The Choice of Technology in Russian Agriculture: An Application of the Induced Innovation Hypothesis

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THE CHOICE OF TECHNOLOGY IN RUSSIAN AGRICULTURE: AN APPLICATION OF THE INDUCED INNOVATION HYPOTHESIS

Abstract

Even after more then ten years after the beginning of the transition process, Russian agriculture shows only limited sign of a recovery. Production has not reached the level of the pre-transition period and investment is still on a very low level. In this paper we use the "Theory of Induced Innovation" in order to access the development of production structures in Russia and to identify the major obstacles for restructuring. We argue that due to multiple market failure (capital, labour) and inappropriate institutional arrangements inherited from Soviet times hinder the development of Russian agriculture. Both reasons causes that agricultural enterprises have difficulties with regard to an adjustment of factor input and production corresponding to the real scarcities of production factors. Agricultural policies based on subsidizing factor use or minimum prices will be an inefficient approach to solve the problems. A promising approach instead would be encouraging market transactions and fostering the integration of agricultural enterprises in the regional and domestic factor and product markets.

Keywords: *Technical Change, Efficiency, Russia, Agriculture, Induced Innovation Theory*
JEL: Q11, Q16

1. Introduction

More than ten years after the beginning of transition there are still limited signs of a recovery of Russian agriculture. Moreover, the sector did not participate in the general upswing of the Russian economy during the last years (*Voigt,* 2005). Several economic and institutional factors responsible for this stagnation have been identified. Already during Soviet times agriculture was the Achilles heel of the economy. Compared to the non-agricultural part of the economy the creation of competitive farm enterprises progressed only slowly during the 1990s. No sector of the economy showed such a stiff resistance against reforms. As a consequence, low profitability and productivity of the agricultural sector result in an inferior position in the hard competition with other branches of the economy for capital and labour forces (*Svetlov,* 2003), managerial and technological skills are still lacking in agriculture (*Serova,* 2000). Additionally, the decline of rural areas accompanied by severe social problems and a massive rural migration deteriorate the local social and economic environment of agricultural enterprises (*Uzun et al.*, 1999). An unstable and unpredictable political and legal environment within regions and concerning the relations of regions to the federal government aggravate the existing problems further and obstruct any solution (*Serova,* 2000). Especially agriculture is subjected to far reaching non-coordinated interventions of regional and local authorities (*Kopsidis,* 2000). Beside these fundamental defaults many problems which could be redressed in the short run obstruct the recovery of Russian agriculture as well. Among them a lack of short term capital (*Svetlov,* 2003; *Epstein, Tillack,* 1999), machinery (*Zinchenko,* 2001), labour, livestock and other important inputs have to be mentioned. Mainly particular frictions in input flows heavily disturb the necessary constant supply of resources to maintain production within farm enterprises. Poorly developed specific market institutions even 15 years after transition has started, a lack of infrastructure or just a shortage of particular resources available to other sectors are responsible for this precarious problem.

Our paper extends former analyses by taking a more explicit look at the mutual interdependence between institutional environment and production techniques. Not only a lack of capital goods but also the choice of unsuited technology not adjusted to the given factor price relations can cause growth reducing inefficiencies reinforcing stagnation in agriculture. Most of the recent literature concerning Russia implicitly assumes that high technology is always most efficient and necessary for inducing growth in Russian agriculture. This widespread view ignores completely the experiences of developing countries and the vast empirical and theoretical literature dealing with questions of appropriate technology to induce growth focusing on relative factor supplies and prices. After 40 years of experi-

ences and research it is quite clear that the use of capital intensive, labour saving high technology in an underdeveloped agriculture operating under the conditions of excessive capital cost and low wages like in Russia results in severe sectoral and macroeconomic efficiency losses and stagnated growth. A malfunctioning institutional framework and poor infrastructure leading to non functioning factor and capital markets further aggravates economic stagnation (*Meier*, 1995).

Hayami and Ruttan showed in their *Theory of Induced Innovation* that depending on factor and product price relations diverse kinds of technical change, technologies, and institutions are necessary to realize agricultural growth in a most efficient way. There is no technology that fits for every economy as early development economics had assumed taking the USA and Europe as models for all developing economies completely ignoring the very different factor price relations (*Hayami, Ruttan, 1985*). The breakdown of the kolkhoz-system with its heavily mechanized extremely subsidized technology during the early 1990s urgently puts the question on the agenda whether under the condition of high capital costs and low wages a capital intensive labour saving agricultural technology is really appropriate to promote the recovery of Russian agriculture as many Russian and Western experts believe.

An application of Hayami and Ruttan's theory will deepen our understanding of the severe transition crisis significantly and help to explain the slow recovery of Russian agriculture. Within this context, we will

- identify the mechanisms how institutional frictions in Russia influence the choice of technology and the adoption of technological changes,
- assess the adverse consequences for efficiency in agricultural production and
- derive policy recommendations helping to bring technical change into a closer relation to relative factor supplies and prices.

The paper is organized as follows: The next section provides information about the development of agricultural production and factor use within Russia. Since according to the theory of induced innovation relative factor prices are essential for the choice of techniques special emphasize is provided to factor proportions. In Chapter 3 the theoretical approach will be presented. Chapter 4 discusses the development in Russian agriculture in the light of the theoretical consideration. Inefficiencies resulting from the choice of inappropriate techniques and the reasons for this suboptimal behaviour are analyzed. However, since an assessment of the production structure is only possible when reference systems are available, the factor intensities will be compared to those in Europe and the US. The last chapter discusses policy options aiming at agricultural and rural development.

