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RISK IN AGRICULTURE AS IMPEDIMENT TO RURAL LENDING – THE CASE OF NORTH-WESTERN KAZAKHSTAN

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ABSTRACT

On the basis of portfolio selection theory, this paper finds that whole-farm risk must be regarded as a major reason for the low level of credit flow to agriculture in North-western Kazakhstan. A quadratic programming model was used in order (a) to demonstrate the comparatively high overall risk exposition of a typical farm, (b) to show that an inflow of working capital could contribute to risk reduction, and (c) to illustrate short-term risk management strategies. Although there may be a role for the government in reducing risk exposition of agriculture in its current form, natural and economic constraints suggest to pave the way for structural reforms that reduce the importance of agriculture in the rural economy.

JEL: Q 14, G 11, C 61.
Keywords: Agricultural credit; Kazakhstan; Portfolio selection theory; Risk programming.

ZUSAMMENFASSUNG

Auf Grundlage der Portfolio selection-Theorie kommt dieser Beitrag zu dem Ergebnis, dass das einzelbetriebliche Risiko in der Landwirtschaft Nordwest-Kasachstans als ein Hauptgrund für geringen Kreditzufluss angesehen werden muss. Ein quadratisches Programmierungsmodell wurde verwendet, um (a) die vergleichbar hohe Riskoexposition eines typischen Betriebes zu verdeutlichen, (b) zu zeigen, daß ein Zufluss von Umlaufkapital zur Risikoreduktion beitragen kann und (c) kurzfristige Risikomanagement-Strategien zu illustrieren. Obwohl es bestimmte Politikoptionen zur Verminderung des Risikos in der Landwirtschaft in ihrer gegenwärtigen Form gibt, legen natürliche und ökonomische Rahmenbedingungen tiefgreifendere Strukturreformen nahe. Diese sollten dazu beitragen, mittelfristig die Bedeutung der Landwirtschaft im ländlichen Raum zu verringern.

JEL: Q 14, G 11, C 61.
Schlüsselwörter: Agrarkredit, Kasachstan, Portfolio selection-Theorie, Risiko-Programmierung.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ABG	Agrarwirtschaftliche Beratung Göttingen GmbH
BML	Bundesministerium für Ernährung, Landwirtschaft und Forsten
CAD	Canadian Dollar
CV	Coefficient of Variation
DM	Deutsche Mark
FSU	Former Soviet Union
GAMS	General Algebraic Modelling System
ha	hectare
MAD	Mean Absolute Deviation
MINOS	Modular In-core Non-linear Optimisation System
mln	million (= 1,000,000)
MOTAD	Minimisation of Total Absolute Deviation
SEU	Subjective Expected Utility
tenge	Kazakh currency unit
USD	US Dollar

1 INTRODUCTION[1]

There is a body of anecdotal evidence indicating that farm enterprises in the Former Soviet Union (FSU) generally have little access to external finance. Furthermore, it is widely believed that this lack of credit severely hampers the restructuring and modernisation of farms, and therefore prevents the safeguarding of agricultural incomes and delays the adaptation of farm structures to a liberalised market environment. Both statements form the basis upon which most recent literature on the topic draws. The observation that agricultural producers cannot attract external funds in order to improve their economic stance has recently been explained by low profitability of farms (PEDERSON *et al*., 1998; PETRICK, 1999b), insufficient institutional solutions to problems of asymmetric information and transaction costs (SWINNEN and GOW, 1999), or lack of managerial capacity and willingness of banks to become engaged in agriculture (HEIDHUES and SCHRIEDER, 1998).

This paper seeks to establish an additional reason for little credit funding of farm enterprises in transition, which seems to be often overlooked by analysts and advisors. It is argued that both agricultural policy during Soviet times with its one-sided, output oriented emphasis on extending crop areas even in regions less favourable for crop production, and market frictions due to a hesitant transition towards a market economy after the Soviet collapse result in a heavy risk burden for agricultural producers in the FSU. Since market instruments for risk management are often not available, this risk is regarded as an important obstacle to a more significant engagement of banks in agriculture.

A second objective of the paper is to investigate how credit affects profit and risk exposition of farms. Risk exposition makes on-farm risk management a task of major concern for farm managers. However, it is hypothesised that risk management may be severely hampered by liquidity constraints. Due to high risk, only small amounts of credit may be available for farms at initial stages, and farm managers have to make the best out of what is possible in the given limitations of available technology and farm equipment. The presented analysis will demonstrate ways how this can be done.

The aim of the paper is thus to analyse the complex interrelationship of risk exposition and credit supply both theoretically and empirically. This will result in an explanation of bank behaviour on the rural credit market. In addition, the effects of increased farm liquidity will be explored, and short-term risk reducing measures in agriculture will be presented. As will be shown, the portfolio selection theory provides a well-fitting framework for dealing with these issues. Corresponding to this, a programming model will be used to yield empirical results.

North-western Kazakhstan with its unique history of crop area extension and its particularly critical natural conditions for crop production can be regarded as a precedent with respect to these issues. As the authors could draw on data collected in this region, it will be used as empirical background for the further analysis.

The paper is organised as follows: Section 2 outlines the background of agricultural production in North-western Kazakhstan, briefly describes the main sources of risk, and presents some information on the current level of external funding in Kazakh agriculture. Section 3 sets the theoretical framework for further reasoning. Section 4 presents the programming approach used to model risk in agriculture, and Section 5 contains the model results. Section 6

[1] Major parts of this paper draw on PETRICK (1999c). It benefited greatly from various discussions at IAMO, comments on earlier versions by K. Frohberg, S. Abele, L. Hinners-Tobrägel and G. Peter are gratefully acknowledged. Thanks go to G. Weber for assisting in programming issues. The usual disclaimer applies.

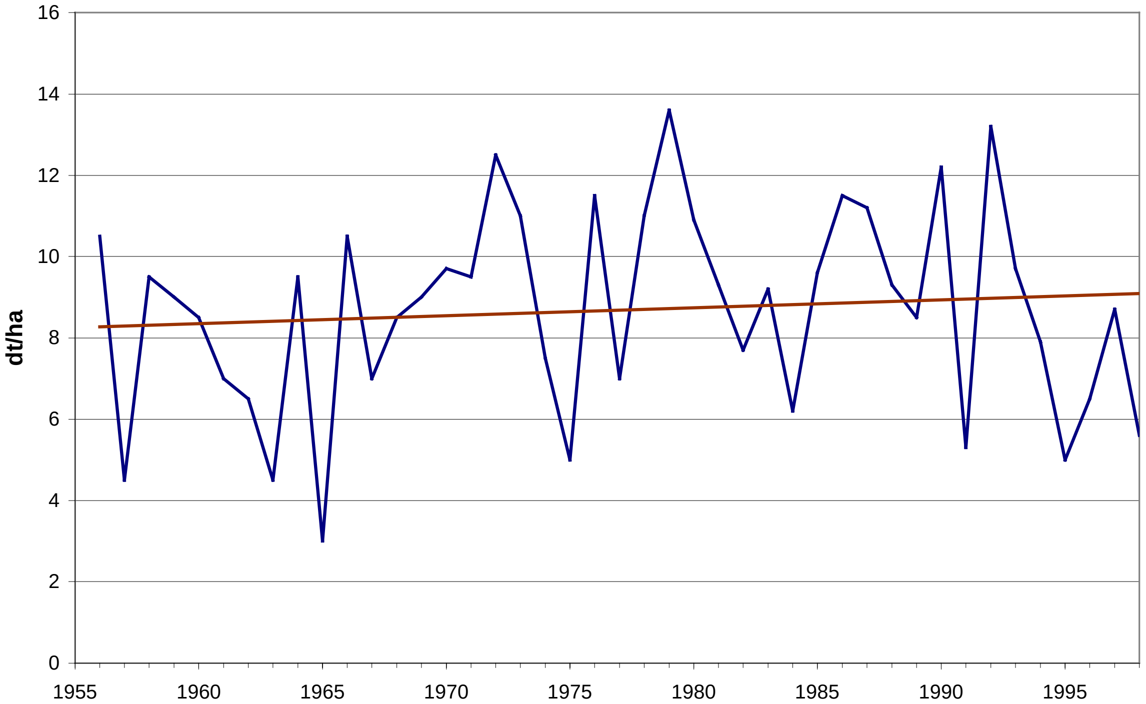
concludes with some policy implications. An annex was attached to compare the results of this study with the findings of PETRICK (1999c), where a different programming method was used.

