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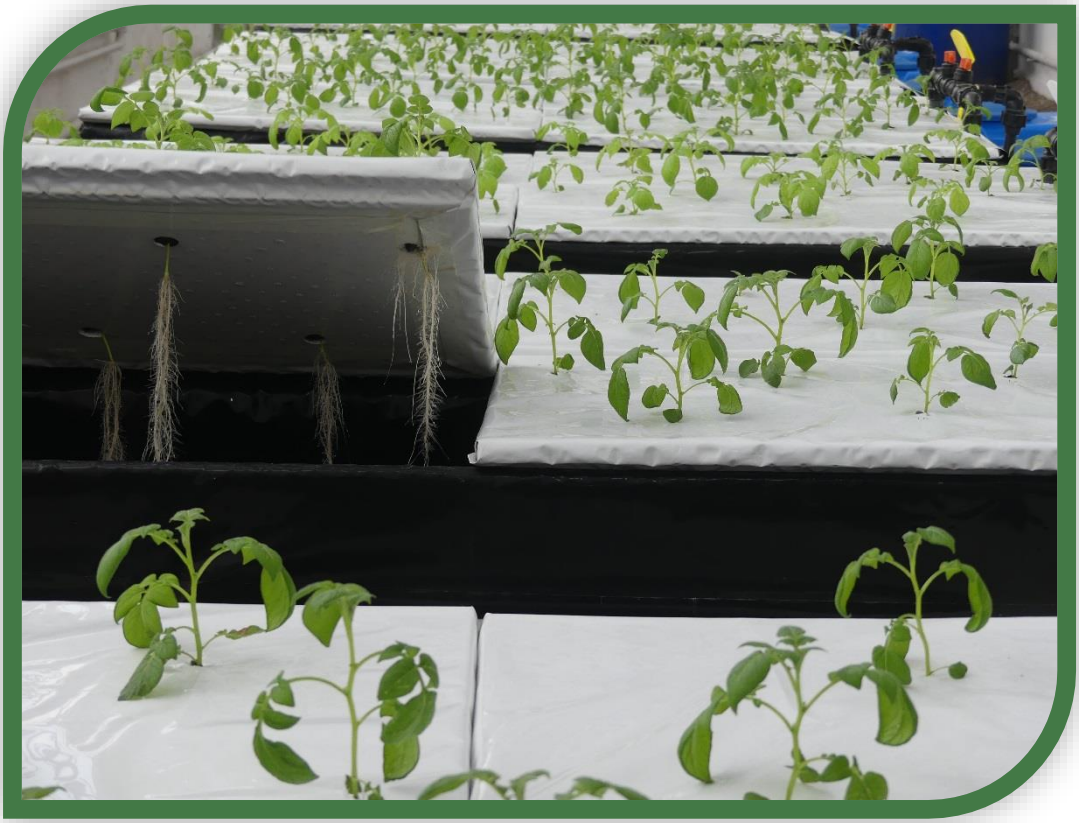
Cost Analysis of Plant Breeding and Seed Production



German - Mongolian Cooperation Project "Sustainable Agriculture"

Dr. Purev Byamba & Baasansuren Sandui (Short-term Experts)

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"Sustainable Agriculture"

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TABLE OF CONTENTS

LIST OF TABLES

ACRONYMS

CBA	Cost-Benefit Analysis
DRC	Domestic Resource Cost Ratio
EPC	Effective Protection Coefficient
GDP	Gross Domestic Product
HTC	Hydrothermal Coefficient
IPAS	Institute of Plant and Agricultural Sciences
IRR	Internal Rate of Return
MNT	Mongolian Tugrik
NPCI	Nominal Protection Coefficient on Tradable Inputs
NPCO	Nominal Protection Coefficient on Outputs
NPV	Net Present Value
PAM	Policy Analysis Matrix
PCR	Private Cost Ratio
PED	Price Elasticity of Demand
PES	Price Elasticity of Supply
SMC	Seed Multiplication Centre
USD	United States Dollar

1. INTRODUCTION

The importance of securing domestic supply of high-quality seeds and planting materials in stabilising and improving crop yields and quality is widely recognized in Mongolia. Furthermore, breeding of new crop varieties with increased yield potential, disease resistance and stress tolerance through is increasingly acknowledged as an essential requirement for the sustainability of crop production, not least due to the increasing impacts of climate risks. As demonstrated by the "Mongolian Potato" program, per-hectare yields of potato reach 20.6 to 23.7 tons i.e. twice the national average through the use of superior varieties such us Impala, Santa and Vitara. Barkley et al. (2002) also estimated the benefit-cost ratio of public investments in wheat breeding at 14.99, implying that each dollar invested in wheat breeding returns a benefit of USD 14.99.

While recognizing the need to support plant breeding and secure domestic seed supply the policies have not resulted in any significant improvement since 1990. The substantial progress in plant breeding and domestic seed production that was achieved during the last decades of the pre-1990 era was followed by a breakdown of the seed sector, which resulted in deterioration of seed quality and increased use of seeds of uncertain origin. Certified seeds of registered varieties, for instance, were sown on only 65% of wheat fields in 2016, compared to 96.3% in 1984. A major reason for the ineffectiveness of policy efforts is that the current policies are largely adopted from the pre-1990 period of planned economy, hence not fit for the requirements of the market economy, to which the country shifted after 1990. Revival of the seed and variety sector requires, along with ongoing and efficient state support, new policies, structures and mechanisms that adhere to the principles of the market economy e.g. by stimulating involvement of the private sector in plant breeding in relation to the fact that such involvement has been absent over the last 28 years. The main reason for the reluctance of the private sector has been the uncertainty of outcomes of large-scale investments and long-term operations that plant breeding requires.

This study is a response of the German-Mongolian cooperation project "Sustainable Agriculture" to the need of providing an analytical basis for policy decisions regarding the establishment of a strong seed and variety sector based on involvement and partnerships of the public and private sectors in Mongolia. The overall goal of the study is to provide benchmarks for costs and benefits of investments in variety breeding and seed production of wheat and potato, which are the main crops grown in Mongolia. While the analysis is largely focused on assessing public investments the results can also be used in pre-assessment of private sector investments e.g. in feasibility studies. The specific objectives of the study are:

- to estimate the costs of wheat and potato breeding;
- to estimate the scope of investments required for establishment of elite seed production centres;
- to assess economic and social impacts of government interventions required for establishment of elite seed production centres;
- to determine the market equilibria for wheat and potato prices; and
- to estimate the impacts of seed quality, measured in multiplication rate, on seed production costs of wheat and potato.

2. ESTIMATION OF COSTS OF WHEAT AND POTATO BREEDING

2.1 Material and methods

2.1.1 Research design and data on breeding operations

In this analysis, the actual breeding program of the wheat variety 'Darkhan 131', a hypothetical wheat breeding program that uses the same method of selection as in the case of 'Darkhan 131' for a shorter program duration[1], and a current hybrid potato breeding program are used as references for cost calculation.

Data on breeding operations such as plot sizes, number of breeding lines, replications and check varieties for the 'Darkhan 131' breeding program and the potato breeding program were obtained from the Institute of Plant and Agricultural Sciences (IPAS), which conducted the prior and currently conducts the latter program. In the case of the hypothetical wheat breeding program, data on breeding operations were derived from a simulation using the program design illustrated in Brennan & Martin (2006) and reference data from the 'Darkhan 131' breeding program.

2.1.2 Outlines of breeding operations

The breeding program 'Darkhan 131' started in 1987 and, using a modified pedigree selection scheme[2], continued for 16 years until the release of the variety in 2003. The stages F0 to F6 can be summarised as early generations i.e. stages before multi-location trials. Out of approx. 7000 to 10,000 breeding lines produced in the F2 stage, 1000 to 1500 lines remained after F6 to be assessed in the yield trials starting at the stage F7 (Table 2.1).