2. Production and factor use in Russian Agriculture

2.1. Agricultural production

Figure 1 provides information about the changes of agricultural output. Crop as well as animal production dropped significantly as a consequence of the macro-economic instabilities resulting from the Russian crisis in 1998. Moreover, there is only a slow recovery in recent years. However, this development is surprising, because the crisis was accompanied by a drastic devaluation of the Russian Rouble. It could have been expected that the increase in import prices and the higher competitiveness of Russian exports would have induced higher production incentives. However, the fact that these price incentives on the macro-level were not transferred to agriculture indicates that other factors exist which hampered the recovery in this sector.

The changes of agricultural production by farm type is given in Figure 2. Corporate farms are the successors of the former kolkhoz. This group is characterized by large scale enterprises cultivating several thousand hectares. Private farms, on the other hand, show an extremely heterogeneous structure stretching from household plot production to family farms like in the West and some few large farms in individual ownership[1].

[1] This heterogeneity makes it nearly impossible to interpret statistical data concerning private farming. It only can taken for sure that the by far biggest share of output, land and labour in private farming refers to household plot production.

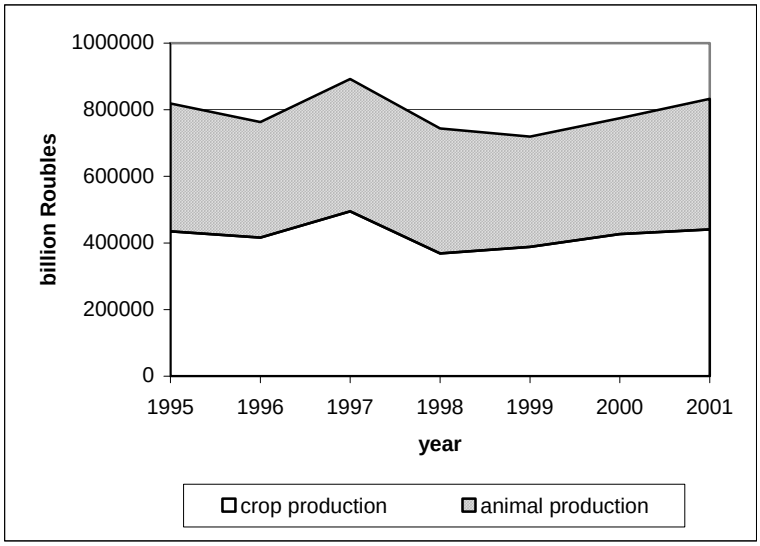

Figure 1: Total agricultural production in prices of 2000.
Source: *Goskomstat, 2002, own calculations.*

Presently the share of corporate farms in crop production is about 40%. In 1998 the share dropped, however, it reached again relatively fast the level of the period before the crises. The pattern for animal production is different. Large-scale animal production was reduced significantly before 1998. Animal production in corporate farms dropped dramatically until 1998, since then the share stabilizes at about 50%.

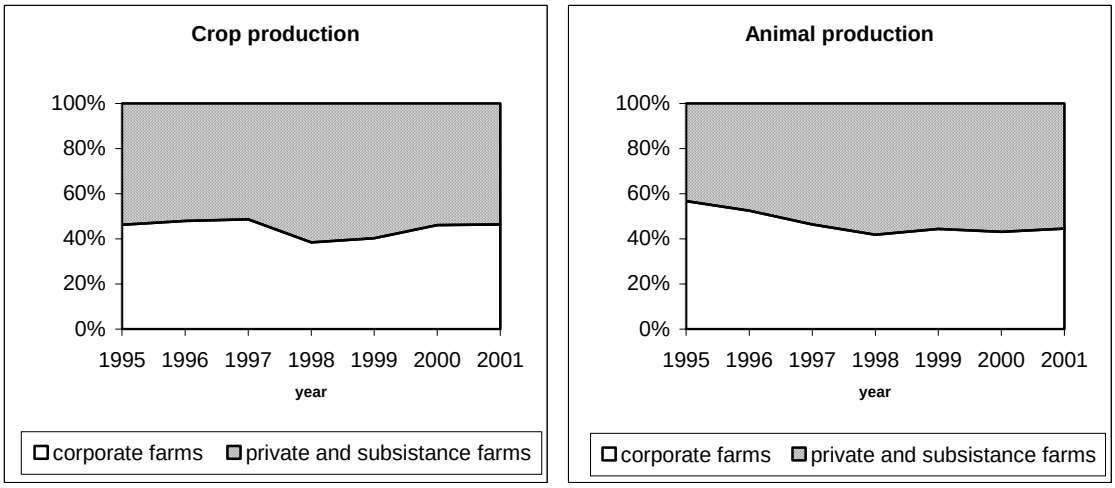

Figure 2: Agricultural production by farm type.
Source: *Goskomstat, 2002, own calculations.*

However, not only because of serious uncertainties in the data concerning private farming it makes sense to concentrate on corporate farms. The extremely big share of household plot production is a result mainly of the impoverishment of many groups of the Russian population in the course of the transition crisis and of lacking wage funds in agricultural enterprises. This kind of subsistence economy did not expand on functioning markets due to its competitiveness compared to other forms of farm enterprises. Russian subsistence agriculture on household plots rather represents a consequence of economic crisis and indicates the lack of a functioning market economy (*Seeth et. al.*, 1998).

