and trans-disciplinary research at several institutes (Heichel).

The coordination of activities at such a large scale and over such a long period of time could hardly be a 'byproduct' of market competition. It usually requires complex organization (program, strategic alliances, collaborative private-public actions etc.) of these polyvalent links. This is why the role of the national and transnational coordination bodies (Academies, Joint Councils, Priority Boards etc.) is growing. In addition, modes (conferences, workshops, etc.), formal governance bodies (representation committees) and informal organizations (informal colleges) have developed to facilitate transactions in different directions that are specific to the innovation sphere. In contrast, research laboratories at private companies are usually organized at the top hierarchical level where the possibility for direct control of transacting is greatest.

Secondly, because of the small market appropriability (high spillover rate) of some intellectual agrarian products, the agents set up private modes for transacting in order to protect property rights and to capture a higher return on their investments. For instance, trade secrets are broadly used to overcome inefficiency in market transacting. Besides, private partners develop a variety of profit (risk) sharing arrangements (joint ventures, strategic alliances, cross equity financing of innovations etc.) to secure returns on their investments in innovation activities. For example, 'large firm size' is associated with successful research and development programs since only big (monopolistic) companies are able to absorb failure by innovating across a broad technological front and possess the market power to reap the rewards of innovations (Schumpeter). The recent boom in direct investments, mergers and takeovers of agrarian innovation firms

are all forms of internalizing transactions and overcoming market risk. When uncertainty and therefore the possibility of moral hazard in technology transfer is high (as in developing countries) then a lump-sum rather than output-based royalty payment transacting is the preferred mode (Larson and Anderson).

Next, when a party makes highly transaction-specific investments, he can either lose their value (if the transaction does not occur or is prematurely terminated) or he may face unfavorable trading conditions when the transacting renewal time comes. When investments are 'locked' in a particular transaction, they are usually protected by some form of a long term contract or ownership. For example, investments in the human capital of scientists are highly specific to a particular area of research or even a project. The productivity related to a person's (firm's) capital is much smaller in alternative use and cannot be transferred to other uses without a substantial loss in value. Researchers would not invest capital highly specific to the transaction unless the investment were governed by a stable organization such as a permanent employment contract. In addition, specific forms develop for the securing of long term commitments by both transacting parties (e.g. sharing of training costs between employee and employer) and for stimulating individual investments in the specific capital (Government regulation of researchers' salaries, domination of tenure contracts etc.).

Likewise, when a private company finances public research or acquires know-how from a private laboratory, it secures pay-back for its specific investments through a license contract for exclusive commercial use. When assets have high **bilateral dependency**, tight vertical integration of transaction is the common mode. For example, if innovation investments are in highly symmetrical interdependency with the manufacturing, marketing, etc. assets of a company, then they are always integrated in a common structure. Study also shows that full

ownership integration through in-house research (in-sourcing) is the dominant mode for major (core) projects of private firms, and out-sourcing is used for complementary projects and gaining superior knowledge (Ulset). This is why equity rather than debt (e.g. bank loan) financing is the most likely form for funding risky investments in specific intangible assets (patents, trade secrets, know-how, organizational culture, etc.).

Fourthly, because of the asymmetry of information and high uncertainty, a party may be exposed to opportunistic behavior before or during the execution of transactions (e.g. difficulties in verifying the quality of a new agro chemical, the expertise of a researcher competing for a project grant or for a position, etc.). In order to overcome transacting difficulties, partners would prefer to rely on a method more effective than the (spot) market form of organization of transacting such as brand names, demonstrations, guarantees, consideration of reputations, peer review or apprenticeship.

The interlinked mode of transacting with industry is a common mode for the introduction of new technologies in farming and a 'free' extension service is supplied in a package with input supply transactions. When there are mutual assets (capacity, technology, quality, timing etc.), dependency on a long term contract is the preferred form of governing transactions. Such strong bilateral coordination between farmers and processors exist in the beef, pig, and poultry industries and is supported by tightly interlinked marketing, inputs, innovation, extension supply contracts total production management or even complete vertical integration by a processor (Sporleder 1992). In addition, more 'market-like' mechanisms are being extensively introduced in public institutions (direct financing from industry, fees for services, competitive funding, etc.) to interlink incentives (transactions) to the real demand of the final customers for agrarian innovations. Moreover, a recent tendency towards a greater share of private financing in public research and extension

is a way of filling the possible gap between central (competitive, overhead, etc.) funding and the real demands for the activities of the public innovation sector.