Table 2.1: Operations in the breeding program of the wheat variety 'Darkhan-131' (1987 to 2003)

Stage	Year	Number of breeding lines	Evaluation conducted
F0	1987	100-150	Cross parents
F1	1988	100-150	Select single plants in rust nursery
F2	1989	7000-10000	Evaluate for diseases and tolerances plus seed increase row
F3	1990	3000-5000	Yield in replicated trials, early generation quality and selections from families
F4	1991	2000-5000	
F5	1992	1000-1500	
F6	1993	2000-2500	
F7	1994	1000-1500	Yield in replicated trials small number of locations, early generation quality and evaluation for a range of tolerances and disease resistance traits
F8	1995	500-750	
F9	1996	150-200	Yield in replicated trials medium number of locations, confirm evaluation for a range of tolerances and disease resistance traits
F10	1997	80-150	
F11	1998	50-80	Yield in replicated trials large number of locations, detailed quality evaluation, confirm previous disease evaluation and detailed evaluation of some diseases and tolerances.
F12	1999	50-60	
F13	2000	30-50	
F14	2001	30-50	Yield in replicated trials large number of locations, detailed quality evaluation, confirm previous disease evaluation and detailed evaluation of some diseases and tolerances. Commence large scale seed increase.
F15	2002	30-34	
F16	2003	30-32	

[1] The 'Darkhan 131' breeding program faced budgetary constraints causing delays in program implementation. A 'hypothetical' wheat breeding program without such delays can be completed within 12 years instead of 16 years.

[2] The modified pedigree selection method involves evaluation and selection of parents and hybridization to provide useful gene recombinations.

The hypothetical wheat breeding program refers to a typical conventional breeding program based on pedigree selection methods, in which a new variety is released after 10 to 12 years (Brennan & Martin, 2006). Approximately after F5 generation, breeding lines become fixed and their progeny are the same each generation. In our simulation, at the end of the early generation stages (F5), from 150 crosses made and 10000 breeding lines in F2, 750 lines remain to be assessed in the yield trials at F6 (Table 2.2).

Table 2.2: Operations in the hypothetical wheat breeding program

Stage	Number of breeding lines	Evaluation conducted
F0	150	Cross parents
F1	150	Select single plants in rust nursery
F2	10000	Evaluate for a range of diseases and tolerances plus seed increase row
F3	5000	Yield in replicated trials, early generation quality and selections from families
F4	1500	
F5	2500	Yield in replicated trials small number of locations, early generation quality and evaluation for a range of tolerances and disease resistance traits
F6	750	Yield in replicated trials medium number of locations, confirm evaluation for a range of tolerances and disease resistance traits
F7	200	
F8	80	Yield in replicated trials large number of locations, detailed quality evaluation, confirm previous disease evaluation and detailed evaluation of some diseases and tolerances.
F9	60	
F10	50	
F11	32	Yield in replicated trials large number of locations, detailed quality evaluation, confirm previous disease evaluation and detailed evaluation of some diseases and tolerances. Commence large scale seed increase.
F12	31	

The hybrid potato breeding program of IPAS started in 2012 and is expected to be completed i.e. to release a new variety in 2025. The breeding operations are outlined in Table 2.3.

Table 2.3: Operations in the hybrid potato breeding program

Stage	Year	Number of plants	Evaluation conducted
F0	2012	50-80 cultivars and varieties	Midparent values used to predict mean performance of crosses for quantitative traits +other genetic information
F1	2013	30-50 crosses	Choose and cross parents
F2	2014	5000-10000 plants	Visual assessment of seedlings in a glasshouse
F3	2015	5000-10000 tubers	Visual assessment of single-spaced plants at seed site and limited post-harvest assessment of quality and disease resistance
F4	2016	500-600 clones	Visual assessment of unreplicated small plots at seed site and limited post-harvest assessment of quality and disease resistance
F5	2017	70-80 clones	
F6-F7	2018-2019	15-20 clones	Yield trials at breeding station, seed production at seed site and disease and quality testing
F8-F10	2020-2022	6-8 clones	Multisite trials, larger-scale seed production at seed site and assessment for yield, disease and quality testing
F11-F13	2023-2025	4-5 clones	Multisite trials, larger-scale seed production and assessment for yield, disease and quality testing

The number of plants (seed sites) increases while the number of clones decreases as the stages progress. Furthermore, from the third stage of breeding nursery, around 15-20% of harvested seedlings will be selected to the next stage on the basis of the assessment of yield, disease and quality tests. Therefore, costs of operations in each stage depend on the size of the cultivated area (sown field) and its replications, and the quantity of seed sown and net harvest.

2.1.3 Approach to costing

Typically, the costs of a plant breeding program will vary markedly on factors such as the degree of mechanization and labour intensity, unit labour and capital costs, the degree of crossing, the structure of the program's operations, the amount of quality testing etc. The cost function of the breeding programs analysed in this study is:

$$C = C_k + C_l + C_o,$$

where C_k is the annual capital and overhead cost; C_l is the annual labour cost; and C_o is the annual operating cost.

Estimation of costs used actual resources from the 'Darkhan 131' wheat breeding program and the current potato breeding program of IPAS. In the case of 'Darkhan 131', costs were estimated in total and at each stage of the breeding program. The average costs per stage were then used in the estimation of the total costs of a hypothetical wheat breeding program with a shorter duration. In the case of the potato breeding program, cost estimation per stage was not performed since the current potato breeding program at IPAS, with its planned duration of 14 years, is typical of most relatively large programs, hence making cost estimation of a hypothetical potato breeding program unnecessary.

Capital costs are based on the depreciation of machinery or equipment used in the breeding programs. Direct inputs such as parts, bags, envelopes, etc, were estimated by the IPAS. Leasing costs for land used in the program were also included in the costs. In the estimation of labour costs, we used generic 2017 salary levels to avoid using confidential information. Labour inputs of each member of the breeder teams were estimated per breeding operation (site identification and preparation, field operations, machinery maintenance, trial design and management, seed preparation, sowing, field evaluations, harvesting, post-harvest seed handling, data preparation and selection of breeding lines to advance).

Cost estimations are presented in the following sections at current prices of 2017 as well as 2010 prices, which are commonly referred to as 'constant prices' in statistics. A deflator of 1.612 was used for conversion of the costs to 2010 prices.

2.2 Estimated costs of wheat breeding

The total costs of the 16-year breeding program of the wheat variety 'Darkhan 131' were estimated at MNT 527.6 million (USD 216.2 thousand) at 2017 prices, and MNT 327.3 million (USD 241.4 thousand) at 2010 prices. Capital and overhead costs, and labour costs accounted for 24% and 74% of the costs, respectively (Tables 2.4 and 2.5).

Based on the average costs per stage of the breeding program (Table 2.6) and the assumption that the best breeding line is to be released as a new variety after 12 years of program implementation, the total costs of a hypothetical wheat breeding program with a 12-year duration were estimated at MNT 391.8 million (USD 160.5 thousand) and MNT 243.1 million (USD 179.3 thousand) at 2017 and 2010 prices, respectively (Table 2.7).

Along with our cost estimation, we estimated the quantity of elite seed to result from the hypothetical breeding program at 488.9 tons.