The future of Russian agriculture mainly depends on the adjustment of corporate farms whose size may allow the realization of economies of scale. If the creation of competitive corporate farms could be carried out successfully Russian agriculture will become a global player on the world market.

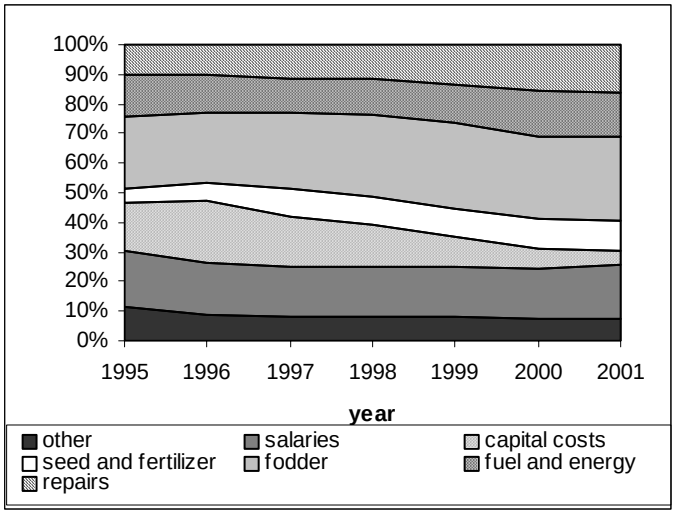

Figure 3: Factor shares in agriculture (corporate farms only)
Source: Goskomstat, 2002, own calculations.

2.1. Factor use

Figure 3 represents changes in the cost of agricultural production. The data cover the development in large-scale enterprises, only. Remuneration of labour showed with about 20% a relatively constant share in factor costs. The main changes between 1995 and 2001 concern capital costs and material inputs. From 1995 to 2001 the cost of capital decreased significantly. In 2001 this segment accounts for less than 5% of total costs. On the contrary, material cost (seed and fertilizer, fuel and energy, fodder) increased relatively strong from about 55% to more than 70%. Within this group especially purchased material inputs increased their share. The stake of fodder, an input that to a large extent produced by the sector itself, remains constant.

Table 1: Factor input in agriculture

		1995	1996	1997	1998	1999	2000	2001
labour	total (m workers)	9.7	9.3	8.6	8.7	8.5	8.4	7.9
	- corporate farms (%)	69	67	66	61	60	56	53
	- private farming (%)	31	33	34	39	40	44	47
land	total (m hectare)	209.6	208.4	206.2	195.2	197.6	197	195.9
	- corporate farms (%)	82	81	80	84	82	80	79
	- private farming (%)	18	19	20	16	18	20	21
capital	# of tractors (1000)	1052.1	966.1	911.4	856.7	786.8	746.7	697.7
materials	fertilizer (m tons)	1.5	1.5	1.5	1.3	1.1	1.4	1.3

Source: Goskomstat (2002), own calculations.

Factor shares do not allow identifying the forces driving the adjustment process, i.e. whether the development is caused by changes in prices or quantities. However, some general features can be deduced. Constant production and an increase in the share of purchased material inputs indicate that this rise is caused by price effects. Otherwise one would expect a growth of production. The decline of capital costs points to rather low investment activities in Russian agriculture. This view is confirmed by the increase in repair. With low investment the rate of replacement of machinery and equipment can be only relatively small. Consequently, the vintage of capital inputs increase. Corresponding with a higher operating life of the equipment the requirements regarding maintaining and repairs will increase (Table 1).

3. Induced innovation hypothesis

According to the classification of Pavitt (1984) agriculture belongs to the supply dominated sectors. Technological advances usually are process innovations developed in related industries (input supplier, processors). This feature requires that two aspects have to be taken into account. The first concerns creation of economic signals regarding research incentives and technology adoption (induced technological innovation). The second has to deal with the institutional arrangements allowing an efficient transfer of the signals (induced institutional innovation).

3.1. Induced technological innovation

The theory of induced innovation was introduced in the early 1970s by Hayami and Ruttan[2]. It stresses the significance of demand as the major source of research incentives. Ruttan (2001) admits that not all research should be considered as demand driven. Especially in basic research the supply push component may be considerable. However, the induced innovation hypothesis concerns mainly applied research, and thus, research activities conducted by private companies. Without an at least latent demand for new products, firms could not sell and no incentives for research exists. For example, if imperfect factor- and capital markets cause a decline in effective demand investments in research remain too low.

Ahmad (1966) pioneered the microeconomics of induced innovations. He introduced many of the concepts of an innovation possibility curve (IPC) which is also central in the Hayami - Ruttan framework. At a given time the state of knowledge defines a set of production techniques latently available. However, before a special technique can be applied, it has to be designed, i.e. resources have to be devoted to (applied) research and development (R&D). The IPC represents the envelope of these processes and thus, is a presentation of production techniques which may be generated with R&D. Accordingly, the IPC shows larger possibilities of substitution among inputs than the individual techniques characterized by their isoquants. A change in the state of knowledge is equivalent to a shift in the IPC and the occurrence of new production possibilities. With given factor prices, the increase of knowledge leads to generation of production techniques along a given trajectory (for instance labour intensity). However, a change in factor prices does not only alter factor intensities along the production technique but will also lead to a change of the production process[3].