2 KAZAKH AGRICULTURE: HISTORY OF GRAIN AREA EXPANSION, SOURCES OF RISK, AND CURRENT DEBT LEVELS

In 1954, as response to an impending dependence on imported grain and unstable yields in existing grain producing regions, N. KHRUSHCHEV ordered a vast expansion of Soviet cropland by ploughing up the virgin and idle lands located beyond the lower Volga and north Caucasus and extending into eastern Siberia (WEIN, 1980; ZOERB, 1965). Although a number of large-scale regional development programmes were implemented during the Soviet era (ROSTANKOWSKI, 1979; STADELBAUER, 1996), this “Virgin Lands Campaign” must be regarded as historically unique. 492 Sovkhozes were established until 1963, encompassing around 19 mln ha newly developed crop area; the average Sovkhoze covered 25,000 to 30,000 ha of mostly grain area. Thus, in a nine year period, new cropland larger than that of Germany was created. Although privatised, many of these “Grain Factories” principally still exist today, most of them are situated in the north-west of the now independent Republic of Kazakhstan.

From today’s perspective, Soviet expectations concerning a reliable increase of national grain supply as a result of the Virgin Lands Campaign were far too great. According to its geographic and climatic location, North-western Kazakhstan suffers from highly variable plant growing conditions due to the permanent risk of drought and both late and early frost (BULLER, 1985). Since adequate production technologies in order to mitigate the adverse impact on plant production were not available or not practised, annual yields per ha up to now varied greatly, imposing a substantial risk burden on agricultural producers (Figure 1). Furthermore, the trend shows that average yield per ha did not increase significantly during the whole period 1956-1998, which implies that technical progress in plant production has been very modest. The average yearly yield improvement amounts to 0.02 dt/ha only.

Figure 1: Grain yields Kazakhstan 1956-1998



Source: ROSTANKOWSKI (1979), Narodnoye khozaystvo Kazakhstana var. issues.

Since national independence, Kazakhstan gradually has shifted towards a market economy. This process has a significant impact on the importance of risk for agricultural producers: While risks were mostly borne by the state during Soviet times, nowadays farm managers have to cope with the task of risk management themselves in order to keep their enterprises operating. Recently, agricultural markets have been widely liberalised, agricultural enterprises have been privatised and bankruptcy laws have been adopted (CSAKI and NASH, 1998). Hard budget constraints, a lack of working machinery, and scarce working capital resulted in even less favourable conditions for crop production compared to earlier years. Yield risk continues to exist or even increases for the same reasons. National markets for agricultural products, though liberalised, are highly disintegrated, which can be seen in a low level of price correlation between regional markets for major crops.[2] At least, due to the low integration of markets, demand may be rather inelastic, resulting in a price compensation for variations in supplied quantity. Wheat prices follow world market prices only with a significant deduction, and distribution channels are highly uncertain. As a result, farm managers face a significant price and marketing risk.[3]

Yield-, price-, and marketing-risk currently accumulate to a complex overall risk exposition in Kazakh agriculture. However, risk reducing measures may involve substantial capital investment, e.g. improvement of technical equipment and transport facilities, or restoring and extending the irrigation network. Creditworthiness is thus likely to play a major role in opening development perspectives for farms. Still, it can be assumed that lending decisions made by

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2 A rough but simple measure for market integration is the correlation coefficient. The correlation coefficients of weekly prices for Almaty and Astana for the period 01/97 to 01/99 are: 0.83 for wheat (elevator), 0.55 for potatoes (retail), and 0.43 for milk (retail; own calculations based on TACIS AGROINFORM, 1999).

3 The latter is exemplified by the anecdotal theft of large amounts of sugar beets on their rail transport to the sugar factory.

banks are substantially affected by the perceived risks of the borrower. For this reason, a low level of indebtedness in Kazakh agriculture must be expected.

Table 1 presents the debt situation of farms in Kazakhstan, based on a small sample of enterprises from Akmola and Almaty oblasts. The table distinguishes gross debts and receivables; the difference represents net debts per farm and per ha, respectively. For the sake of a rough comparison, the table further contains the same values for corporate farms in the New German Bundesländer, and average figures for Saskatchewan region in Canada. The latter is often used for comparisons with North-western Kazakhstan due to the similar natural and climatic conditions for crop production (ROSTANKOWSKI, 1979; ZOERB, 1965).

Table 1: Size and debt situation of Kazakh farms in comparison to Eastern Germany and Saskatchewan (Canada) in 1998

	Mean Akmola[a]	Mean Almaty[b]	Mean total[c] (CV in %)	Eastern Germany[d]	Saskatchewan[e]
Arable land per farm (ha)	14,413	3,915	7,782 (120)	1,521[f]	466[f]
Gross debts per farm (USD)	387,731	90,196	199,814 (168)	1,722,160	68,502
Gross receivables per farm (USD)	115,218	12,843	50,560 (301)		
Net debts per farm (USD)	272,513	77,353	149,254 (146)		
Net debts/ha (USD/ha)	14	17	16 (118)	1133[g]	147[g]

Notes: [a] sample of 7 farms of different organisational forms in Akmola oblast; [b] sample of 12 farms of different organisational forms in Almaty oblast; [c] total of [a] and [b]; [a b c] figures for mid 1998; [d] average figures for corporate farms (New Bundesländer) as of 30.6.98; [e] average figures for Saskatchewan region as of 31.12.98; [f] including pastures; [g] gross debts/ ha. Exchange rates: 85 tenge/USD; 1.75 DM/USD; 1.40 CAD/USD.

Source: Own calculations based on: [a b c] ABG project data; [d] BML (1999); [e] Saskatchewan Agriculture and Food.

The table allows the following conclusions: First, measured in land allotment, farms in Kazakhstan are significantly larger on average than farms in Eastern Germany or Saskatchewan.[4] Second, though highly variable from farm to farm, debts per ha are substantially lower than those in Germany and Saskatchewan. In fact, the values of debts per ha for Kazakhstan, Saskatchewan, and Eastern Germany differ by a factor of about nine. Furthermore, Kazakh farms to a substantial extent act as creditors themselves. It follows that, according to the presented data, the level of farm debts in North-western Kazakhstan seems to be low by international standards.

In summary, it has been shown that Kazakh farms operate in a particularly risky natural and economic environment, and that debt levels in agriculture are low. The portfolio selection theory outlined in the following section is able to link these two phenomena and provides some further theoretical insights.

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[4] Notice that Almaty oblast is not part of the virgin lands territory, therefore the reported farm sizes are smaller than the average farm in the north-west of the country.

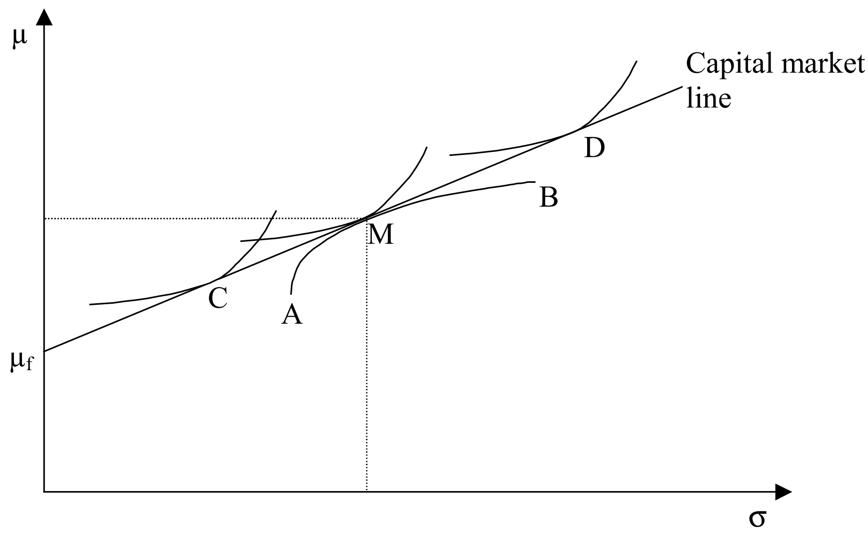
3 THEORETICAL IMPLICATIONS OF PORTFOLIO SELECTION FOR RURAL BANKING AND RISK MANAGEMENT IN AGRICULTURE

The theory of portfolio selection as introduced by MARKOWITZ (1952) attempts (a) to understand how investors' engagement in a specific portfolio of risky assets can be explained, and (b) to recommend on how risk diversification of a portfolio can be pursued rationally (PERRIDON and STEINER, 1997, p. 249). It has thus both positive and normative implications, which both will be of relevance for the issues dealt with in this paper. The positive aspect concerns an explanation of low credit supply to risky agriculture, while the normative aspect is relevant for the derivation of risk management strategies, as will be shown in the following.

Considering first the positive implications, the behaviour of investors may be conceptualised as a decision of selecting an optimal portfolio of assets with uncertain returns. This problem can be operationalised by assuming that investors' preferences depend only on the first two moments μ and σ (mean and standard deviation) of the random return of their portfolio. This is justified under the assumption that investors have quadratic VON NEUMANN/MORGENSTERN preferences, or else that stochastic distributions of returns are normal (HIRSHLEIFER and RILEY, 1992). If the investor is risk-averse, the theory of portfolio selection claims that all potential portfolios (i.e. combinations of risky assets) can be found on an efficiency line in the form of half a branch of a parable (PERRIDON and STEINER, 1997, p. 250).