Table 2.4: Estimated total costs of the wheat breeding program 'Darkhan 131', at 2017 prices

Stage	Year	Number of breeding lines	Costs, MNT			
			Labour costs	Operating costs	Capital costs and overheads	Total
F0, Cross	1987	150	-	-	-	-
F1-F6	1988-1993	10000	126,848,715	864,000	49,263,852	176,976,567
F7-F8	1994, 1995	750	47,185,874	172,000	15,555,497	62,913,371
F9-F10	1996, 1997	150	53,686,618	776,000	15,318,497	69,781,115
F11-F13	1998-2000	80	81,411,425	3,579,000	22,410,146	107,400,571
F14-F16	2001-2003	32	80,268,379	3,756,000	26,493,746	110,518,125
Total		27,178	389,401,011	9,147,000	129,041,738	527,589,749
Total in USD (USD 1 = MNT 2440.6)			159,551	3,748	52,873	216,172
Share in total costs			74%	2%	24%	100%

Table 2.5: Estimated total costs of the wheat breeding program 'Darkhan 131', at 2010 prices

Stage	Year	Number of breeding lines	Costs, MNT			
			Labour costs	Operating costs	Capital costs and overheads	Total
F0, Cross	1987	150	-	-	-	-
F1-F6	1988-1993	10000	78,690,270	535,980	30,560,702	109,786,952
F7-F8	1994, 1995	750	29,271,634	106,700	9,649,812	39,028,146
F9-F10	1996, 1997	150	33,304,354	481,390	9,502,790	43,288,533
F11-F13	1998-2000	80	50,503,365	2,220,223	13,902,076	66,625,664
F14-F16	2001-2003	32	49,794,280	2,330,025	16,435,326	68,559,631
Total		27206	241,563,903	5,674,318	80,050,706	327,288,926
Total in USD (USD 1 = MNT 1355.9)			178,158	4,185	59,039	241,381
Share in total costs			74%	2%	24%	100%

Table 2.6: Average costs of wheat breeding program 'Darkhan 131' per stage, at 2017 prices

Stage	Year	Number of breeding lines	Average costs per stage and breeding line	
			MNT	USD
F0, Cross	1987	150	0	0
F1	1988	150	59,470	24
F2	1989	10000	3,361	1
F3	1990	5000	6,722	3
F4	1991	5000	6,722	3
F5	1992	1500	22,407	9
F6	1993	2500	13,444	6
F7	1994	1500	20,971	9
F8	1995	750	41,942	17
F9	1996	200	174,453	71
F10	1997	150	232,604	95
F11	1998	80	447,502	183
F12	1999	60	596,670	244
F13	2000	50	716,004	293
F14	2001	50	736,787	302
F15	2002	34	1,151,230	472
F16	2003	32	1,188,367	487

Table 2.7: Estimated total costs of a hypothetical wheat breeding program with a 12-year duration

Stage	Year	Number of breeding lines	Total costs, MNT	
			At 2017 prices	At 2010 prices
F1	1	150	8,920,462	5,533,785
F2	2	10000	33,611,221	20,850,633
F3	3	5000	33,611,221	20,850,633
F4	4	1500	33,611,221	20,850,633
F5	5	2500	33,611,221	20,850,633
F6	6	750	31,456,686	19,514,073
F7	7	200	34,890,558	21,644,267
F8	8	80	35,800,190	22,208,555
F9	9	60	35,800,190	22,208,555
F10	10	50	36,839,375	22,853,210
F11	11	32	36,839,375	22,853,210
F12	12	31	36,839,375	22,853,210
Total		20,353	391,831,095	243,071,399
Total in USD (USD 1 = MNT 2440.6 in 2017 and MNT 1355.9 in 2010)			160,547	179,269

2.3 Estimated costs of potato breeding

The total cost of the potato breeding program of IPAS that shall result in the release of a new variety were estimated at MNT 236.2 million (USD 107.8 thousand) at 2017 prices and MNT 163.3 million (USD 120.4 thousand) at 2010 prices (Tables 2.8 and 2.9).

The quantity of elite seed potatoes that the breeding program would be able to supply upon its completion was estimated at 3.4 tons.

Table 2.8: Estimated total costs of the potato breeding program of IPAS, at 2017 prices

Stage	Year	Number of plants	Costs, MNT			
			Labour costs	Operational costs	Capital costs and overheads	Total
F0	2012	50-80 varieties	14,646,226	738,000	0	15,384,226
F1	2013	30-50 crosses	14,646,226	18,000	2,654,167	17,318,392
F2	2014	5000-10000 plants	14,646,226	68,000	5,555,263	20,269,489
F3	2015	5000-10000 tubers	14,646,226	18,000	1,960,000	16,624,226
F4	2016	500-600 clones	20,903,825	18,000	1,930,000	22,851,825
F5	2017	70-80 clones	20,903,825	1,438,960	2,151,667	24,494,451
F6	2018	15-20 clones	20,903,825	228,000	2,101,667	23,233,491
F7	2019	15-20 clones	20,903,825	228,000	2,101,667	23,233,491
F8	2020	6-8 clones	14,646,226	18,000	1,965,000	16,629,226
F9	2021	6-8 clones	14,646,226	18,000	1,965,000	16,629,226
F10	2022	6-8 clones	14,646,226	18,000	1,965,000	16,629,226
F11	2023	4-5 clones	14,646,226	18,000	1,965,000	16,629,226
F12	2024	4-5 clones	14,646,226	18,000	1,965,000	16,629,226
F13	2025	4-5 clones	14,646,226	18,000	1,965,000	16,629,226
Total			230,077,555	2,862,960	30,244,430	263,184,945
Total in USD (USD 1= MNT 2440.6)			94,271	1,173	12,392	107,836
Share in total costs			87.4%	1.1%	11.5%	100%

Table 2.9: Estimated total costs of the potato breeding program of IPAS, at 2010 prices

Stage	Year	Number of plants	Costs, MNT			
			Labour costs	Operational costs	Capital costs and overheads	Total
F0	2012	50-80 varieties	9,085,748	457,816	0	9,543,564
F1	2013	30-50 crosses	9,085,748	11,166	1,646,505	10,743,420
F2	2014	5000-10000 plants	9,085,748	42,184	3,446,193	12,574,125
F3	2015	5000-10000 tubers	9,085,748	11,166	1,215,881	10,312,795
F4	2016	500-600 clones	12,967,633	11,166	1,197,270	14,176,070
F5	2017	70-80 clones	12,967,633	892,655	1,334,781	15,195,069
F6	2018	15-20 clones	12,967,633	141,439	1,303,763	14,412,836
F7	2019	15-20 clones	12,967,633	141,439	1,303,763	14,412,836
F8	2020	6-8 clones	9,085,748	11,166	1,218,983	10,315,897
F9	2021	6-8 clones	9,085,748	11,166	1,218,983	10,315,897
F10	2022	6-8 clones	9,085,748	11,166	1,218,983	10,315,897
F11	2023	4-5 clones	9,085,748	11,166	1,218,983	10,315,897
F12	2024	4-5 clones	9,085,748	11,166	1,218,983	10,315,897
F13	2025	4-5 clones	9,085,748	11,166	1,218,983	10,315,897
Total			142,728,012	1,776,030	18,762,053	163,266,095
Total in USD (USD 1 = MNT 1355.9)			105264	1310	13837	120412
Share in total costs			87.4%	1.1%	11.5%	100%

3. PROFITABILITY AND IMPACT ASSESSMENT OF PUBLIC INVESTMENTS IN REGIONAL SEED MULTIPLICATION CENTRES

3.1 Material and methods

3.1.1 Purpose and design of the assessment

This assessment examines the profitability and impacts of public investments in hypothetical Seed Multiplication Centres (SMCs) in the Central, Western and Eastern regions. The underlying assumption is that the SMCs shall be able to generate sufficient incomes through seed multiplication as to sustain their operation without any further support from the government.

The investment appraisal is based on the Cost-Benefit Analysis (CBA) method and the impact assessment uses the Policy Analysis Matrix (PAM) framework.

3.1.2 Basic assumptions

Locations of the SMCs: The SMCs will be instructed and supervised by the IPAS in Darkhan-Uul aimag and its regional branches in Uws and Dornod aimags. Accordingly, the locations of the SMCs are:

- Central region: Darkhan-Uul aimag, Khongor soum;
- Western region: Uws aimag, Baruunturuun soum; and
- Eastern region: Dornod aimag, Sumber soum.