Another theoretical background is constituted by the work of Herlemann and Stamer (1958) on agricultural development and farm size. Their basic conjecture is that countries specialize on those production techniques that uses abundant factors intensively[4]. The scarcity of factors find their expression in relative prices. Moreover, since economic growth leads to a change in availability of inputs there is an ongoing change in factor price relations. This, in turn, induces adjustments of the production processes applied. By making implicit use of the concepts employed in the induced innovation literature, Herlemann and Stamer were able to identify development trajectories for different initial factor endowments. In particular, they showed the development paths for countries with high and low land endowment.

Equipped with this theoretical background the theory of induced technological innovation can be easily explained (Figure 4)[5]. The axes of Figure 1 depict factor input: A, C, and L represent land, capital (equipment) and labour respectively. The initial production technology is given by isoquant y_0. The

[2] See Hayami and Ruttan (1985)

[3] The microeconmics of the induced innovation hypothesis where also formulated in Binswanger (1978) and Hockmann(1992). Both approaches use deterministic research technologies. Stochastic research results are considered in Hockmann (2001).

[4] Their approach represents an extension of the Heckscher-Ohlin model of international trade. This approach states that countries specialize on the production of those goods which show the most intensive use of the abundant factor.

[5] The figure demonstrates labor-saving technologies. They are typical for countries with high land endowment. However, this kind of innovations can also occur in countries where land is scarce. For instance, economic growth leads to a high increase in the demand for labor accompanied by a strong increase of wages. Given a constant price of capital a substitution of labor by capital will happen. The scarcity of labor, in the interpretation of Herlemann and Stamer, implies the adoption of technologies which uses the relatively abundant factor intensively.

IPC is the envelope of other production technologies which may exist latently. When the relation of land rents and wages is α the optimal production point is P or (L_0, A_0). An increase of wages leads to factor price relation β. With technology y_0 cost minimization will change the optimal input mix to Q. Moving along the IPC curve allows for further reduction of production costs. The optimal production point is given where the rate of substitution of the IPC is equal to the factor shares (S or (L', A')). This point is associated with the choice of another production technique y' which compared to y_0 requires a lower amount of labour but more land input. Using more land per worker requires in general an increase in machinery. Thus, land and capital are characterized by a complementary relationship (line M M').

At this point it has to be emphasized that the shift between the production techniques occurred without a change in the stock of knowledge. Since the availability of the technique is only latently available applied research is needed to realize the potentially available new technology on a given IPC. When the movement on the given IPC allows a larger saving on production cost as resources are devoted to research, the movement is beneficial from a social point of view. However, there exist other options that allow a switch. In an open economy technology may be exchanged either by external trade or by foreign direct investment. However, both require that appropriate technologies are used.

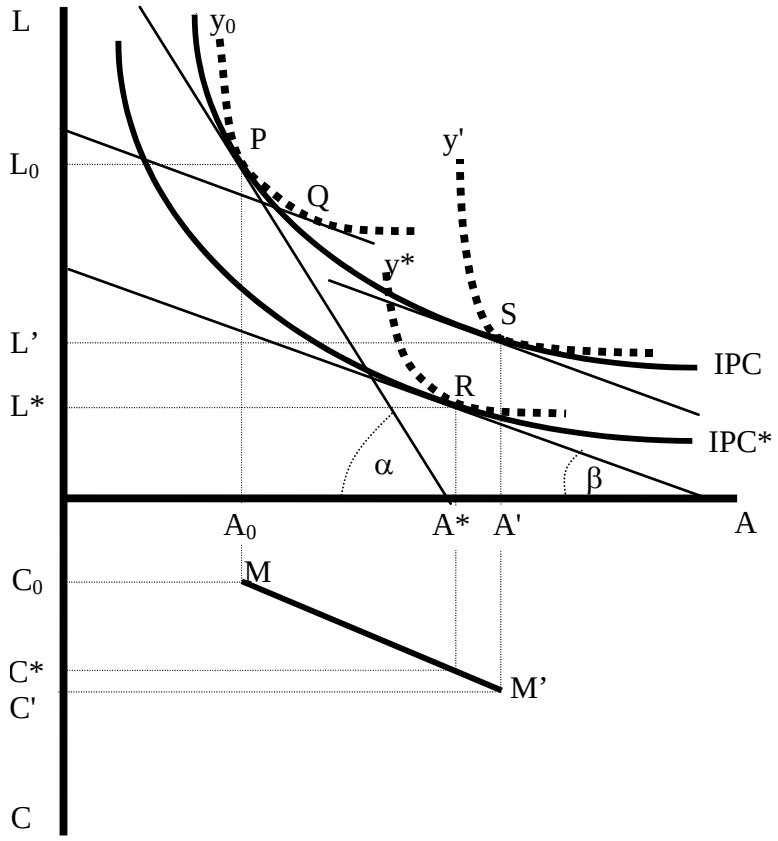

Figure 4: Induced Technological Innovation (labour-saving).
Source: adapted from Hayami, Ruttan (1985)

In a dynamic environment the state of knowledge changes and a new IPC* emerges which now represents the latent available techniques. Given the requirements for production techniques which result from the new factor price relations, it is no longer profitable to conduct applied research along the trajectory implied by y_0. Instead, the optimal choice would be to improve the technologies represented by y'. In the figure it is assumed that applied R&D produces a technique y* with optimal factor combination (A*, L*, C*). However, because this trajectory is adjusted to the change in factor price relation, one can assume that all will benefit from technological advances. In the figure, it is assumed that complementary relationship between land and capital did not change. Thus land and capital benefit from the increased state of knowledge proportionally.