Fifthly, participants in the innovation process very frequently risk missing markets for some products and services—e.g. highly specialized scientific equipment, qualified researcher in a particular area, know-how etc. That is why they have to develop these activities using internal or joint (non-profit) organization. For instance, in-service training is usually a part of the innovation project, the design of scientific equipment is a sub-project or involves a substantial contribution from researchers who will eventually use it. Various consortiums and joint ventures are also organized on a large multinational scale for the mutual exchange of know-how, biological materials etc.

Sixthly, innovation transactions that would otherwise be beneficial for all parties fail to occur at optimal scale without protection of agrarian intellectual property rights, if their enforcement is very expensive⁵ or if monopoly rights on some innovations lead to market distortions. In this case, participants in agrarian innovations (farmers, researchers, etc.) must develop an **organization for demand of public goods** (with their specific set of property rights) for third parties (local authority, central Government, foreign assistance programs, etc.) involvement in innovation transactions. The outcome could be some kind of regulation of transactions (price ceilings, mandatory testing for safety standards, etc.), the introduction of new monopoly rights on intellectual agrarian products in order to increase incentive for ownership organization of transacting, the enforcement of special modes of organization of private transacting (e.g. mandatory licensing), the introduction of preferences (subsidies, tax breaks, international transfer liberalization) for private investment in innovation, the assisting

⁵ For instance, the case with a new self-pollinated variety.

Seventh, technological non-separability of activities is not an important factor that could determine the minimal size of innovation organization. With very few exceptions in modern microbiology, it is almost impossible to give examples of research and innovation in which the form of organization is unilaterally determined by technology. There are usually plenty of alternative modes for the organization of agrarian transactions using the same research (innovation) technology and methodology. For example, the development of a new variety could be organized by a state research institute, an independent university department, stand-alone or in-house private laboratories, by contract with a research team, by collective (farmers') organization, in hybrid mode, be imported (transferred) from abroad through license agreement or be obtained from an international research center.

Thus, in most cases the individual agent (basic unit of transacting) also determines the minimal possible size of innovation organization⁶. Beyond this question of size, various private, public, and mixed (hybrid) organizations in transacting develop to achieve economies of scale and scope in the innovation process. For instance, the size of the internal organization of a transaction in specialized or related activities will increase to the extent that there is potential for technological economy of size (scale) (overheads, building, library etc.). Potential for managerial economy is also substantial in innovations. Instead of transacting with each individual (high asymmetry of information), the funding agency signs a contract with a leading scientist or delegates the executive rights to an

⁶ In fact, 'one man' laboratories were the major mode for organization of agricultural research until the founding of the first experimental station in the nineteenth century. However, in the modern research alike, individual human capital is usually the factor which determines the minimal size of research organization (project, laboratory, firm, etc.). It is almost a rule that all major breakthroughs in research are associated with the names of *individuals* rather than institutions. The opposite case is that of modern technological innovations which greatly depend of the specific intangible capital of a particular *organization*.

of 'quasi' public organization of innovation (e.g. mandatory levies for the collective supply of research and development), the public financing of innovation activities, in-house organization and direct public provision of agrarian research and extension services.

It is always necessary to assess various alternative modes for third party involvement in particular innovations in the minimizing of comparative transaction costs. For example, when the costs of the introduction and enforcement of agrarian intellectual property rights are enormous for all parties, other options for intervention must be considered. Experience shows that while the change of property rights concerning biological innovation has significant impact on private research and development in the USA and Western Europe, there is no or only weak evidence for such an impact in many Latin American countries (Perrin).

Likewise, if the transaction cost of the organizing of the competitive funding of public institutions is high (for writing and evaluating proposals, for rent seeking and lobbying, for avoiding 'friendships', for finding buyers for research products, lost opportunity as a result of unproductive use of researchers' time, etc.) then core funding is to be undertaken. Moreover, if the intensity of transacting is not high (e.g. small country size) and foreigners are not allowed to compete, this mode would involve only additional costs and no benefits. Specialized research markets only exist in large countries and usually in small numbers (quasi-monopoly). Bidding participants with highly specialized capital (human capital, infrastructure etc.) for a particular project will always win. Even if there is initially a large number of competitors, few will be left when project extension time comes. This is an example of how the 'fundamental process transformation' described by Williamson occurs in the sphere of research and innovation.

administrator. In this way, all sides save large costs for finding the best partners, for negotiating conditions of exchange, for writing and discussing contracts, for current adjustment during the contract execution stage, etc. This is how program (project) organization develops in the innovation sphere. It combines top-down management (long term coordination) and decentralized bottom-up management ('self-organization' of research). Besides, research (innovation) management separates from development in conditions of funding crisis and is a specialized activity of proposal writing, lobbying for winning contracts and subcontracting of the real execution of the project, etc.