Scope of operation: Given the strategic importance of wheat, the SMCs shall be specialised on multiplication of elite and certified seeds of wheat. Each SMC has a total cultivation area of 1000 hectares and uses the typical wheat-fallow rotation: 500 ha will be sown each year and the remaining 500 ha will lay fallow. Per-hectare yields will vary, depending on weather conditions, between 1 and 1.89 tons. Accordingly, the total harvest will be between 600 to 935 tons. At a cleaning rate of 80%, the SMCs together will produce 1320 to 2168 tons of elite and certified wheat seed per year, in addition to 330 to 542 tons of grain sold as bread wheat (cf. sections 4.3 to 4.5).

Staffing and salary fund: Each SMC will be staffed with 7 employees in total and the salary fund will be MNT 60.6 million per year (Table 3.1).

Table 3.1: Staff positions and salary fund of each Seed Multiplication Centre

№	Position	Monthly salary, MNT	Annual salary, MNT
1	Director	900	10,800
2	Accountant & Sales manager	800	9,600
3	Threshing floor manager	750	9,000
4	Seed agronomist	750	9,000
5	Seed centre engineer	750	9,000
6	Mechanic	600	7,200
7	Guard	500	6,000
	Total	5050	60,600

3.1.3 Cost-Benefit Analysis

The CBA assesses the profitability of a project by comparing costs and benefits over a specific period. The CBA is a financial analysis from an entrepreneur's perspective, but it is also an economic analysis from a societal perspective since it reveals the costs and benefits of a project to the society as a whole, regardless of who pays and who gains. While a financial analysis performed through the CBA method is concerned with real costs and benefits at market prices an economic analysis using the CBA method incorporates direct and indirect effects of a project at the community, region or country level, in addition to comparing costs and benefits using economic prices that are converted from the market price by excluding tax, profit, subsidy, etc. to measure the legitimacy of using national resources to certain projects.

In this analysis, we performed both financial and economic analysis over a period of 10 years for assessing the profitability of the hypothetical SMCs. Profitability is measured using two indicators: Net Present Value (NPV) and Internal Rate of Return (IRR). A project is considered acceptable if the NPV equals zero or is positive and the IRR is equal or higher than the discount rate determined in the CBA.

Production costs of the SMCs were estimated using standardised technological cards[3] based on 2017 prices and the assumptions in section 3.1.2. Economic values were determined using the specific and standard conversion factors defined in the GDP National Accounts of 2016 and 2017.

3.1.4 Policy Analysis Matrix

The policy analysis matrix (PAM) provides a framework for assessing the impacts of government intervention in certain production systems. The PAM can be described as a product of two accounting identities: one defining profit as the difference between revenues and costs and the other measuring the effects of divergence (distorting policies and market failures) as the difference between observed parameters and parameters that would exist if the divergences were removed.

The two distinct characteristics of PAM are the classification or disaggregation of the costs of inputs into their tradable and non-tradable components and the valuation of revenues, costs and benefits using both market (private) and efficiency (social, shadow or economic) prices. Private profit measures the private profitability faced by the producer for the production of a certain product. Social profit is a measure of social profitability (Table 3.2).

Table 3.2: Structure of the Policy Analysis Matrix (PAM)

Category	Revenues	Tradable Inputs	Non-tradeable inputs		Profits
			Labour	Capital	
Private	A	B	C	C	D (private profit) =A-B-C
Social	E	F	G	G	H (social profit) =E-F-G
Divergences	I (output transfer) =A-E	J (tradable input transfer) =B-F	K (non-tradable input transfer) =C-G	K (non-tradable input transfer) =C-G	L (net transfer) =D-H=I-J-K

Source: Monke & Pearson (1989).

[3] A 'technological card' is a sheet for cost calculation in crop production, specifying inputs and related costs for each process required for growing and harvesting a certain crop on a specified size of arable land. An example is provided in Appendix 1.

The measures shown in Table 3.2 are absolute figures that provide information on the extent of profitability and distortions faced by production systems. To be used in comparative assessments these figures are turned into a set of relative indicators. The indicators are broadly categorised into:

- Profitability and value-added indicators using market prices (such as Private Cost Ratio and Private Value-Added Ratio, which inform about the impacts of policy interventions under investigation on private agents;
- Profitability and value-added indicators at reference prices (such as Domestic Resource Cost Ratio and Social Value-Added Ratio), which use economic prices to assess profitability and value-added intensity of interventions; and
- Protection indicators[4] (such as Nominal Protection Coefficient on Outputs, Nominal Protection Coefficient on tradable inputs and Effective Protection Coefficient).

The indicators used in assessment of the impacts of public investments in regional SMCs are described in Table 3.3.

Table 3.3: Indicators used in the PAM analysis

Indicator	Formula	Interpretation
Private Cost Ratio (PCR)	PCR=C/(A-B)	If PCR=1, the activity breaks even (D=0); If PCR>1, the activity generates losses (D<0); If 0<PCR<1, the activity generates profit (D>0).
Domestic Resource Cost Ratio (DRC)	DCR=G/(E-F)	If DRC=0, the opportunity cost of factors is zero If 0<DRC<1, part of the value added is absorbed to remunerate factors at their opportunity cost and the remainder generates profit; If DRC=1, the activity breaks even; If DRC>1, the activity generates losses
Nominal Protection Coefficient on Outputs (NPCO)	NPCO=A/E	If NPCO>1, producers are benefitting the protection, having higher revenues at market prices than the revenues accruing to the society; If NPCO<1, producers are negatively affected by the prevailing policy and market setting as they produce more revenue accruing to the society than what they receive.
Nominal Protection Coefficient on tradable inputs (NPCI)	NPCI=B/F	If NPCI>1, private agents pay higher prices than the opportunity costs to the society to get the inputs, thus implicitly transferring wealth to the society through the consumption of such inputs; If NPCI<1, producers pay less than the cost accruing to the society to use the inputs in the production process.
Effective Protection Coefficient (EPC)	EPC=(A-B)/(E-F)	If EPC>1, private agents enjoy a higher value added than the society, thus benefitting from a net transfer from the society to engage in such activity; If EPC<1, private agents enjoy a lower value added than the society, thus transferring in various forms portions of the value added they generate to the society.

[4] Market imperfections and policy failures materialize in the form of incentives or disincentives to private agents which alter their revenues, costs and related margins with respect to what would happen under optimum conditions. Increases in revenues and/or reduction of costs constitute implicit transfers from the society to private agents which protect them from competitors, who do not benefit from the same transfers, on the output or input and factor markets. On the other hand, decreases of revenues and/or increases of costs constitute implicit outlays from private agents to the society, which act as a negative protection and weaken the position of private agents with respect to competitors who do not bear this burden.

3.2 Investment requirements

Each SMC requires a total investment of MNT 768.1 million, with facilities and equipment accounting for 22% and 78% of the total requirement, respectively (Table 3.4).