The central element guiding an efficient development are relative prices. Malfunctioning markets as a result of policy interventions or a poorly developed institutional framework and infrastructure often set incentives in a direction that decisions of farmers and related industries will not be guided by the correct signals. Retarded growth accruing from an inefficient factor use are the consequences. Furthermore, from a social point of view malfunctioning factor and credit markets lead to a choice of inefficient techniques between a set of given technologies and technology adoption will not be guided by social factor scarcities. This points to the institutional aspect induced innovations.

3.2. Induced institutional innovation

The "institutional" part of the induced innovation hypothesis relies on the conjecture that technological change induce imbalances in the economic relations between individuals. The discrepancies create a demand for institutional innovation which together with the supply of institutions, i.e., their availability, establishes a new equilibrium.

Demand for institutional change is driven by two factors (Ruttan 1978):

- the change of factor scarcity with economic development
- the changes in income streams and income distribution resulting from technological change.

The result of these factors is the emergence of new property rights structures, more efficient market structures, contractual arrangements or non-market institutions. Their common feature is that these innovations offer the possibility for a more efficient use of resources compared to the pre-innovative period (*Hayami, Ruttan*, 1985). Examples in this direction are agrarian reforms enforcing full property rights on land; non market institutions like public research institutes and contractual arrangements like the foundation of unions as a reaction on exploitation of labour.

The supply of institutional innovations depend on the fact whether it is possible to mobilise corresponding political resources. Mobilisation of political resources incurs costs. Thus, decision makers will be only willing to implement or accept a new regulation when the costs are smaller than expected outcome. Clearly, institutional innovation will be the easier and the faster the lower the resource costs and the higher the benefits for decision makers. Culture including ideology and religious traditions will have a considerable influence on the supply of institutions. These features influence in particular the cost of institutional changes. Other things constant, new regulations will be adopted faster when they are closely related and comparable to the existing institutional and cultural environment of a society (*North, 1992, Feldmann*, 1999). A further impact on innovation supply may result from advances in social sciences. Knowledge about the effects and causes of institutional arrangements can be used to substitute cost intensive "trial and error" processes. Whether the arrangements will increase or decrease welfare depends on the institution itself and on the influence of innovation-supporting interest groups.[6] However, the problem is to identify institutional arrangements providing incentives for agricultural producers which are in accordance with the scarcity of production factors and the social factor price relations (shadow prices). Otherwise efficiency losses and stagnation are the consequences.

[6] Especially rent seeking behavior may result in welfare losses. Providing quotas, licenses or price support usually creates distorted incentives which lead to a suboptimal allocation of resources from an economic point of view.

4. Russian agriculture in the light of the Induced Innovation theory

This section discusses the empirical observations discussed in chapter 2 with regard to the induced innovation hypothesis. We presume a constant return to scale technology, a simplifying assumption that nevertheless appears to be well suited for Russian agriculture. It is claimed that one of the advantages of Russian agriculture are significant economies of scale realized by large agricultural holdings. However, *Voigt* (2005) estimate that economies of scale in Russian agriculture are only slightly above one. The assumption of constant returns to scale allows a normalisation of labour and land use in corporate and private farming by the amount of production and to derive the unit isoquant (in 1000 Roubles in figure 5). In addition, we suppose that during the period of investigation technological change had no significant impact on agricultural production possibilities[7].

According to our results production on Russian private farms is relatively labour intensive. Additionally, private farms use less labour and less land to produce one unit of output than corporate farms. This on the first sight astonishing result suggests that these farms operate more efficient than corporate farms.[8] Moreover, according to this outcome private farms seem to define the IPC for Russian agriculture. Assuming free disposability and convexity, the IPC is simply given by a parallel line to the axis in the figure. The figure also provides that corporate farming is not technically efficient. These farms could reorganise factor input without affecting the amount of production.

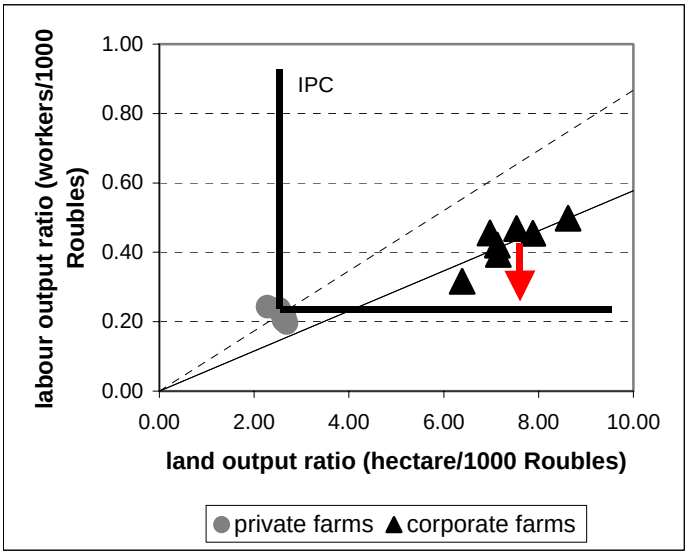

Figure 5: Factor intensities and technology in Russian agriculture
Source: *Goskomstat (2002), own calculations.*