Modern research projects very often need to have minimum size and team efforts to be successful at all. This is because of the strong interdependence of the researchers in the various fields, disciplines, specialized activities, etc. It is also a result of the high 'dependency' of researchers' human capital on the unique scientific equipment that can only be found at the leading research centers. Moreover, the ideal (non rival) character of scientific knowledge enables saving at a national and more commonly at an international scale. Innovation also becomes increasingly expensive and requires reducing unnecessary duplication (competition) of activities. Strong cooperation to enhance productivity and risk sharing is the norm rather than the exception in the innovation process. Many private companies use university or public research facilities through joint venture operations and collaboration agreements. They thus use outside capacity without performing transactions by means of expensive internal modes (e.g. employment contracts). In addition, various hybrid modes such as strategic alliances develop to increase management control of the innovation process without losing the incentives for innovation observed in the hierarchical modes. Private alliances have great advantages in conditions of high uncertainty since they allow flexibility in exploring the (outside) economy of scale without involving large specific investments (low exit cost). Various hybrid public-

private modes are developed extensively both to govern direct collaboration between public and private laboratories⁷ and to create an effective 'public infrastructure'⁸ for the development of private research and innovations.

New modes of organization are also being widely introduced in the public sector. Since pre-patent competition is a large public waste, a new trilateral form for organization of transactions has been invented recently. Public subsidies are awarded to productive researchers and they are allowed to patent publicly funded inventions. This means that competition (and unnecessary duplication) is restricted only to the proposal drafting stage since the winning (subsidized) researchers subsequently have comparative advantages in obtaining positive results. This hybrid mode preserves powerful ('market-like') incentives in competing for public grants and for obtaining private property rights on output. This is an example of an 'intelligent' mode of transacting which combines strong public involvement (priority setting, providing infrastructure, finance etc.) with the incentive advantages of private organization.

With a very high frequency of transactions in horizontal or vertical directions, internal organization saves repeated costs of market transacting. For instance, instead of renting a land plot for research experiments year after year, a research institute can use a long lease or ownership mode. For the same reason, different functional, problem or location-specific, commodity or customer oriented organizations for innovation develop. The internalization of transacting is enhanced when the specificity of investments increases. Here, the continuation of relationships with a particular partner/particular partners is of high value. In addition, efforts (long term costs) to design a special mode are

7 For instance joint ventures, research consortiums and alliances, joint patenting etc.

8 Such public collaboration is crucial for the development of modern private research and innovations. It takes many forms, such as public support of basic and pre-technological research, the creation of material and financial environments, the development of research and innovation parks, the training of personnel, etc.

justified since they can be recovered for repeated transacting (current cost saving). For instance, a modern supply of extension services becomes highly location- and farm-specific. This is why extension supply transactions are broadly internalized by a joint ownership mode (e.g. a farm cooperative) as a way of exploring the economy of scale in a manner highly specific to the members' capital.

When the frequency of internal transacting is not very high and assets are not held in bilateral dependency, then internal organization incurs only additional management costs without any extra benefits. This is why the innovation activities in agriculture are distributed between a number of specialized organizations rather than all transacting being carried out by a nation-wide company.

Technology and its development are very important for determining the effective size of an innovation organization. This is particularly important in the minimizing of transaction costs. The development of information and communication technologies is also revolutionizing transaction organization. For example, use of the Internet makes the costs to an individual close to zero for a large part of innovation transacting. It intensifies research and development through cheap direct transactions between individuals and on-line arrangements for informal modes on a large (practically world-wide) scale. It also decreases the time and cost of finding the best partners for cooperation and trade, for access to innovation databases, for seeking the best prices of agrarian innovations, for invention promotion, for public disclosure of cheating etc. All these developments have begun to replace the traditional (old) model of innovation organization and to lead to effective smaller size operations in both the public and the private sectors.