Table 3.4: Investment requirement of the Seed Multiplication Centre

Items	Model name/Capacity	No. of pieces	Unit price	Total price	Depreciation
Grain bin	100 ton	1	40.0	40.0	1.60
Paved area	20x50m concrete	1	15.0	15.0	0.19
Office	6x10m sandwich building	1	30.0	30.0	1.58
Office supplies	Computer, Lab equipment	1	20.0	20.0	1.60
Seed lab equipment	Miscellaneous items			55.0	4.40
Fence		1	11.0	11.0	0.58
Facilities subtotal				171.0	9.95
Tractor	MTZ-1221.2 or John Deere-1024	1	100.0	100.0	8
Combine	Sampo 2025	1	180.0	180.0	14.4
Tank trailer	500 l	1	6.6	6.6	0.5
Trolley	TL 1000	1	2.1	2.1	0.2
Plough	PLN-4-35	1	8.8	8.8	1.0
Grain loader	ZPS-100	1	8.6	8.6	0.7
Cultivator	Lider-4	1	15.0	15.0	1.7
Sprayer	Eurolux 800 TM	1	40.0	40.0	3.2
Seeder	Omichka	1	38.0	38.0	3.0
Grain grader	CM-4	1	27.6	27.6	2.2
Seed cleaner	OBC25	1	34.5	34.5	2.8
Disc harrow	5.4m wide	1	10.9	10.9	1.2
Harvester roll	ZhVK-6	1	6.5	6.5	0.5
Combine	SK-5ME-1 Niva Effect	1	105.5	105.5	8.4
Lorry	Kia	1	13.0	13.0	1.0
Equipment subtotal				597.1	48.9
Total				768.1	58.9

3.3 Cost-Benefit Analysis

3.3.1 Seed Multiplication Centre in the Central region

Summary of revenues and costs

Based on the assumptions in section 4.1.3 and cost calculations based on technological cards (cf. Appendix 1), the revenues and costs of wheat seed production were estimated at three (medium, low, minimum) risk levels, which primarily relate to weather conditions. Depending on the risk level, the net revenue of the SMC ranges between MNT 442.3 million and MNT 703.5 million, the total costs between MNT 385 million and MNT 390.4 million, and the net profit between MNT 57.4 million and MNT 313.1 million, respectively (Table 3.5).

Table 3.5: Revenue and production costs of a hypothetical Seed Multiplication Centre in the Central region at different levels of production risks

Items	Medium-risk scenario	Low-risk scenario	Minimum-risk scenario
Sown area, ha	500	500	500
Yield before cleaning, ton per ha	1.2	1.54	1.87
Total harvest, ton	600	770	935

Cleaning rate	80%	80%	80%
Amount of wheat seed sold, ton	480	616	748
Amount of bread wheat sold, ton	120	154	187
Price of wheat seed, MNT 1000 per ton	830	850	850
Price of bread wheat, MNT 1000 per ton	560	560	560
Sales revenue, MNT	465,600	609,840	740,520
Income tax, MNT	23,280	30,492	37,026
Net revenue, MNT	442,320	579,348	703,494
Operational costs, MNT			
Salary	5,521	6,055	6,573
Social insurance,12%	663	727	789
Fuel & lubricants	48,649	49,014	49,368
Seed & fertilizer	161,000	161,000	161,000
Electricity	4301	553	672
Transport	4,295	4,684	5,062
Food	6,930	7,277	7,640
Repairs & maintenance	41,869	42,679	43,465
Occupational Safety	1,675	1,675	1,675
Package	6,000	7,700	9,350
Depreciation	37,105	37,674	38,226
Others	2,868	2,008	1,147
Land payment	1,500	1,500	1,500
Subtotal operating costs, MNT	*318,505*	*322,544*	*326,466*
Management costs, MNT			
Salary	55,079	54,545	54,027
Social insurance,12%	6,610	6,545	6,483
Fuel	2,419	2,228	2,212
Seed certification service	768	768	768
Others	1,579	1,106	474
Subtotal management costs	*66,454*	*65,192*	*63,964*
Total costs, MNT	384,959	387,735	390,430
Net profit, MNT	57,361	191,613	313,064

Financial analysis

The financial analysis reveals that the SMC will be profitable, hence able to sustain its operation without any support. The initial investment will be paid back within 9 years. The NPV is MNT 178.9 million and the IRR is 15.9% at a discount rate of 12% for a 10-year horizon (Table 3.6).

Economic analysis

The economic analysis indicates even higher profitability of the SMC. At an NPV of MNT 629.9 million and an IRR of 28.1%, the investment can be recovered within 6 years (Table 3.7).

Table 3.6: Financial analysis of a hypothetical Seed Multiplication Centre in the Central region

	Investme	1	2	3	4	5	6	7	8	9	10
Seede price		830	830	830	850	850	850	850	850	850	850
Wheat price		560	560	560	560	560	560	560	560	560	560
Total harvest		600	600	600	770	770	770	935	935	935	935
Sale amount, t ton		480	480	480	616	616	616	748	748	748	748
Revenue		465600	465600	465600	609840	609840	609840	740520	740520	740520	740520
Revenue tax		23280	23280	23280	30492	30492	30492	37026	37026	37026	37026
Revenue after tax		442320	442320	442320	579348	579348	579348	703494	703494	703494	703494
Operational cost											
Salary		5521.0	5521.0	5521.0	6054.8	6054.8	6054.8	6572.9	6572.9	6572.9	6572.9
Social insurance premiume		662.5	662.5	662.5	726.6	726.6	726.6	788.8	788.8	788.8	788.8
Fuel and labricants		48648.9	48648.9	48648.9	49013.6	49013.6	49013.6	49367.5	49367.5	49367.5	49367.5
Seed and chemicals		161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0
Electricity		430.9	430.9	430.9	553.0	553.0	553.0	671.5	671.5	671.5	671.5
Transport		4295.0	4295.0	4295.0	4684.0	4684.0	4684.0	5061.5	5061.5	5061.5	5061.5
Food		6930.0	6930.0	6930.0	7276.5	7276.5	7276.5	7640.3	7640.3	7640.3	7640.3
Repairs and maintanence		41868.6	41868.6	41868.6	42678.8	42678.8	42678.8	43465.1	43465.1	43465.1	43465.1
Occupational safety		1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8
Packages		6000.0	6000.0	6000.0	7700.0	7700.0	7700.0	9350.0	9350.0	9350.0	9350.0
Depreciation		37105.2	37105.2	37105.2	37674.1	37674.1	37674.1	38226.2	38226.2	38226.2	38226.2
Other costs		2868.0	2868.0	2868.0	2007.6	2007.6	2007.6	1147.2	1147.2	1147.2	1147.2
Land payment		1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Total operational cost		**318504.8**	**318504.8**	**318504.8**	**322543.6**	**322543.6**	**322543.6**	**326465.9**	**326465.9**	**326465.9**	**326465.9**
Management cost											
Salary		55079.0	55079.0	55079.0	54545.2	54545.2	54545.2	54027.1	54172.0	54172.0	54172.0
Social insurance premiume		6609.5	6609.5	6609.5	6545.4	6545.4	6545.4	6483.2	6500.6	6500.6	6500.6
Fuel and labricants		2418.9	2418.9	2418.9	2227.8	2227.8	2227.8	2212.0	2212.0	2212.0	2212.0
Seed sertification service		767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7
Other costs		1579.3	1579.3	1579.3	1105.5	1105.5	1105.5	473.8	473.8	473.8	473.8
Total management cost		**66454.4**	**66454.4**	**66454.4**	**65191.6**	**65191.6**	**65191.6**	**63963.8**	**64126.1**	**64126.1**	**64126.1**
Total cost		**384959.2**	**384959.2**	**384959.2**	**387735.3**	**387735.3**	**387735.3**	**390429.7**	**390592.0**	**390592.0**	**390592.0**
Investment											
Building and constraction	170950.0	22%									
Mashinery and equipment	597100.0	78%									
Total investment	768050										
Net income	-768050	**57360.8**	**57360.8**	**57360.8**	**191612.7**	**191612.7**	**191612.7**	**313064.3**	**312902.0**	**312902.0**	**312902.0**
Profitability		0.15	0.15	0.15	0.49	0.49	0.49	0.80	0.80	0.80	0.80
Discount rate	**0.12**	**NPV_{10}=**	**178869.4**	**IRR_{10}=**	**15.9%**						
				9							

Table 3.7: Economic analysis of a hypothetical Seed Multiplication Centre in the Central region