Beside analyzing differences in technical efficiency between private and corporate farming we want to look which kind of production technologies is adjusted more appropriate to the factor scarcities in Russia. Answering this requires to investigate the capital, land and labour market. Land markets in Russia are still underdeveloped. Although, agricultural land is in private ownership the possibilities of land transfer are rather limited. Since purchase of agricultural land is still prohibited by law, the only mode of exchange of land is by leasing arrangements. As experiences in Western Europe show, these arrangements could well lead to a transfer of land to the most efficient producers. Thus, it can be

[7] This assumption corresponds also with empirical observations. See *Voigt* (2005).
[8] However, this statement has to be interpreted rather carefully. It has been mentioned above, that statistical information about private farming is by far not as reliable as for corporate farming. In particular, there exist only limited and questionable data on farm size and labour input. Given these restrictions, the results for private farms allow only a very uncertain approximation to the existing production technology. However, rough estimates are possible. The differences to corporate farms are quite large. This suggests that our general conclusions regarding the differences and the efficiency of production technologies hold.

expected that the situation on the land market will not lead directly to a distortion in factor input. Moreover land cannot be regarded as a scarce factor in Russian agricultural production.

However, the fact that property rights are not strongly defined has a consequence for the capital market. Because of their difficult situation, corporate farms need credits to conduct their investment plans. The infeasibility to contract on all future contingencies creates the possibility to gain from opportunistic behaviour. Thus, an adverse selection problem exists that hampers the development of the capital market. In Western countries, this problem is usually circumvented by using agricultural land as the collateral. However, this mechanism can only be adopted, when property rights on land are well defined. A failure in this respect will lead to credit rationing and a suboptimal capital input from a social point of view. In addition, on the supply side a poorly developed rural credit system restricts the functioning of the capital market (*Csaki et. al.*, pp.79). Thus, an industrialised economy like the Russian is only provided with a malfunctioning capital market more typically for underdeveloped countries. This problem concerns corporate as well as private farms. However, the latter cultivate only small plot on which a substitution of capital by labour is technically relatively easy.

The impact of the malfunctioning capital market on agriculture can be seen in Table 2. The Russian statistics provide no information about the aggregate productive agricultural capital stock. Thus, we approximated capital input by the number of tractors used in agricultural production. Between 1995 and 2001 capital input decreased significantly as indicated by the reduction of the number of tractors by more than 30%. During this period, investment in agriculture remained mainly constant, however, it reached only 3-4% of agricultural output.[9] The constant shrinking of the capital stock in agriculture since 1990 mainly affects the highly mechanized corporate farms.

Table 2: Capital and financial structure of investment capital

		1995	1996	1997	1998	1999	2000	2001
capital	# of tractors (in 1000)	1052.1	966.1	911.4	856.7	786.8	746.7	697.7
investment	in m Rouble, prices of 2000	37285	28719	29658	29460	23304	31442	32300
	share of production (%)	4.6	3.8	3.3	4.0	3.2	4.1	3.9
financial structure	equity capital	56.3	64.6	63.3	71.8	59.8	67.1	77.4
	debt	43.7	35.4	36.7	28.2	40.2	32.9	22.6
	of that government	30.6	22.5	20.9	9.2	6.6	8.5	5.6
	of that federal budget	16.8	10	9	3.4	3	3.9	2
	of that regional budget	13.8	12.5	11.9	5.5	3.2	4.3	3.4

Source: Goskomstat (2002), own calculations.

The table also reveals that equity capital is the main source of investment. Moreover, its share increased between 1995 and 2001 by about 20 percent points to 75%. The decreasing importance of debt in investment financing is mainly the result of a withdrawal of public means. Both, the share of the federal as well as the regional governments decreased from one third to an almost marginal amount. Within the whole period, the financial sources provided by banks and private institutions remain roughly constant. The private non-agricultural sector provided only 15-20% of the investment capital. With regard to our theoretical considerations these figures present a good illustration of the impact of capital market imperfections on agriculture.

Rural labour markets are also poorly developed. Seven decades of socialism in the former Soviet Union have created a complex mix of formal and informal institutions, that certainly had an impact on the subjective models of the economic agents in post-soviet Russia that determine today's institutional choices. Before 1990, labour input was not determined by profit maximization. In addition, farms were also obliged to provide the infrastructure within the rural areas. This, however, concerns not only transport facilities or medical care a. o. m. but also the provision of jobs for the rural population (Koester 2003). The lack of economic pressures to adjust the institutional environment in rural areas

[9] However, even this share is insufficient to keep capital input (in financial terms) constant. For example, German figures could be found in BMVEL (2002). In Western Europe more than 10% of gross output is reinvested into agriculture.

together with the inertia of informal institutions (North 1992) has caused a significant hidden unemployment on corporate farms. Moreover, the institutional settings prevent the release of labour. Often, only the complete failure of such a farm leads to the necessary adjustment processes. Through this, managers are only endowed with limited possibilities to create incentive compatible labour input, and thus, to solve the principle agent problem regarding labour input (Hockmann et al. 2003). Furthermore, because of the fact that a strong labour demand of the non-agricultural sectors does not occur the low real wages in agriculture are not under pressure to increase. Indeed, no intersectional competition pushing up the rural wage level does exist.