Effective modes of organization of transactions in agrarian innovations

A simplified governance matrix for the organization of various transactions in agrarian innovations is summarized in Table 1. The complicated spectrum of transactions in which the innovation agent participates is divided into five main groups: knowledge supply, labor supply, capital supply, input supply, and marketing transactions. We show only two levels (the extremes) of the critical dimensions of transacting—high and low. In real life, there are various grades (a continuum) of appropriability, asset specificity, uncertainty and frequency in transactions in agrarian innovations. In fact, the different agents have different perceptions of the factors of transaction costs as well as quite different personal preferences for their market, private, hybrid and public modes of transacting. For this reason, the matrix proposed is only a general framework for economic analysis and for organizational design. A deeper approach is required for observation of the microeconomic factors surrounding each particular transaction.

The most effective governing modes differ according to the type of transacting and depend on a combination of appropriability⁹, asset specificity, uncertainty and frequency of transactions. When appropriability is high and there is no asset dependency, and when uncertainty is low and frequency high, the market is the best mode for the organization of innovation transacting. When appropriability is high but assets are increasingly specific and transacting is characterized by high uncertainty and frequency, then private organization based on ownership or tight integration is the most effective method. However, when appropriability decreases and asset specificity and uncertainty is high, market and private transactions fail to

⁹ As the opposite of exclusion costs.

occur on an effective scale. A strong necessity for a different set of property rights (meaning third-party/government involvement) is then on the agenda. The development of an agrarian innovation system would be substantially deformed if effective modes for public involvement (assistance, regulation, public provision, etc.) were not introduced at the right time. In the uneasy designing process of the forms of Government intervention, the critical dimensions of transactions and the cost/benefit advantages of the different modes for improving incentives and overcoming the possibilities for opportunism in the innovation process should be borne in mind once again.

Conclusions

The incorporation of transaction cost minimizing in agrarian innovations is far from complete. Firstly, further identification of the transaction costs in research and innovation is required. Secondly, the available arsenal of alternative modes for governing innovation transacting should be specified and their comparative potential for economizing the costs of transacting should be determined. Thirdly, 'theoretical analysis' should be extended to 'practical' case studies of the critical dimensions of transaction costs, the institutional framework, and forms of governance in various agrarian innovations. Fourthly, traditional statistical and accounting data, etc. would be less valuable for our analysis, and microdata collecting, storing and exchange will be necessary. Fifthly, the relationships between transaction costs and production costs and the economics of research and innovation activities are to be clarified. Moreover, it is often impossible in practice to separate the 'transaction' and 'production' costs of innovation.

Finally, transaction cost minimizing can hardly provide answers to all the problems associated with the organization of agrarian innovations. Research and innovation activities are very complex and their organization depend on many social, psychological, political, cultural and other factors, and among them, the legal-economic nexus pointed out by Samuels. Transaction cost economizing will contribute to our multidisciplinary approach to agrarian innovation phenomena. Several studies of the governing of agrarian innovations in this respect have already been published (Argyres N. and J.Liebeskind, Byé P. et al.).

Table 1 Alternative Modes for Organization of Agrarian Innovation Transactions

Critical dimensions of transaction														Appropriability		Low		High		Asset Specificity		High		Low		Uncertainty		High		Low		Frequency		High		Low	
Type		of		transaction		High		Low		High		Low		High		Low		High		Low		High		Low		High		Low		High		Low					
Knowledge supply	PS	PS	CC	CC	RC	RC	NPO	NPO	O	SA	VI	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA					
Labor supply	PC	C	PC	C	TBC	C	OBC	C	PC	SA	PC	SA	PC	P	TBC	M	OB	M	PC	C	PC	C	TBC	C	OBC	C	PC	SA	PC	P	TBC	M					
Capital supply	CF	CF	PF	CF	PF	PF	FS	FS	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O	JV	O				
Input supply	C	RC	C	CC	RC	RC	CC	CC	O	C	VI	CC	CC	RC	BN	M	M	C	RC	CC	CC	CC	RC	BN	M	M	C	RC	CC	CC	RC	BN	M				
Marketing	PP	PP	PP	CC	CC	CC	RC	RC	O	TPA	I	SA	SA	RC	TPA	CC	CC	M	PP	PP	PP	CC	CC	CC	RC	RC	RC	RC	RC	RC	RC	RC	RC				

Modes of transacting: M - market, CC - classical contract, RC - rational contract, I - interlinked contract, O - ownership, JO - joint ownership, P - partnership, C - cooperative (corporation), VI - vertical integration, SA - strategic alliance, PC - permanent employment contract, TBC - time based employment contract, OBC - output based employment contract, BN - brand name, TPA - third part arbitration, PS - public supply, PP - public provision, PF - public financing, CF - collective financing, FS - fee for service financing, NPO - non profit organization

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