	Conversion factors	Investme	1	2	3	4	5	6	7	8	9	10
Seede price			830	830	830	850	850	850	850	850	850	850
Wheat price			560	560	560	560	560	560	560	560	560	560
Total harvest,ton			700	700	700	825	825	825	850	850	850	850
Sale amount, ton			560	560	560	660	660	660	680	680	680	680
Revenue	0.987		459547.2	459547.2	459547.2	601912.1	601912.1	601912.1	730893.2	730893.2	730893.2	730893.2
Revenue tax												
Revenue after tax			459547.2	459547.2	459547.2	601912.1	601912.1	601912.1	730893.2	730893.2	730893.2	730893.2
Operational cost												
Salary	1		5521.0	5521.0	5521.0	6054.8	6054.8	6054.8	6572.9	6572.9	6572.9	6572.9
Social insurance premiume												
Fuel and labri	0.988		48065.2	48065.2	48065.2	48425.4	48425.4	48425.4	48775.1	48775.1	48775.1	48775.1
Seed and cher	0.969		156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0
Electricity	0.96		413.7	413.7	413.7	530.9	530.9	530.9	644.7	644.7	644.7	644.7
Transport	1		4295.0	4295.0	4295.0	4684.0	4684.0	4684.0	5061.5	5061.5	5061.5	5061.5
Food	0.969		6715.2	6715.2	6715.2	7050.9	7050.9	7050.9	7403.5	7403.5	7403.5	7403.5
Repairs and m	0.71		29726.7	29726.7	29726.7	30301.9	30301.9	30301.9	30860.2	30860.2	30860.2	30860.2
Occupational safety			1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8
Packages			6000.0	6000.0	6000.0	7700.0	7700.0	7700.0	9350.0	9350.0	9350.0	9350.0
Depreciation			37105.2	37105.2	37105.2	37674.1	37674.1	37674.1	38226.2	38226.2	38226.2	38226.2
Other costs			2868.0	2868.0	2868.0	2007.6	2007.6	2007.6	1147.2	1147.2	1147.2	1147.2
Land payment			1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0
Total operational cost			**299893.5**	**299893.5**	**299893.5**	**303613.4**	**303613.4**	**303613.4**	**307225.1**	**307225.1**	**307225.1**	**307225.1**
Management cost												
Salary	1		55079.0	55079.0	55079.0	54545.2	54545.2	54545.2	54027.1	54172.0	54172.0	54172.0
Social insurance premiume												
Fuel and labri	0.988		2389.8	2389.8	2389.8	2201.1	2201.1	2201.1	2185.5	2185.5	2185.5	2185.5
Seed sertification service			767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7
Other costs			1579.3	1579.3	1579.3	710.7	710.7	710.7	473.8	473.8	473.8	473.8
Total management cost			**59815.9**	**59815.9**	**59815.9**	**58224.7**	**58224.7**	**58224.7**	**57454.0**	**57598.9**	**57598.9**	**57598.9**
Total cost			**359709.4**	**359709.4**	**359709.4**	**361838.0**	**361838.0**	**361838.0**	**364679.1**	**364824.1**	**364824.1**	**364824.1**
Investment												
Building and constraction		170950.0	22%									
Mashinery and equipment		597100.0	78%									
Total investm	0.76	583718.0										
Net income		#######	**99837.8**	**99837.8**	**99837.8**	**240074.1**	**240074.1**	**240074.1**	**366214.1**	**366069.2**	**366069.2**	**366069.2**
Profitability			0.28	0.28	0.28	0.66	0.66	0.66	1.00	1.00	1.00	1.00
Discount rate		**0.12**	**NPV_{10}=**	**629879**	**IRR_{10}=**	**28.1%**						
				6								

3.3.2 Seed Multiplication Centre in the Western Region

Summary of revenues and costs

Depending on the level of production risks, the net revenue of the hypothetical SMC in the Western region ranges between MNT 405.5 million and MNT 624.5 million, total costs between MNT 384.1 million and MNT 388.7 million, and the net profit between MNT 21.3 million and MNT 235.8 million, respectively (Table 3.8).

Table 3.8: Revenue and production costs of a hypothetical Seed Multiplication Centre in the Western region at different levels of production risks

Items	Medium-risk scenario	Low-risk scenario	Minimum-risk scenario
Sown area, ha	500	500	500
Yield before cleaning, ton per ha	1.10	1.38	1.66
Total harvest, ton	550	690	830
Cleaning rate	80%	80%	80%

Amount of wheat seed sold, ton	440	552	664
Amount of bread wheat sold, ton	110	138	166
Price of wheat seed, MNT 1000 per ton	830	830	850
Price of bread wheat, MNT 1000 per ton	560	560	560
Sales revenue, MNT	426,800	546,480	657,360
Income tax, MNT	21,340	27,324	32,868
Net revenue, MNT	405,460	519,156	624,492
Operational costs, MNT			
Salary	5,364	5,804	6,243
Social insurance,12%	644	696	749
Fuel & lubricants	41,630	42,298	42,965
Seed & fertilizer	161,000	161,000	161,000
Electricity	395	496	596
Transport	4,181	4,501	4,821
Food	6,930	7,277	7,640
Repairs & maintenance	42,622	42,741	42,860
Occupational Safety	1,675	1,675	1,675
Package	11,000	13,800	16,600
Depreciation	36,938	37,406	37,875
Others	3,015	2,882	1,232
Land payment	1,500	1,500	1,500
Subtotal operating costs, MNT	*316,893*	*320,575*	*324,257*
Management costs, MNT			
Salary	55,236	54,796	54,357
Social insurance,12%	6,628	6,576	6,523
Fuel	1,607	1,607	1,607
Seed certification service	768	768	768
Others	3,011	2,108	1,205
Subtotal management costs	*67,250*	*65,854*	*64,459*
Total costs, MNT	384,143	386,429	388,715
Net profit, MNT	21,317	132.727	235,777

Financial analysis

The financial analysis reveals a profitability index between 0.06 and 0.6, hence indicating a profitable operation of the hypothetical SMC in the Western region. The investment will be recovered in 10 years. The NPV is MNT 19.2 million and the IRR is 12.5 percent (Table 3.9).

Economic analysis

The economic analysis reveals an NPV of MNT 460 million, an IRR of 25.4% and an investment recovery period of 6 years (Table 3.10).

Table 3.9: Financial analysis of a hypothetical Seed Multiplication Centre in the Western region