This can be used to analyse the lending behaviour of a risk-averse bank (NEUBERGER, 1994, pp. 15-28). Risk-aversion of the bank can be justified if there is a probability that banks can go bankrupt and if this bankruptcy causes costs. Both is applicable for the case of Kazakhstan. It is further assumed that, alternatively to the risky portfolio, the bank has the option to invest in riskless government bonds of return μ_f. Additionally, the bank can borrow capital from the central bank at the same rate μ_f. Then the problem can be depicted graphically as in Figure 2.

Figure 2: Portfolio selection with fixed-interest bonds

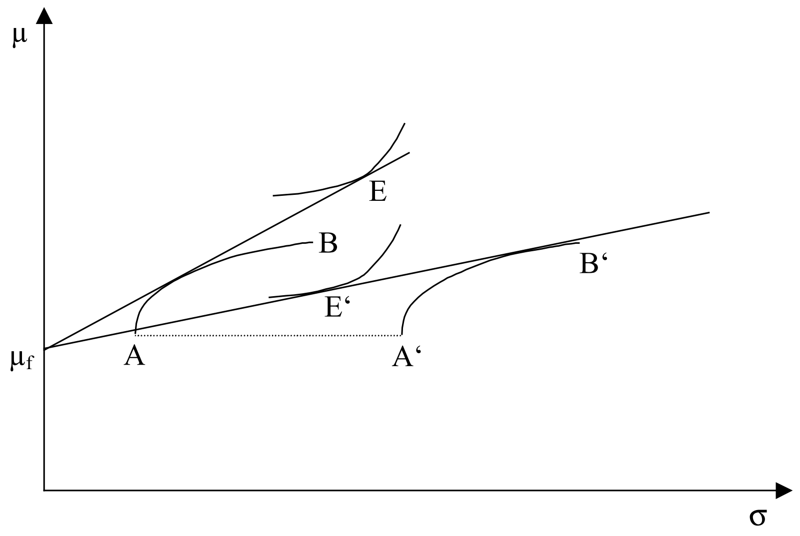


Source: BRANDES and ODENING (1992), p. 229, modified.

The bank chooses to invest in the given portfolio of risky assets represented by its $\mu\sigma$-curve AB, or in bonds with a return μ_f. All efficient combinations can be found on the so called capital market line starting in μ_f and touching M. The tangential point of the respective indifference curve and the capital market line indicates the optimal combination for a given degree of risk-aversion. Differences in risk-aversion have the following consequences: A point on the left of M means that the bank invests only part of its capital in the risky portfolio, while the remainder is invested in bonds (C). Vice versa, a point right of M indicates that the bank is willing to borrow additional capital from the central bank that can be invested in the risky portfolio (D). Only if the indifference curve touches the capital market line in exactly point M, the bank solely invests in the risky portfolio. Notice that point M at the same time represents the one selection of the portfolio AB that is optimal for the bank.

It is now straightforward to investigate how differences in the riskiness of portfolios affect the lending decision of banks (Figure 3). Consider first the portfolio AB. According to the indifference curve, the bank even borrows from the central bank in order to invest in the portfolio (E). The latter is now shifted to the right (A'B'), which means the same return but increased risk. The new optimum is found in point E', implying a strong reduction of investment in the portfolio, and buying of government bonds instead. As a result, the amount of credit granted by the bank is inversely correlated with the risk of the portfolio.

Figure 3: Portfolio selection – different risk profiles



Source: NEUBERGER (1994), p. 23, modified.

This can be applied to rural financial markets as follows. The specification "rural" means that the portfolio of a bank is limited to a number of risky assets mainly related to agriculture. These assets may encompass single agricultural production activities, on-farm investment projects etc.[5] The efficient combinations of these assets may be realistically depicted by the μσ-curves of either AB or A'B' in Figure 3. The figure shows that the extent of credit supply to agriculture depends on the return-risk trade-off of the rural portfolio. For a risk-averse bank, the volume of credit granted is c.p. negatively correlated with risk in agriculture.

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5 This approach focuses on issues of risk assessment and management within agriculture as the major field of lending for rural banks. A paper that takes into account several non-agricultural lending activities (e.g. various types of risky bonds) but reduces agriculture to one activity in a bank portfolio is ROBISON and BARRY (1977).

The discussion can be summarised as follows: The amount of credit granted to agriculture is c.p. the larger, (a) the less risk-averse the bank, (b) the lower the fixed interest rate μ_f, (c) the higher the expected return on investment, and (d) the smaller risk in agriculture.

The normative implications of portfolio selection theory concern the possibilities of risk diversification within a given portfolio. All efficient combinations of return and risk can be found on the μσ-curve, which therefore can be used as a guide to diversification strategies.

In our context, it is of particular interest to analyse the risk diversification potential within a certain agricultural enterprise, which is a further application of portfolio selection theory. To obtain this, however, an additional assumption is necessary: The selection of risky assets must be limited to those combinations that can be realised on a certain farm. Different points on the μσ-curve then reflect different investment programmes of that farm which yield maximum return for a corresponding extent of risk. In this way, the μσ-curve can be used to derive risk management strategies for agricultural enterprises by means of diversification of the investment programme.[6]

Notice that the presented theory assumes a constant return on investment independent of the total amount, which is of course unrealistic in most cases. The theory neither allows for economies of size and indivisibilities of investment projects in agriculture, nor for capital market imperfections, and neglects the temporal dimension of credit contracts (ODENING, 1991). Furthermore, it is difficult to quantify the degree of risk-aversion of a bank. However, the quantification of a farm-specific μσ-curve is possible and yields interesting results concerning the credit-worthiness of farms and the potential for whole-farm risk management. It will thus be pursued in the following.

4 A PROGRAMMING MODEL FOR THE ANALYSIS OF WHOLE-FARM RISK

~~4.1~~1.1 Model specification

The portfolio selection theory and its application to agriculture can be well quantified in the framework of a mathematical programming model if the risk exposition of agriculture is explicitly taken into account. It would be most interesting to include all types of potential investment projects into such a model. However, the data needs are tremendous in this case, since not only return and variation of a certain asset, but also information on correlation between assets is necessary (BRANDES and ODENING, 1992). Particularly for hypothetical investment objects, this information is usually unknown (see also below). Therefore, the choice of activities is limited to existing agricultural production activities (e.g. crops), which can be regarded as short-term investment projects. Furthermore, to analyse both the impact of additional working capital and the potential for risk diversification on a certain farm, the model is constructed in such a way that the portfolio must be realisable on a farm. Hence, the μσ-curve depicts a set of production programmes and shows the impact of risk-aversion on optimal farm organisation (HAZELL and NORTON, 1986, pp. 79-81). As a consequence, the model is in fact a farm model. The bank can choose between different types of whole farms, and not between combinations of independent investment projects. This may be an undue abstraction, which was however accepted for the aforementioned reasons.

6 With regard to farm management decision making, the μσ-curve of an enterprise can also be used to theoretically determine an "optimal" degree of indebtedness in agriculture. This approach regards the farm manager as the decision maker who chooses between a portfolio of risky assets and a fixed-interest credit, analogue to the bank decision outlined above (ODENING, 1991).

The modelling is done by incorporating information on the joint yield and price distribution of farm activities into the traditional programming model, and by calculating the respective variation for several levels of total farm income. Most often, time series of yields and prices are used for this purpose. If the above mentioned theoretical restrictions of the μσ-model are accepted, it is consequent to apply a quadratic programming algorithm. This is usually formulated in such a way that variance is minimised with a parameterised restriction on profit (HARDAKER, HUIRNE, and ANDERSON, 1997; HAZELL and NORTON, 1986).[7]

For the presented analysis, a quadratic programming approach was chosen by using GAMS (General Algebraic Modelling System) and the non-linear solver MINOS (Modular In-core Non-linear Optimisation System). The following optimisation problem was solved:

$$\min V = x'Q\,x \qquad (1)$$

subject to

$$c\,x = E,\ E \text{ varied} \qquad (2)$$

$$A\,x \leq b \qquad (3)$$

$$x \geq 0 \qquad (4)$$

with V being the variance of total gross margin, x an n by 1 vector of activity levels, Q an n by n activity gross margin variance-covariance matrix, c an 1 by n vector of expected activity gross margins, E expected total gross margin, A an m by n matrix of technical coefficients, and b an m by 1 vector of resource stocks and other technical constraints.