To sum up, multiple market failure is responsible for the unsatisfactory performance of most large farm enterprises in Russia. One important reason for the better performance of private farms could perhaps be seen in their capability to adapt easier to the adverse conditions of inefficient factor markets, the lack of functioning distribution channels and malfunctioning capital markets compared to highly mechanized underfinanced corporate farms depending on wage labour and a constant supply of non agricultural inputs. The adverse conditions of an extreme case of multiple market failure characterize Russian agriculture during the whole transition crisis since 1990. However, the overwhelming difficulties of large scale farms to survive under the conditions of non-functioning markets says nothing about their future competitiveness after the transition crisis will be overcome.

Under the conditions of multiple market failures on factor and credit markets which severely obstruct any intersectional flow of inputs and goods essential for any kind of modern farming and having in mind the missing self interest of rural wage labourers the transaction costs of family labour are much lower than for wage estates especially in labour intensive animal production stronger depending on inputs like fodder produced on the farm. All in all, family farms can adjust much better to multiple market failure which often prevails in the agriculture of developing countries. According to all experiences of developing countries showing only poorly functioning factor and capital markets lower transaction costs of family farms generally more than offset advantages of more capital intensive large estates even if the latter are preferred by governmental agricultural policy for example through special credit subsidies (*H.P. Binswanger et. al.,* 1995). Such programs favouring large farms occurred in Russia as well.

Whereas the low rate of investment and insufficient replacement of machinery and equipment in Russian agriculture is discussed extensively in the literature the suitability of Russian machinery imports to the prevailing economic conditions has never been discussed. Implicitly nearly all Western as well as Russian experts seem to assume that expensive high technology presents the optimal solution for building up the capital stock in Russian agriculture. This fixation on high technology was one of the big mistakes of early development policy during the 1950s and 1960s channelling a huge amount of limited resources into the purchase of expensive capital goods for agriculture. Countries which have followed this kind of development strategy paid a high price for their mistake. General economic growth slowed down, relatively abundant factors in agriculture –mainly labour- stayed unemployed and rural migration soared. To sum it up, stagnation and fast spreading rural poverty were the consequences of a capital intense developing path completely ignoring the relative factor scarcities and prices of poor countries (*Saith*, 1990). Having these experiences in mind it makes sense for Russia to ask whether the increasing import of modern Western agricultural technology really contributes to a solution of the lasting stagnation of Russian agriculture and what the reasons are that an agricultural technology better adjusted to Russian conditions, which is indeed produced within the country by domestic or foreign suppliers, does not penetrate the Russian market.

The theory of induced innovation, often proved by extensive empirical research, can contribute a lot to answer these vital questions for Russian agriculture. Figure 6 shows the differences of land and labour productivity as well as land-man ratios for Russia, Germany and the USA. The latter two countries show higher labour as well as land productivities. Furthermore, Germany and the USA are highly developed countries with intense exchange of goods and technology. This suggests that agriculture in both countries operates on the same IPC. However, since population density in Germany is relatively high, it is a typical example of a country applying land saving technologies. The USA which, on the other hand, has only a low population density uses technologies that are more labour saving.

The fact that corporate farms as well as private farms in Russia do not reach the productivity levels of the other two countries points out that Russian agriculture is operating on a different IPC. Taking the land labour relationship as an indicator of the kind of machinery to be applied the data suggest

that Russian agriculture should orientate on the German specialisation in technologies.[10] However, pursuing this strategy is questionable, since the stage of development and thus the relative factor scarcities of the German and the Russian economy are very different. Because of the high cost of labour, agricultural technology in Germany has both, land saving and labour saving characteristics. In comparison, the cost of labour in Russia is very low. This calls for a relative labour intense technology. Moreover, the input structure in Russian agriculture is biased by the malfunctioning of the capital market and the burden of social functions that have to be financed by agricultural enterprises. Both effects induce a technology with relative high labour input to absorb excess labour. Thus, it has to be concluded, that neither modern German nor the US technology is appropriate for Russian agriculture. Rather, Russian enterprises should look for technologies that were applied in both countries before the rapid economic growth of the post war period pushed up agricultural rural wages to unprecedented levels[11].