	Investme	1	2	3	4	5	6	7	8	9	10
Seede price		830	830	830	850	850	850	850	850	850	850
Wheat price		560	560	560	560	560	560	560	560	560	560
Total harvest,ton		550	690	690	690	690	690	830	830	830	830
Sale amount, ton		440	552	552	552	552	552	664	664	664	664
Revenue		426800.0	535440.0	535440.0	546480.0	546480.0	546480.0	657360.0	657360.0	657360.0	657360.0
Revenue tax		21340.0	26772.0	26772.0	27324.0	27324.0	27324.0	32868.0	32868.0	32868.0	32868.0
Revenue after tax		405460.0	508668.0	508668.0	519156.0	519156.0	519156.0	624492.0	624492.0	624492.0	624492.0
Operational cost											
Salary		5364.0	5803.6	5803.6	5803.6	5803.6	5803.6	6243.2	5268.0	5268.0	5268.0
Social insurance premiume		643.7	696.4	696.4	696.4	696.4	696.4	749.2	632.2	632.2	632.2
Fuel and labricants		41630.4	42297.6	42297.6	42297.6	42297.6	42297.6	42964.7	42964.7	42964.7	42964.7
Seed and chemicals		161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0
Electricity		395.0	495.6	495.6	495.6	495.6	495.6	596.1	596.1	596.1	596.1
Transport		4180.5	4500.9	4500.9	4500.9	4500.9	4500.9	4821.3	4821.3	4821.3	4821.3
Food		6930.0	7276.5	7276.5	7276.5	7276.5	7276.5	7640.3	7640.3	7640.3	7640.3
Repairs and maintanence		42621.9	42741.05	42741.05	42741.05	42741.05	42741.05	42860.19	42860.19	42860.19	42860.19
Occupational safety		1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8
Packages		11000.0	13800.0	13800.0	13800.0	13800.0	13800.0	16600.0	16600.0	16600.0	16600.0
Depreciation		36937.8	37406.3	37406.3	37406.3	37406.3	37406.3	37874.9	37874.9	37874.9	37874.9
Other costs		3014.5	2881.9	2881.9	2881.9	2881.9	2881.9	1231.9	1231.9	1231.9	1231.9
Land payment		1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Total operational cost		**316892.6**	**322074.5**	**322074.5**	**322074.5**	**322074.5**	**322074.5**	**325756.5**	**324664.3**	**324664.3**	**324664.3**
Management cost											
Salary		55236.04	54796.42	54796.42	54796.42	54796.42	54796.42	54356.8	54356.8	54356.8	54356.8
Social insurance premiume		6628.3	6575.6	6575.6	6575.6	6575.6	6575.6	6522.8	6522.8	6522.8	6522.8
Fuel and labricants		1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7
Seed sertification service		767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7
Other costs		3011.4	2108.0	2108.0	2108.0	2108.0	2108.0	1204.6	1204.6	1204.6	1204.6
Total management cost		**67250.2**	**65854.4**	**65854.4**	**65854.4**	**65854.4**	**65854.4**	**64458.6**	**64458.6**	**64458.6**	**64458.6**
Total cost		**384142.7**	**387928.9**	**387928.9**	**387928.9**	**387928.9**	**387928.9**	**390215.1**	**389122.8**	**389122.8**	**389122.8**
Investment											
Building and constraction	170950.0	22%									
Mashinery and equipment	597100.0	78%									
Total investment	768050										
Net income	-768050	**21317.3**	**120739.1**	**120739.1**	**131227.1**	**131227.1**	**131227.1**	**234276.9**	**235369.2**	**235369.2**	**235369.2**
Profitability		0.06	0.31	0.31	0.34	0.34	0.34	0.60	0.60	0.60	0.60
Discount rate	**0.12**	**NPV_{10}=**	**19213.9**	**IRR_{10}=**	**12.5%**						
			10								

Table 3.10: Economic analysis of a hypothetical Seed Multiplication Centre in the Western region

	Conversion factors	Investme	1	2	3	4	5	6	7	8	9	10
Seede price			830	830	830	850	850	850	850	850	850	850
Wheat price			560	560	560	560	560	560	560	560	560	560
Total harvest,ton			550	690	690	690	690	690	830	830	830	830
Sale amount, ton			440	552	552	552	552	552	664	664	664	664
Revenue	0.986		420824.8	527943.8	527943.8	538829.3	538829.3	538829.3	648157.0	648157.0	648157.0	648157.0
Revenue tax												
Revenue after tax			420824.8	527943.8	527943.8	538829.3	538829.3	538829.3	648157.0	648157.0	648157.0	648157.0
Operational cost												
Salary	1		5364.0	5803.6	5803.6	5803.6	5803.6	5803.6	6243.2	5268.0	5268.0	5268.0
Social insurance premiume			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel and labri	0.988		41130.8	41790.0	41790.0	41790.0	41790.0	41790.0	42449.2	42449.2	42449.2	42449.2
Seed and cher	0.969		156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0
Electricity	0.96		379.2	475.7	475.7	475.7	475.7	475.7	572.3	572.3	572.3	572.3
Transport	1		4180.5	4500.9	4500.9	4500.9	4500.9	4500.9	4821.3	4821.3	4821.3	4821.3
Food	0.969		6715.2	7050.9	7050.9	7050.9	7050.9	7050.9	7403.5	7403.5	7403.5	7403.5
Repairs and m	0.71		30261.6	30346.1	30346.1	30346.1	30346.1	30346.1	30430.7	30430.7	30430.7	30430.7
Occupational safety			1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8
Packages			11000.0	13800.0	13800.0	13800.0	13800.0	13800.0	16600.0	16600.0	16600.0	16600.0
Depreciation			36937.8	37406.3	37406.3	37406.3	37406.3	37406.3	37874.9	37874.9	37874.9	37874.9
Other costs			3014.5	2881.9	2881.9	2881.9	2881.9	2881.9	1231.9	1231.9	1231.9	1231.9
Land payment			1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0
Total operational cost			**298167.3**	**303239.2**	**303239.2**	**303239.2**	**303239.2**	**303239.2**	**306810.6**	**305835.4**	**305835.4**	**305835.4**
Management cost												
Salary	1		55236.0	54796.4	54796.4	54796.4	54796.4	54796.4	54356.8	54356.8	54356.8	54356.8
Social insurance premiume			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel and labri	0.988		1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4
Seed sertification service			767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7
Other costs			3011.4	2108.0	2108.0	2108.0	2108.0	2108.0	1204.6	1204.6	1204.6	1204.6
Total management cost			**60602.5**	**59259.5**	**59259.5**	**59259.5**	**59259.5**	**59259.5**	**57916.5**	**57916.5**	**57916.5**	**57916.5**
Total cost			**358769.9**	**362498.7**	**362498.7**	**362498.7**	**362498.7**	**362498.7**	**364727.1**	**363751.8**	**363751.8**	**363751.8**
Investment												
Building and constraction		170950.0	22%									
Mashinery and equipment		597100.0	78%									
Total investm	0.76	583718.0										
Net income		#######	**62054.9**	**165445.1**	**165445.1**	**176330.5**	**176330.5**	**176330.5**	**283429.9**	**284405.1**	**284405.1**	**284405.1**
Profitability			0.17	0.46	0.46	0.49	0.49	0.49	0.78	0.78	0.78	0.78
Discount rate		**0.12**	**NPV_{10}=**	**459997**	**IRR_{10}=**	**25.4%**						
				6								

3.3.3 Seed Multiplication Centre in the Eastern Region

Summary of revenues and costs

Depending on the level of production risks, the net revenue of the hypothetical SMC in the Eastern region ranges between MNT 368.6 million and MNT 711 million, total costs between MNT 383.3 million and MNT 390.6 million, and the net loss/profit between MNT -14.7 million and MNT 320.4 million, respectively (Table 3.11).

Table 3.11: Revenue and production costs of hypothetical a Seed Multiplication Centre in Eastern region at different levels of production risks

Items	Medium-risk scenario	Low-risk scenario	Minimum-risk scenario
Sown area, ha	500	500	500
Yield before cleaning, ton per ha	1.00	1.45	1.89
Total harvest, ton	500	725	945
Cleaning rate	80%	80%	80%

Amount of wheat seed sold, ton	400	580	756
Amount of bread wheat sold, ton	100	145	189
Price of wheat seed, MNT 1000 per ton	830	850	850
Price of bread wheat, MNT 1000 per ton	560	560	560
Sales revenue, MNT	388,000	574,200	748,440
Income tax, MNT	19,400	28,710	37,422
Net revenue, MNT	368,600	545,490	711,018
Operational costs, MNT			
Salary	5,207	5,914	6,604
Social insurance,12%	625	710	793
Fuel & lubricants	48,434	48,917	49,389
Seed & fertilizer	161,000	161,000	161,000
Electricity	359	521	679
Transport	4,066	4,581	5,084
Food	6,930	6,999	7,034
Repairs & maintenance	41,392	42,464	43,513
Occupational Safety	1,675	1,675	1,675
Package	6,191	8,976	11,700
Depreciation	36,771	37,524	38,260
Others	3,752	2,627	721
Land payment	1,500	1,500	1,500
Subtotal operating costs, MNT	317,902	321,907	326,451
Management costs, MNT			
Salary	54,885	54,806	54,726
Social insurance,12%	6,586	6,577	6,567
Fuel	1,607	1,607	1,607
Seed certification service	768	768	768
Others	1,579	1,337	474
Subtotal management costs	65,425	65,094	64,142
Total costs, MNT	383,326	387,000	390,593
Net profit, MNT	-14,726	158,490	320,425

Financial analysis

The financial analysis reveals a negative profitability index for the medium-risk scenario, hence indicating that the hypothetical SMC in the Eastern region will only be profitable in low- and minimum-risk scenarios. The investment recover period is 10 years. The NPV is MNT 70.1 million and the IRR is 13.5 percent (Table 3.12).