The objective function to minimise thus concerns the variance of total gross margin of the production portfolio subject to a linear constraint on the expectation value that was varied in small steps. By subtracting operating overhead costs not including permanent labour costs from total gross margin, the net operating profit is obtained. Allowances for permanent labour including management were not made since "payment" of farm workers' wages most often occurs in rather obscure ways. Frequently there is no legal payment at all, instead simply theft of farm products is tolerated. Farm managers and owners often cannot be distinguished, so the farm management is assumed to have decision power concerning the use of the profit. For the aforementioned reasons, the presented profit value has thus to be treated with caution.

Time series of gross margins to calculate the variance-covariance matrix were introduced as described by HARDAKER, HUIRNE, and ANDERSON (1997). Main resources of the farm enterprise encompass 1,200 ha of irrigated cropland, 9,500 ha of cropland for dry farming, and 9,200 ha of extensive steppe. Most farms in North-western Kazakhstan entail both crop and animal production. However, only crop production is explicitly modelled here, while animal production is taken into account through fodder crops. Their yield is multiplied with the value of the animal output produced with the respective fodder crop in order to obtain a revenue for it. Revenue for animal products is held constant during the time period, the variation of fodder plants' gross margins is therefore likely to be overestimated. Major crops are shown in Table 2. In the model, a share of 16 percent of cropland for dry farming must be black fallow without vegetation cover in order to control moisture losses, build up organic matter, and control weeds. This share is still relatively small compared to official recommendations based on research results (MEYER, 1982). Since soil treatment is necessary for the required kind of fallow, costs are incurred by this activity. Further constraints of the model concern upper mar-

7 Another possibility would be to use the popular linear algorithm called MOTAD (minimisation of total absolute deviation), as has been done in a previous paper (PETRICK, 1999c). For a discussion of these two possible ways, a comparison of results, and some more technical details see the annex below.

keting limits for several cash crops, implying a rather inelastic regional demand as indicated above. A minimum share of silage maize was imposed on the model in order to ensure a minimum level of nutrition for the ruminants. In times of high rural unemployment, labour was not regarded as being a scarce factor of production.

Table 2: Annual gross margins of production options

Activity	Category	Mean (tenge/ha)	CV (%)
Potatoes	irrigated	67955.83	27.40
Sugar beets	irrigated	120447.22	56.36
Vegetables	irrigated	226554.17	54.16
Silage maize	irrigated	425.00	1630.80
Spring wheat	dry farming	3464.18	84.48
Spring barley	dry farming	2766.43	85.57
Winter rye	dry farming	2342.87	84.12
Oats	dry farming	3241.35	75.54
Millet	dry farming	546.50	245.62
Buckwheat	dry farming	-8.00	-7701.30
Sunflower	dry farming	81.00	945.89
Lucerne	dry farming	2128.17	38.85
Sudan grass	dry farming	50.67	1183.04
Grassland hay	steppe	100.00	126.47

Source: Own calculations based on data sources as mentioned in the text.

A specific feature of the model concerns the investigation of the consequences of scarce working capital. For this purpose, a constraint on maximum working capital was introduced, which could be parameterised later. This allows the assessment of interest on additional working capital, and in this way the potential return on short-term credit.

A principal problem when using time series as a measure of variation concerns the fact that only existing production technologies can be modelled. For this reason, a systematic intensification of crop production e.g. by an increased use of fertilisers is not possible in the model, since variances and co-variances of hypothetically improved technologies are usually unknown. This has the somehow dissatisfying consequence that increased liquidity cannot be used for an intensification of crop production, because input-output ratios for the given crops are fixed. Furthermore, the complex economic consequences of dealing simultaneously with the problems of moisture recovery and water and wind erosion cannot be dealt with in the presented relatively simple model framework.

4.2 Data sources

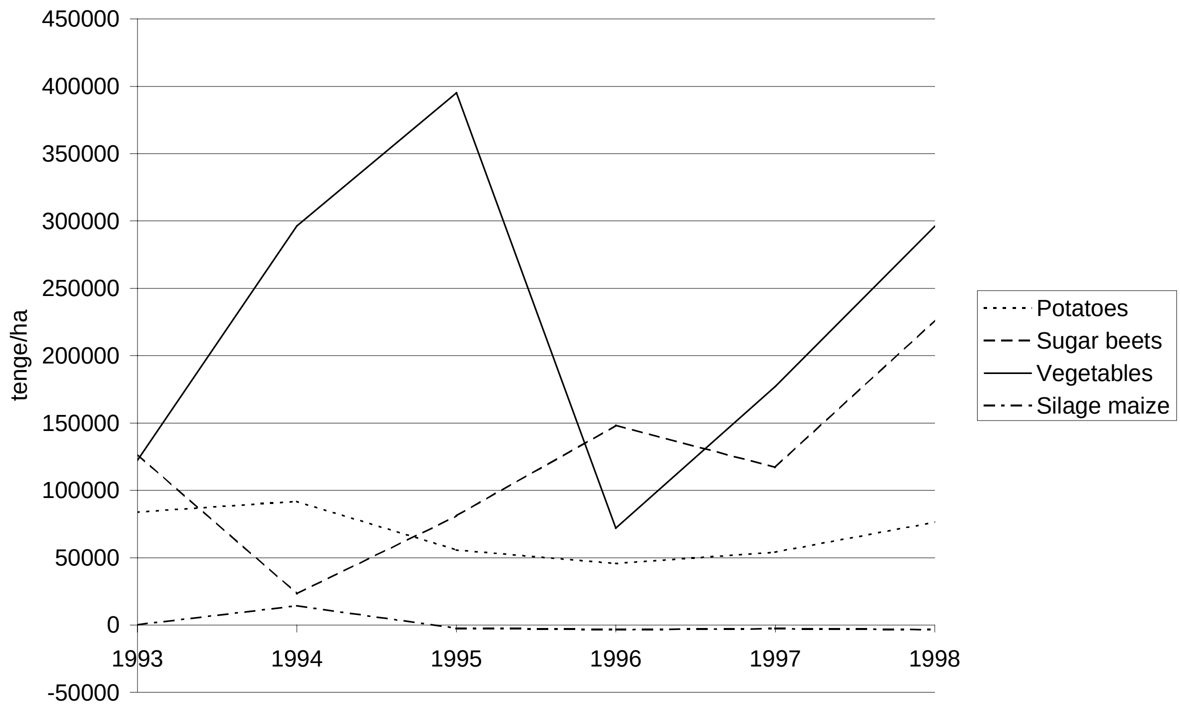
The model was designed to analyse the main interesting features of an average farm in Aktyubinsk region, North-western Kazakhstan. This synthetic farm was constructed to represent the situation in the region as typically as possible. Data and background information on the current situation of agriculture were collected during a research stay of the senior author in Kazakhstan in early 1999. With respect to farm size, organisational structure, resource stocks and cropping pattern, the model presented here takes as a reference a former Sovkhoze near the city of Aktyubinsk. This farm was privatised after national independence and was formally transformed into a joint stock company, which is currently the typical form of business organisation in North-western Kazakhstan agriculture. Information on the cost structure of the different farm activities was taken from a data collection that claims to represent a larger region of North-western Kazakhstan (PETRICK, 1999a). The time series used to model risk entail the respective price-quantity combinations for a period of 1993 to 1998 for all potential crops. Data on yields was taken from farm bookkeeping as given in WILLMS (1998) and, where lacking, was adapted from official statistics. TACIS AGROINFORM (1999) served as source for regional price information. Overhead costs on a hectare basis were taken from BROWN (1997). All statements are in prices prior to the tenge devaluation in April 1999, implying an exchange rate of 85 tenge/USD.

The quality of all official statistics, but particularly of book-keeping data must be treated with caution. It cannot be ruled out that certain numbers were forged to cheat the tax authorities (WILLMS, 1998).

A summary of means of gross margins of the different production options and their variation can be found in Table 2. The table reveals that a number of crops, namely silage maize, millet, buckwheat, sunflower, and sudan grass, show a particularly high variation, which makes their realisation in the model solution unlikely. The same applies for buckwheat due to the negative mean gross margin. Notice that the coefficient of variation can easily take very high values if the mean is close to zero, as is the case e.g. for buckwheat.

Gross margins of different production options are shown in Figure 4 for irrigated land and in Figure 5 for dry farming. Both figures give vivid evidence for the high variability of gross margins. In addition, Figure 5 shows the impact of the two years 1995 and 1996 with particularly averse conditions for rainfed agriculture. Only lucerne and grassland hay are excepted from a deep dent in gross margin. The data therefore suggests that certain fodder crops are better adapted to the prevailing natural conditions. The figures also show that irrigated crops usually earn a much higher return/ha than rainfed crops. As expected, irrigated crops are not systematically affected from drought in these years. Gross margin variability can instead be explained by the bad shape and little reliability of irrigation equipment (WILLMS, 1998).

Figure 4: Gross margins of the model farm 1993-1998 (irrigated crops)



Source: Own calculations based on sources as mentioned in the text.