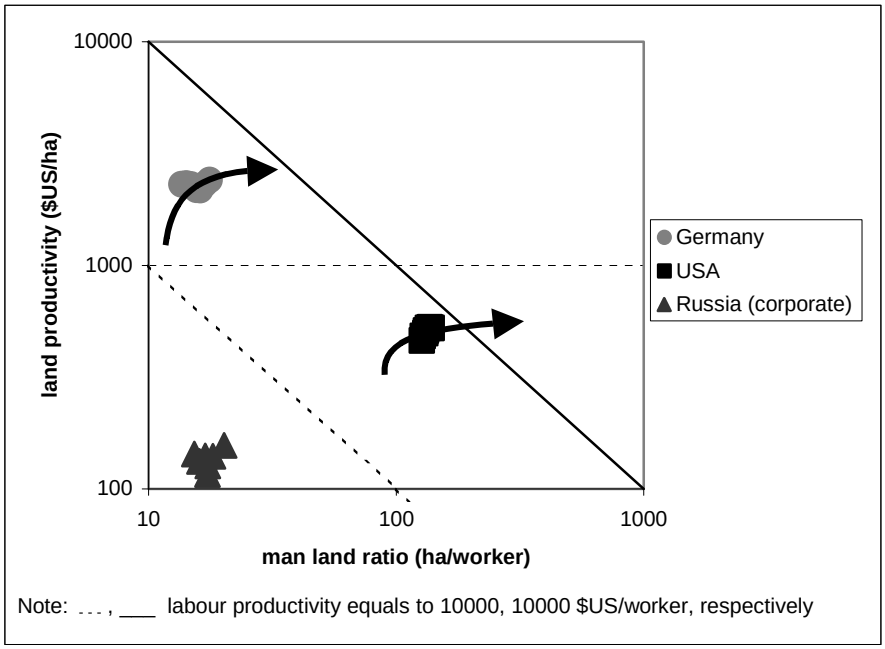

Figure 6: Partial productivities in Russian agriculture and selected Western countries 1995-2001.
Source: Goskomstat (2002), Eurostat(1996ff.) and USDA (1996ff, own calculation.

Having the special Russian situation in mind characterised by stiff agricultural labour markets and restricted capital markets a growing import of expensive, capital intense, labour saving Western technology will not contribute to improve poor efficiency of corporate farms. Moreover, the excess of labour would further increase. In addition, the historical experience of highly developed Western countries (USA, Europe, Japan) clearly shows, that from an macro and micro economic point of view the diffusion of labour saving, highly capital intensive agricultural technology only has paid from a very late moment on: in Europe after 1950 and in Japan after 1970 in the course of the long post war boom. Only in a situation of a long lasting speeding up of real wages accompanied by strongly diminishing capital costs high technology makes a sense to maintain a profitable agriculture (*Y. Hayami / T. Kawagoe*, 1989).

10 Actually there exists some technology import from Germany and other European countries. This concerns equipment for plant (harvesters, tractors,…) as well as for animal (milk machines, …) production. The technologies became mainly available by international co-operations of domestic and foreign agribusiness enterprises or by provision of financial means by domestic non-agricultural enterprises. In the latter case the companies take over control of the farms. See *Hockmann et. al.* (2003).

11 The significance of this problem becomes evident when recognizing the changes which are connected with modern technologies, if applied to Russian agriculture. Often, the most labour saving devices are dismantled in order to employ the existing labour force on the farm.

The Russian situation differs fundamentally from the post war boom 1950-1973 of the Western world. Moreover, the Russian economy suffered a deep transition crisis after 1990 and even if some signs of recovery occurred during the last years Russia's economy presently does not experience a starting boom phase. Factor price relations in Russian agriculture have changed fundamentally after 1990. Capital costs soared whereas labour costs stayed constant or decreased. All in all relative factor prices have changed in favour of labour – quite the opposite of what has happened in post war Europe. Thus nothing speaks in favour of expensive Western machinery imports to enhance efficiency of Russian large farms. What indeed urgently is needed, is a technology considering the relative factor scarcities in Russia's agriculture. This would also help to reduce the labour excess on Russian farms and simultaneously foster efficiency and profitability.

This kind of technology already is available within Russia either produced by domestic or foreign enterprises manufacturing in Russia. If capital market failure could be redressed and the emergence of integrated domestic factor markets would be supported a much better adjusted farm technology could be distributed all over Russia enhancing the productivity and profitability of Russian agriculture. One additional important reason that many corporate farms obviously ignore the changed factor price relations and thus aggravate the consequences of further capital shortage could be that there exists a strong path dependency for capital intensive technology among the decision makers of Russian agriculture as a Soviet heritage. In fact, many corporate farms benefit from governmental credit subsidies but mainly two reasons restrict the effectiveness of credit subsidies to replenish the agricultural capital stock. First, inappropriate technology has been purchased and, second, malfunctioning domestic factor markets impede the sufficient supply of better suited Russian technology.

5. Policy recommendations and further research

The restructuring of Russian agriculture still needs a lot of time and much more resources have to be devoted to it. Due to the fact that Russian technology which is better adjusted to the existing relative factor costs is still available present agricultural policy should focus on impediments disturbing the distribution of existing appropriate Russian technology within the own domestic market. The formation of highly integrated domestic markets for agricultural inputs has to be enforced by the federal government against all odds created by regional authorities. Only, if domestic distribution channels are reliable, Russian farmers are not compelled to rely on imports. Well functioning capital markets would be a great support to accelerate the necessary integration process within Russia. Three areas offer a promising potential for successful policy measures:

- Better access to the capital market through the creation of publicly founded agricultural banks to supply promising corporate farms with the necessary finance.
- To remove all restrictions on domestic factor markets created by regional authorities.
- To support public research in developing new agricultural technology well adjusted to the needs of medium and larger Russian farms.

However, to develop a successful strategy for replenishing the capital stock in agriculture it is absolutely necessary to take into consideration that the Russian Federation contains very different developed regions (*Voigt 2005*). Thus, a regionally differentiated strategy of technological and institutional change is demanded. Further research on these points is urgently demanded. A second important feature of Russian rural regions represents the massive rural migration in many Russian regions. Thus, the reasons for this significant rural exodus which are very different to developing countries and its impact on Russian agricultural labour markets also has to be considered to adjust the analysis better to Russian conditions. Further research in this direction is urgently needed as well.

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