Figure 5: Gross margins of the model farm 1993-1998 (rainfed crops)

Source: Own calculations based on sources as mentioned in the text.

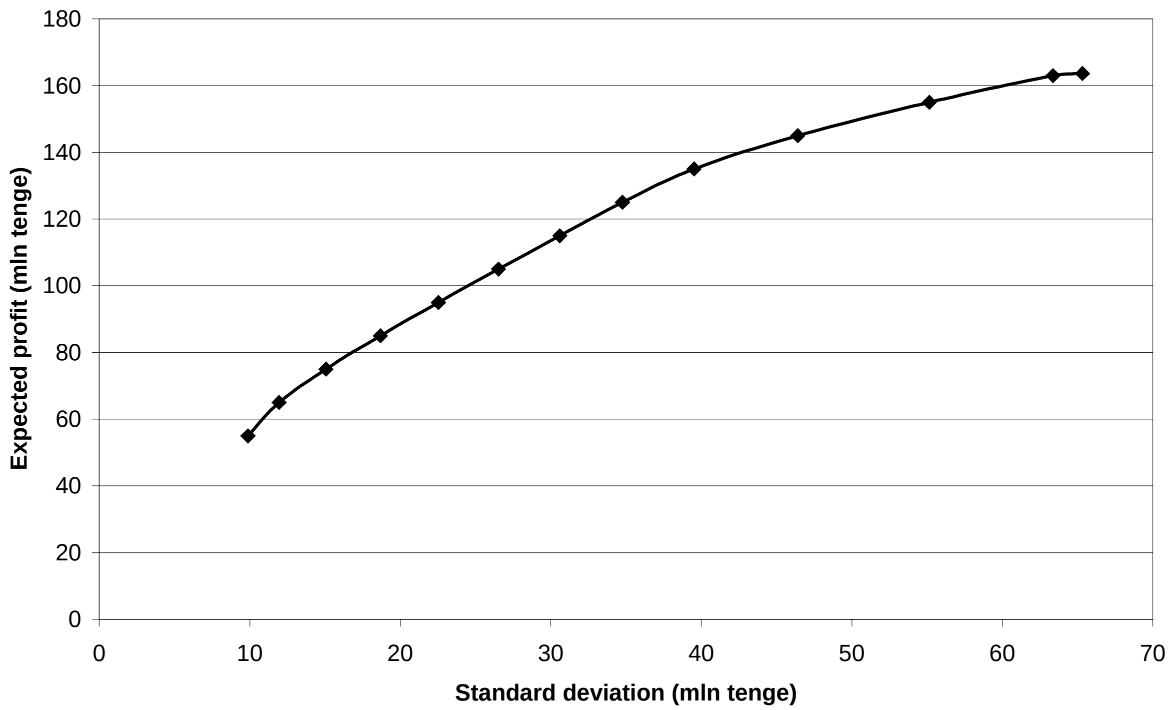
5 MODEL RESULTS

The results are presented in the following manner: First, the μσ-curve generated by the programming model is analysed in order to assess overall risk exposition. Second, results of the parameterisation of working capital are shown which allow to draw some conclusions on the return on short-term credit. Third, potential risk reducing measures as proposed by the model solutions are discussed.

5.1 Assessment of risk exposition

The μσ-curve generated by the quadratic programme is presented in Figure 6. It shows the trade-off between expected profit without labour costs and risk as measured by the standard deviation. As expected, risk over-proportionally increases with profit, implying a concave μσ-curve. The right-hand endpoint of the curve represents the risk-neutral solution, i.e. the maximum obtainable expected profit, while the left-hand endpoint is set at an arbitrarily low value of profit.

Figure 6: μσ-curve of a 20,000 ha farm in NW-Kazakhstan



Source: Model results.

The presented figure differs in an important respect from what would be expected from portfolio selection theory: return and variation are given in absolute terms (expected profit and standard deviation), and not as percentage return on capital. This is due to the fact that data on capital stocks of farms was not available, which somewhat restricts the applicability of the model. However, this also is a reflection of the problems faced by banks when deciding on lending to agriculture: it is hardly possible to get reliable data on return on capital. As reported by BROWN (1997), in a workshop for farm managers, agronomists, and government specialists in Kazakhstan no consensus could be reached on what would be accurate figures for machinery and equipment values, depreciation, or interest due. This can be easily explained with the bad condition of most machinery, little investment made in recent years, and widespread unfamiliarity with western concepts of farm accounting. Even more difficult is an assessment of land value, as long as no land market is established. Without having information about return on capital, the optimal organisation in the sense of the theory outlined above cannot be given.

Nevertheless, to get an idea of the risk exposition of Kazakh farms, the coefficient of variation (CV) as a standardised measure of variation was computed. According to the μσ-curve in Figure 6, the respective CV for different levels of expected profit varies in a range from 18 to 40 percent.[8] Thus, even if the profit is reduced to half of its risk-neutral value, the variation is still higher than 20 percent. Compare this with other potential investment opportunities for banks, for instance a portfolio of shares. The CV of a three-year investment fund classified as medium risk in the standard capital market assessment (FAZ, 1999) is from 10 to 20 percent, and thus quite lower than that of a typical Kazakh farm.

Also farms in other regions of the world facing highly variable production conditions show a much lower variation of income. Although comparability is of course limited due to completely different political and economic environments, Table 3 contains a survey of various farm types analysed by quadratic risk programming models. The survey encompasses Syria, Georgia (USA), Illinois (USA), and for the sake of comparison the official statistics from corporate farms in Eastern Germany, which are no model results. PANNELL and NORDBLOM (1998) in their study on Syria report income variations of less than five percent, which is even lower than the variation of the medium risk investment fund and much lower than the variation of the Kazakh farms' profit. Syria can be regarded as a benchmark in this respect, since "few countries experience such an extraordinarily high degree of variability in national cereal production as Syria" (NGUYEN, 1989, p. 78). Both US farms show a substantially higher return/ha and a much lower variation than the Kazakh farm. The former also applies for the average corporate farm in Eastern Germany.

Table 3: International comparison of farm sizes, return and risk in agriculture

Region	Aktyubinsk, Kazakhstan[a]	North-western Syria[b]	Georgia, USA[c]	Illinois, USA[d]	Eastern Germany[e]
Farm size (ha)	19,900	64	74	162	1521
Maximum return/ha (risk-neutral solution,USD)	97[f]		1119[g]	178[h]	553[f]
Reported risk range CV (%)	18-40	1.8-2.2[i]	0.2-3	4.3-13.7	

Notes: Calculations based on quadratic whole-farm risk programming models. [b] family farm mainly producing grain and sheep; [c] family farm mainly producing cotton, tobacco, peanuts, grain; [d] corn belt family farm; [e] average corporate farm, official statistics, no programming results; [f] expected profit including labour costs; [g] total gross margin; [h] farm income; [i] results generated by utility efficient programming.

Source: Own calculations based on: [a] model results; [b] PANNELL and NORDBLOM (1998); [c] MUSSER *et al.* (1984); [d] SCOTT and BAKER (1972); [e] BML (1999).

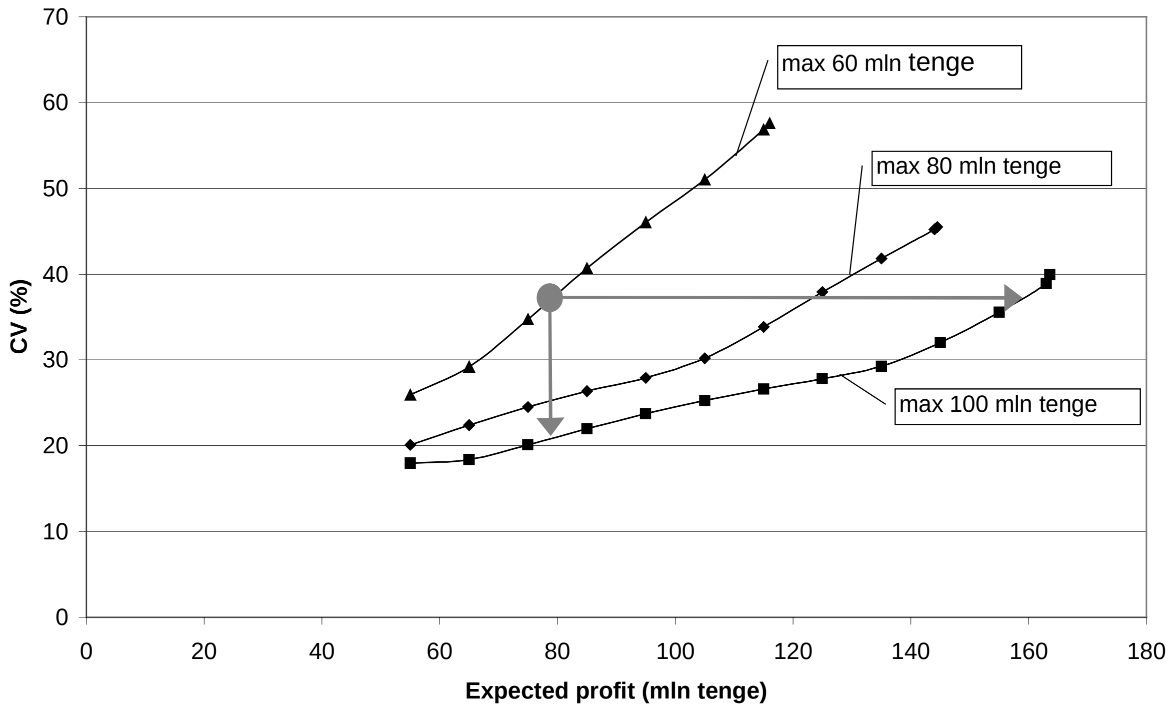
It can thus be concluded that a typical Kazakh farm in Aktyubinsk region shows a considerable risk exposition, which is significantly higher than that of farms in other regions of the world. Furthermore, compared to other investment opportunities, risk in Kazakh agriculture is substantial, which potentially deters investors' engagement.

[8] The presented figures were calculated for a constraint on working capital of 100 mln tenge (see Section 5.2). The CV range for 80 mln tenge is 20-46%, and for 60 mln tenge 26-58%.

5.2 Impacts of liquidity constraints on risk and expected profit

A second question concerns the consequences of liquidity constraints for farm organisation and risk management. To investigate this aspect, the constraint on working capital was parameterised in the model. Selected solutions for three levels of constraints on working capital are presented in Figure 7 in the form of the standardised CV curves, starting with a limit of 60 mln tenge on the left. It can be seen that relaxing the constraint on working capital shifts the CV curve to the right. Hence, holding risk constant, expected profit could be increased (horizontal arrow), or, alternatively holding profit constant, risk could be lowered (vertical arrow) if more working capital were available.

Figure 7: Impact of liquidity constraints on the potential for risk management



Source: Model results.

This has been quantified as follows. Table 4 shows the respective levels of expected profit and the average rate of return on additional working capital for different levels of risk measured by the CV.[9] According to the rule of diminishing returns on increasing input use, the rate of return decreases with an increasingly relaxed constraint on working capital (compare fifth with sixth column).[10] Furthermore, if there is a strong restriction on working capital (fifth column), the rate of return increases with risk, which is consistent with the general evidence of a negative risk-return trade-off. This effect vanishes, as the constraint is relaxed (sixth column). The figures allow the conclusion that the return will suffice for the repayment of short-term credit even at fairly high interest rates, as long as the attached risk is accepted.

[9] Example calculation: The return of 90% for an increase in working capital from 60 to 80 mln tenge and 30% CV is obtained by subtracting the profit for 60 mln tenge working capital from that of 80 mln tenge (i.e. 105-67=38). Given an increase in working capital by 20 mln tenge, (38/20-1)*100 results in 90%.

[10] The working capital is bound for one year.

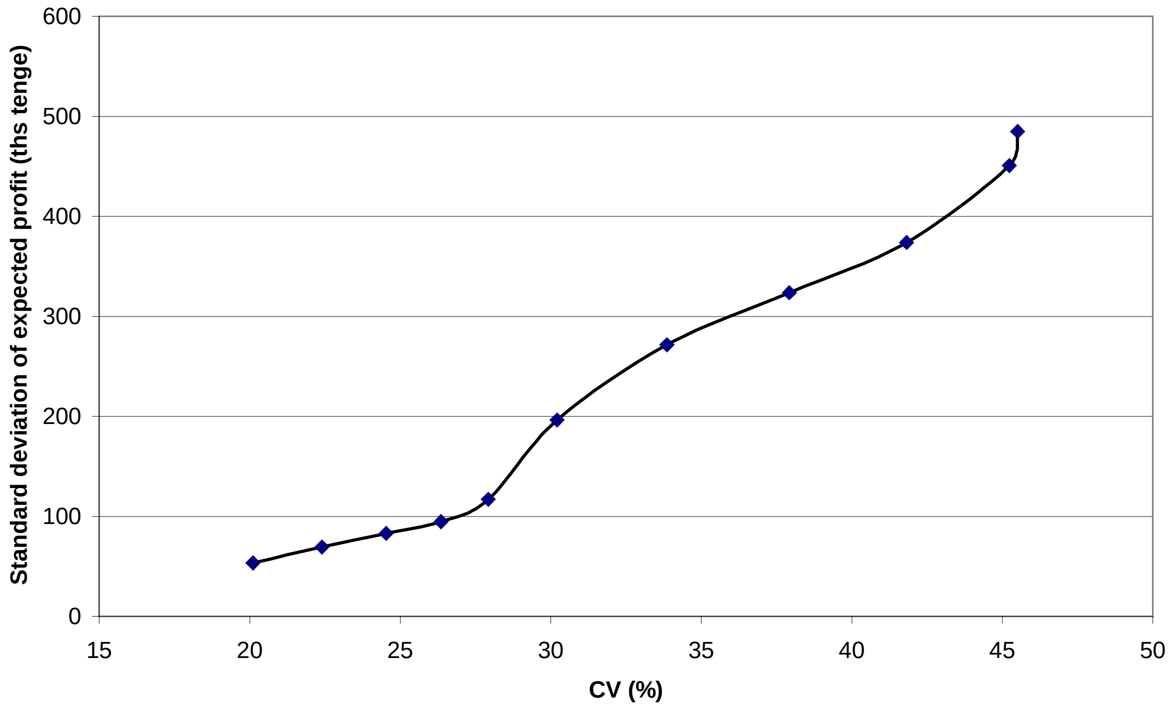
Table 4: Expected profit and return on additional working capital at various risk levels

Risk (CV)	Expected profit (mln tenge)			Annual rate of return on additional working capital	
	Availability of working capital (mln tenge)			Increase in working capital (mln tenge)	
	60	80	100	from 60 to 80	from 80 to 100
30%	67	105	138	90%	65%
35%	76	117	153	105%	80%
40%	84	130	163	130%	65%

Source: Model results.

In the presented form of the model, the impact on risk reduction can be expressed as the imputed marginal value of working capital. Since the objective function of the model minimises the variation, the marginal value has the dimension of total variance, or, as depicted in Figure 8, of standard deviation. It could therefore also be called a "shadow price", although the "price" is not expressed in terms of profit but in variance. Holding the constraint at 80 mln tenge working capital, the imputed marginal value of 1,000 tenge working capital is shown for different levels of risk (as CV). The marginal value monotonically moves upward with increasing risk. This implies that the risk reducing impact of additional working capital is the bigger, the higher the level of risk already attained. At the risk-neutral solution on the right with a CV of 45%, 1,000 tenge more of working capital are worth about 500,000 tenge in profit variation.

Figure 8: Imputed marginal value of 1,000 tenge working capital measured as profit variation



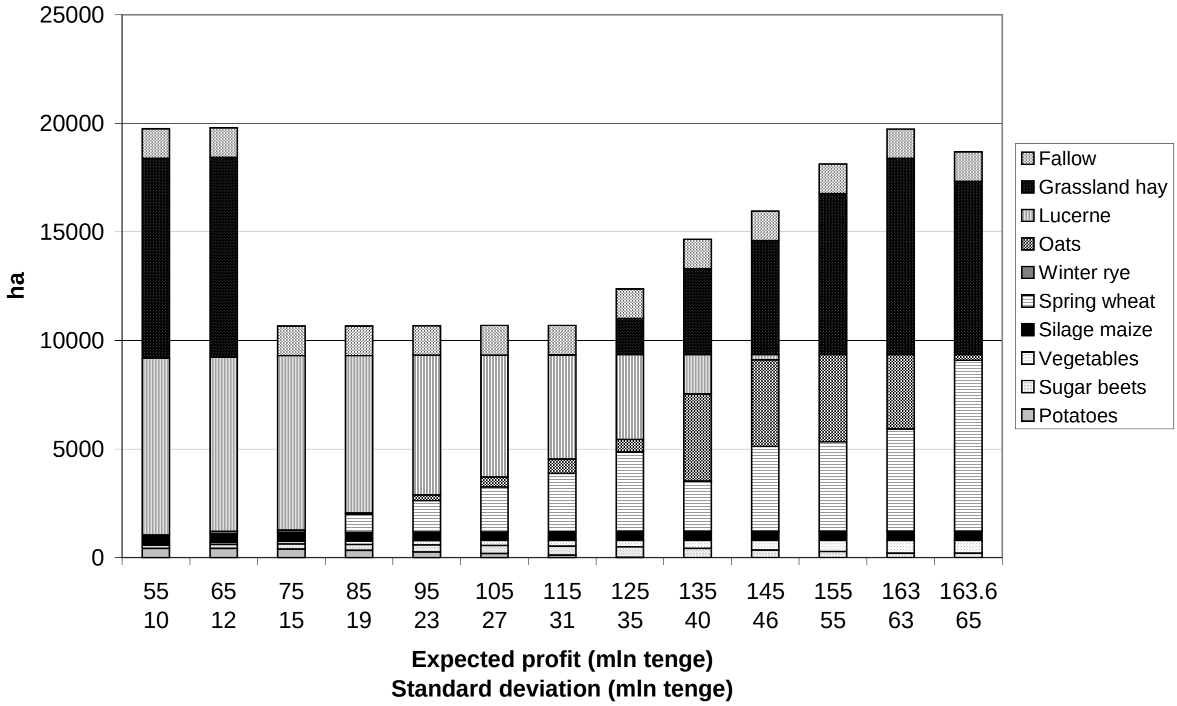
Note: Working capital max. 80 mln tenge.
Source: Model results.

5.3 Short-term measures for risk reduction

A third result of the model concerns the short-term implications of risk reduction for the efficient organisation of the farm if resource stocks (i.e. land, working capital, marketing channels etc.) are fixed. In this case, risk management can only be pursued by means of diversifying production. Figure 9 shows the different efficient land allocations due to increasing levels of expected profit as well as risk from the left to the right according to the corresponding profit and risk values in Figure 6, implying a constraint on working capital of maximal 100 mln tenge. Vice versa, starting from the right, the figure depicts the necessary changes in the farm organisation if risk shall be reduced. In fact, the risk neutral solution on the right hand comes relatively close to reality in North-western Kazakhstan in the early 1990's, with a high share of spring wheat in dry farming and vegetables under irrigation, and nearly full use of the extensive steppe for hay production. Thus, when moving to the left, one can see the necessary steps that must be undertaken in order to reduce risk by diversification. With regard to crops under irrigation, these steps mainly concern a reduction of highly variable vegetable production for the benefit of less risky sugar beets and potatoes. In dry farming, wheat may be replaced partly by oats and rye, and, particularly, by lucerne. The latter can be regarded as a substitution for grassland hay production which is reduced with decreasing profit and risk. In fact, the average gross margin of 1 ha steppe hay is quite low, which explains that this land can easily be given up. At a profit-threshold of around 75 mln tenge, the relatively more risky wheat production is completely given up, which allows the use of the released capital to again extend hay (and animal) production.

Which of the presented farm organisations is optimal depends on the risk aversion of the decision-maker and cannot be stated a priori. In the beginning of the 90's, central planning premises still had some influence on land allocation on the farms. Only recently, farm managers definitely were released from any administrative control (WILLMS, 1998). This explains why current real world production programmes are still oriented towards the ex-Soviet plans. However, farm managers are unlikely to be risk neutral when facing hard budget constraints, and therefore a reorganisation of farms to reduce risk will become necessary. According to the model results, to focus more on the cultivation of extensive fodder plants and the connected livestock production is regarded as a strategy to reduce risk and secure farm survival.

Figure 9: Efficient land use due to changes in expected profit and risk levels



Source: Model results.

It should be pointed out that the model simultaneously considers climatic and economic risk. For this reason, the recommendations for risk reduction as stated above need not to be perfectly in line with what is emphasised by researchers solely concerned with plant production technology. With regard to the selection of appropriate crops, ZOERB (1965, p. 39) states that "wheat is the one crop that is better adapted to the such variable climatic conditions than any other, with the exception of the original grass cover which is now practically destroyed." On the other hand, the well-known former Soviet researcher A. I. BARAEV proposed – apart from the advice to keep a sufficient extent of black fallow – to diversify cereal rotations in order to stabilise yields (MEYER, 1982; ROSTANKOWSKI, 1979). Taking into account the economic risk of wheat production (i.e. mainly the risk of realising a sufficient price), the recommendation to concentrate solely on wheat production must be challenged on the basis of the results presented here.

6 CONCLUSIONS AND IMPLICATIONS FOR GOVERNMENT POLICY

The analysis shows that the risk exposition of a typical 20,000 ha farm in North-western Kazakhstan is substantial compared to medium-risk investment funds or farms in other regions of the world. Although the return on capital could not be calculated due to principal problems of data availability, a low level of credit supply to agriculture must be regarded as rational.

In addition, consequences of increased farm liquidity were investigated. A larger limit principally allows farm managers either to generate an increased expected profit at constant risk, or to reduce risk at constant profit. Therefore, they find themselves in a kind of locked-in situation: the overall risk exposition of the farm hampers the inflow of external funds, but cannot be mitigated due to a lack of working capital. The results suggest that even relatively small amounts of credit could reduce whole-farm risk if a middle course is found which ensures sufficient return on the additional capital and thus attracts banks' interests.

In order to reduce risk in the short-run at given resource stocks of working capital, land, production technologies etc., a strategy of diversifying the production programme can be pursued. However, the effect of this form of risk reduction is limited.

More effective measures of risk management necessarily entail substantial restructuring and reorientation of agricultural enterprises, which implies the need for significant investment in new production technologies (such as irrigation equipment) and processing and distribution channels for farm products (DITGES and BADER-LABARRE, 1994). Most likely, this will only succeed if investors with a large risk-bearing potential can be found who become engaged in the whole production and processing chain.

Though only touched briefly in this analysis, improvements in internal farm organisation and management are crucial for the future development of Kazakh agriculture. As long as payment of workers cannot be guaranteed on a regular base, motivation to work honestly will be low and motivation to embark on illegal practices to secure their livelihoods will be high. Furthermore, many farm managers lack the sufficient knowledge to run a large farm in a market environment. This concerns particularly those aspects of farm management that have not been necessary to perform under socialism, e.g. the need to insist on strict profitability of farm activities, financial management, and decisions on staff reduction (DITGES, 1994).

Assessment of risk and risk management are both necessary in a market economy. If agricultural production in a certain region is considered as being too risky, resources will be better used elsewhere. Although increased liquidity could improve the risk management of farms as shown by the model, the government should abstain from supporting agriculture with soft budget constraints and cheap credit if agriculture in its present form is not viable. Even the introduction of seemingly market-conform measures such as a governmental crop and loan insurance system or a credit guarantee fund (both as proposed by TAKAMBAEV, 1999) should be treated with caution due to well-known problems of adverse selection and moral hazard. The task for the government in tackling the problems of risk in agriculture will be to develop rural transport and telecommunication infrastructure, to remove legal obstacles to collateralisation, to ease Foreign Direct Investment in the sector, and probably to establish or support a rural advisory service. This service would have the tasks of distributing the knowledge on sustainable cultivation practices, disseminating information on marketing channels and prices, and improving internal farm management.

The overall risk exposition of agriculture in North-western Kazakhstan is basically a result of the political decisions made during the Soviet era, when politicians were little impressed by economic constraints. Nowadays, without state support, production structures inevitably have to adapt to natural conditions. In the medium to long run this may imply the termination of agriculture in its present shape. Alternative forms may be found in extensive cattle grazing as had been done prior to collectivisation (GIESE, 1983). In 1997, 39.6 percent of the total Kazakh population lived in rural areas, i.e. roughly 6.7 mln people (OECD, 1999). The future of this rural population – of whom a considerable share was forced to settle in the region by Soviet authorities – remains an open question. A clear government strategy to develop alternative sources of income in rural areas is not in sight yet.

ANNEX: QUADRATIC PROGRAMMING VS. MOTAD

The subjective expected utility theory (SEU) usually serves as a theoretically consistent framework for the analysis of decision-making under risk (ANDERSON *et al.,* 1977; HIRSHLEIFER and RILEY, 1992). However, this theory is rarely directly applied to real-world problems since many concepts of the theory are rather difficult to operationalise. This particularly concerns the formulation of an appropriate expected utility function. With regard to decision-making of a group of people – for example portfolio decisions of a bank or management decisions on a collective farm – this seems to be almost impossible. An often used operationalisation of the SEU theory is therefore the μσ-criterion as applied in this paper, which only requires information on mean and variance of the uncertain parameters. However, if assumptions concerning the utility function should be avoided, the μσ-criterion rests on the precondition that the outcome distribution is normal.[11]

In the literature, risk programming in agriculture based on μσ-analysis has been done primarily by employing two different methods: the first, as applied in this paper, being quadratic programming, and the second being a linear alternative which became popular as MOTAD (minimisation of total absolute deviation). In the following, some issues concerning the choice of either of these methodologies will be discussed, and the results presented in this paper will be compared with results obtained by MOTAD programming as given in PETRICK (1999c).

First, the alternative MOTAD formulation will be specified. In this model, mean absolute deviations (MAD) instead of the variance are used as a measure of variation, and the model is designed to minimise the variation for a given, but parameterised restriction on total gross margin as follows (HAZELL, 1971):

$$\min M = py \qquad (5)$$

subject to

$$Ax \leq b \qquad (2) \text{ as above}$$

$$cx = E, E \text{ varied} \qquad (3) \text{ as above}$$

$$Dx + Iy \geq 0 \qquad (6)$$

$$x, y \geq 0 \qquad (7)$$

with *M* being the mean absolute of deviation of total gross margin, *p* an 1 by *s* probability of states vector, *y* an *s* by 1 vector of negative deviations of total gross margins by state, *D* an *s* by *n* matrix of deviations of activity gross margins from their respective means, and *I* an *s* by *s* identity matrix. The quadratic objective function (1) is thus replaced by a linear one by introducing absolute deviations from means as the measure of variation. The resulting μσ-curve represents an approximation of the μσ-solution of the quadratic programme.

In the years of its genesis, major reasons for developing this linear risk programming formulation were the limited availability of computer codes able to solve large non-linear problems and the time and cash expenses associated with the use of appropriate computer technology.

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[11] In contrast to statements made earlier in this paper and e.g. by HARDAKER, HUIRNE, and ANDERSON (1997), this is not quite correct. In the literature, the assumption of a normally distributed random variable is usually analysed in combination with an exponential utility function. It has been shown that *other* utility functions do *not* necessarily comply with SEU theory (see ODENING, 1994).

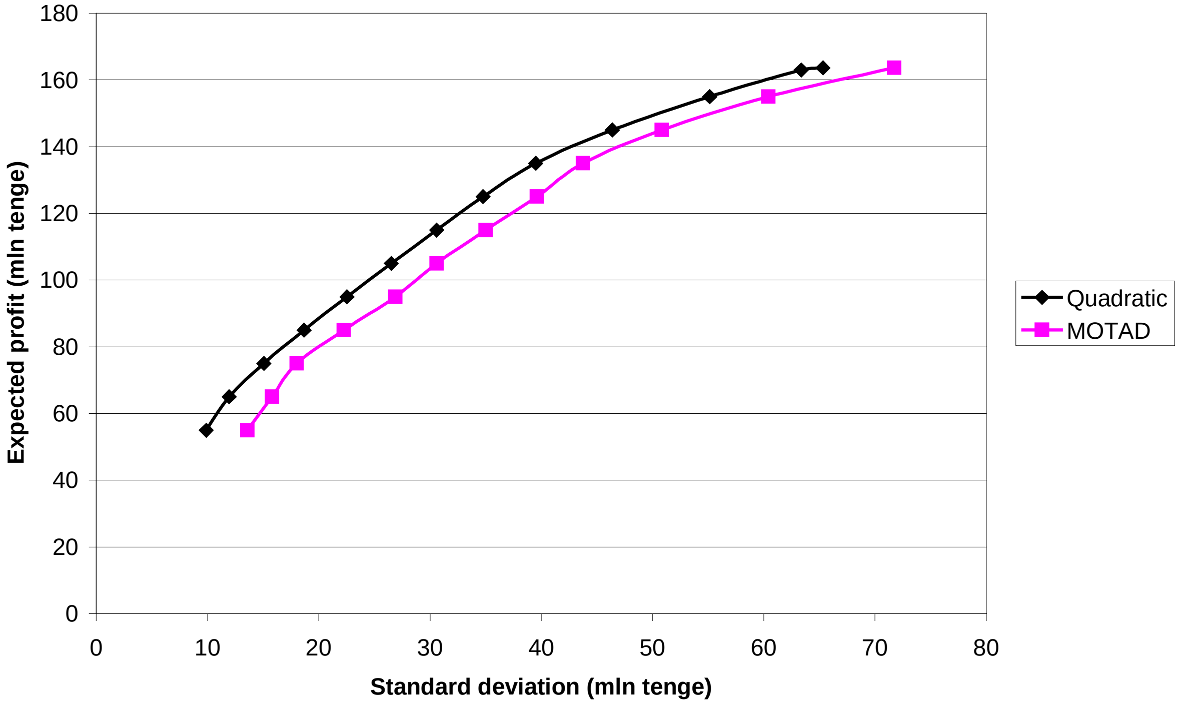
Nowadays, this argument has lost its plausibility, since inexpensive software packages for solving non-linear problems and fast processing units are widespread available. Accordingly, MCCARL and ÖNAL (1989) conclude that the days of linear approximations necessary for large models may be over.

In the literature it has further been argued that a linear optimisation may be inaccurate on theoretical grounds because it introduces an approximation error. MOTAD may therefore be "painlessly put to sleep" (HARDAKER, HUIRNE, BARRY and KING, 1997, p. ix), since it only approximates the quadratic programming solution which already has axiomatic weaknesses compared with SEU theory. However, as MCCARL and TICE (1982) set out, approximation adequacy should not involve closeness to the quadratic programming solution, but rather the real world purpose of the modelling effort. If the assumption of a normally distributed outcome variable is violated – which may often be the case in practice –, in the presence of mixed-normal or χ^2 distributions minimisation of absolute deviations may even perform better in terms of ranking equal-income farm plans (THOMSON and HAZELL, 1972). This may particularly be true for small sample sizes. As the recent contribution of JUST and WENINGER (1999) shows, there is still discussion on the issue of whether crop yields can be treated as normally distributed or not. Since the method of using historic time series as estimators for the variability of parameters generally involves an estimation error, the argument of theoretical consistency is diluted in any case (ODENING, 1994).

A judgement on which methodology is regarded as accurate should therefore include a careful examination of the properties of the underlying data set. Unfortunately, if only small time series are available, it is almost impossible to get a clear picture of the characteristics of the distribution. In the following, we therefore present the results of both ways of calculating, and leave the judgement to the reader.

Figure 10 shows that the MOTAD solution systematically overestimates the variation of the efficient farm plans compared with the quadratic programme by approximately ten percent. The $\mu\sigma$-curve is thus shifted to the right. This seems to be a general property of the MAD estimator, since HAZELL and NORTON (1986, p. 90) as well as MUSSER *et al.* (1984, p. 145) report a similar bias in their comparison of both methodologies. An explanation can be found in the fact that, in quadratic programming algorithms, large deviations from the mean are weighed higher than small ones, in contrast to algorithms using MAD which imply a constant weighting. This squeezes the variance in quadratic programming models compared with MOTAD.

Figure 10: Comparison of μσ-curves generated by quadratic programming and MOTAD



Source: Model results, PETRICK (1999c).

Comparisons of the respective farm plans are given in Table 5. The table shows the standard deviation and the activity levels for a selected number of values of expected profit (which is E minus overhead costs). A closer examination of the values of the activity levels reveals that the differences between the two methods of calculation increase with increasing distance to the risk neutral solution in the most right column. Specifically, the quadratic programming algorithm has a bigger preference for lucerne at the expense of rye and oats, and for potatoes at the expense of sugar beets and vegetables, as compared with MOTAD. On the other hand, the solutions of quadratic programming and MOTAD on the right hand of the table are almost identical. The authors are not aware of an explanation for this phenomenon.

Table 5: Comparison of results generated by quadratic programming and MOTAD

Solution	Model	I	II	III	IV	V	VI	VII
Expected profit (mln tenge)		65	85	105	125	145	155	163.64
Standard deviation	Q	12	19	27	35	46	55	65
(mln tenge)	M	16	22	31	40	51	60	72
Potatoes (ha)	Q	420	331	182	19	-	-	-
	M	242	275	220	60	-	-	-
Sugar beets (ha)	Q	183	280	378	479	362	273	200
	M	220	270	345	451	365	273	200
Vegetables (ha)	Q	95	157	229	302	438	527	600
	M	126	169	220	286	435	527	600
Spring wheat (ha)	Q	-	834	2062	3658	3915	4143	8101
	M	-	-	1731	4052	4143	4143	8143
Winter rye (ha)	Q	106	-	-	-	-	-	-
	M	3103	2604	250	-	-	-	-
Oats (ha)	Q	-	64	467	579	4000	4000	42
	M	-	1919	4000	4000	4000	4000	-
Lucerne (ha)	Q	8037	7245	5613	3906	228	-	-
	M	5040	3620	2162	91	-	-	-
Grassland hay (ha)	Q	9200	-	-	1672	5264	7422	7919
	M	9200	9200	-	1209	5121	7423	7905

Notes: Q denotes solutions of quadratic programming algorithm, M denotes solutions obtained by MOTAD.
Source: Model results, PETRICK (1999c).

In summary, there may be reasons to use either quadratic programming or the MOTAD approach depending on the underlying theoretical assumptions and data distributions. In our case, close to the risk-neutral solution, results of both are nearly identical, while substantial differences in activity levels exist for less risky farm plans. With regard to the computed combinations of expected profit and standard deviation, MOTAD produced a systematically higher variation than quadratic programming.

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