Economic analysis

The economic analysis reveals an NPV of MNT 535.1 million, an IRR of 24.8% and an investment recovery period of 7 years (Table 3.13).

Table 3.12: Financial analysis of a hypothetical Seed Multiplication Centre in the Eastern region

	Investme	1	2	3	4	5	6	7	8	9	10
Seede price		830	830	830	850	850	850	850	850	850	850
Wheat price		560	560	560	560	560	560	560	560	560	560
Total harvest,ton		500	500	725	725	725	725	945	945	945	945
Sale amount, ton		400	400	580	580	580	580	756	756	756	756
Revenue		388000.0	388000.0	562600.0	574200.0	574200.0	574200.0	748440.0	748440.0	748440.0	748440.0
Revenue tax		19400.0	19400.0	28130.0	28710.0	28710.0	28710.0	37422.0	37422.0	37422.0	37422.0
Revenue after tax		368600.0	368600.0	534470.0	545490.0	545490.0	545490.0	711018.0	711018.0	711018.0	711018.0
Operational cost											
Salary		5206.9	5206.9	5913.5	5913.5	5913.5	5913.5	6604.3	6604.3	6604.3	6604.3
Social insurance premiume		624.8	624.8	709.6	709.6	709.6	709.6	792.5	792.5	792.5	792.5
Fuel and labricants		48434.4	48434.4	48917.1	48917.1	48917.1	48917.1	49389.0	49389.0	49389.0	49389.0
Seed and chemicals		161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0	161000.0
Electricity		359.1	359.1	520.7	520.7	520.7	520.7	678.7	678.7	678.7	678.7
Transport		4066.1	4066.1	4581.0	4581.0	4581.0	4581.0	5084.401	5084.401	5084.401	5084.401
Food		6930.0	6930.0	6999.3	6999.3	6999.3	6999.3	7034.3	7034.3	7034.3	7034.3
Repair and maintanence		41392.1	41392.1	42464.3	42464.3	42464.3	42464.3	43512.8	43512.8	43512.8	43512.8
Occupational safety		1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8
Packages		6190.5	6190.5	8976.2	8976.2	8976.2	8976.2	11700.0	11700.0	11700.0	11700.0
Depreciation		36770.5	36770.5	37523.5	37523.5	37523.5	37523.5	38259.7	38259.7	38259.7	38259.7
Other costs		3752.3	3752.3	2626.6	2626.6	2626.6	2626.6	720.8	720.8	720.8	720.8
Land payment		1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Total operational cost		**317901.6**	**317901.6**	**323406.5**	**323406.5**	**323406.5**	**323406.5**	**327951.3**	**327951.3**	**327951.3**	**327951.3**
Management cost											
Salary		54884.79	54884.79	54805.59	54805.59	54805.59	54805.59	54726.38	54726.38	54726.38	54726.38
Social insurance premiume		6586.2	6586.2	6576.7	6576.7	6576.7	6576.7	6567.2	6567.2	6567.2	6567.2
Fuel and labricants		1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7	1606.7
Seed sertification service		767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7
Other costs		1579.3	1579.3	1337.3	1337.3	1337.3	1337.3	473.8	473.8	473.8	473.8
Total management cost		**65424.7**	**65424.7**	**65093.9**	**65093.9**	**65093.9**	**65093.9**	**64141.7**	**64141.7**	**64141.7**	**64141.7**
Total cost		**383326.2**	**383326.2**	**388500.4**	**388500.4**	**388500.4**	**388500.4**	**392093.0**	**392093.0**	**392093.0**	**392093.0**
Investment											
Building and constraction	170950.0	22%									
Mashinery and equipment	597100.0	78%									
Total investment	768050										
Net income	-768050	**-14726.2**	**-14726.2**	**145969.6**	**156989.6**	**156989.6**	**156989.6**	**318925.0**	**318925.0**	**318925.0**	**318925.0**
Profitability		-0.04	-0.04	0.38	0.40	0.40	0.40	0.81	0.81	0.81	0.81
Discount rate	**0.12**	**NPV_{10}=**	**70112.6**	**IRR_{10}=**	**13.5%**						
			10								

Table 3.13: Economic analysis of a hypothetical Seed Multiplication Centre in the Eastern region

	Conversion factors	Investmer	1	2	3	4	5	6	7	8	9	10
Seede price			830	830	830	850	850	850	850	850	850	850
Wheat price			560	560	560	560	560	560	560	560	560	560
Total harvest,ton			500	500	725	725	725	725	945	945	945	945
Sale amount, ton			400	400	580	580	580	580	756	756	756	756
Revenue	0.986		382568.0	382568.0	554723.6	566161.2	566161.2	566161.2	737961.8	737961.8	737961.8	737961.8
Revenue tax												
Revenue after tax			382568.0	382568.0	554723.6	566161.2	566161.2	566161.2	737961.8	737961.8	737961.8	737961.8
Operational cost												
Salary	1		5206.9	5206.9	5913.5	5913.5	5913.5	5913.5	6604.3	6604.3	6604.3	6604.3
Social insurance premiume			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel and l	0.988		47853.2	47853.2	48330.1	48330.1	48330.1	48330.1	48796.3	48796.3	48796.3	48796.3
Seed and	0.969		156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0	156009.0
Electricity	0.96		344.7	344.7	499.9	499.9	499.9	499.9	651.6	651.6	651.6	651.6
Transport	1		4066.1									
Food	0.969		6715.2	6715.2	6782.3	6782.3	6782.3	6782.3	6816.2	6816.2	6816.2	6816.2
Repairs ar	0.71		29388.4	29388.4	30149.7	30149.7	30149.7	30149.7	30894.1	30894.1	30894.1	30894.1
Occupational safety			1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8	1674.8
Packages			6190.5	6190.5	8976.2	8976.2	8976.2	8976.2	11700.0	11700.0	11700.0	11700.0
Depreciation			36770.5	36770.5	37523.5	37523.5	37523.5	37523.5	38259.7	38259.7	38259.7	38259.7
Other costs			3752.3	3752.3	2626.6	2626.6	2626.6	2626.6	720.8	720.8	720.8	720.8
Land payment			1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0
Total operational cost			**299471.6**	**295405.5**	**299985.5**	**299985.5**	**299985.5**	**299985.5**	**303626.8**	**303626.8**	**303626.8**	**303626.8**
Management cost												
Salary	1		54884.8	54884.8	54805.6	54805.6	54805.6	54805.6	54726.4	54726.4	54726.4	54726.4
Social insurance premiume			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel and l	0.988		1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4	1587.4
Seed sertification service			767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7	767.7
Other costs			1579.3	1579.3	1337.3	1337.3	1337.3	1337.3	473.8	473.8	473.8	473.8
Total management cost			**58819.2**	**58819.2**	**58498.0**	**58498.0**	**58498.0**	**58498.0**	**57555.3**	**57555.3**	**57555.3**	**57555.3**
Total cost			**358290.8**	**354224.7**	**358483.4**	**358483.4**	**358483.4**	**358483.4**	**361182.0**	**361182.0**	**361182.0**	**361182.0**
Investment												
Building and constraction		170950.0	22%									
Mashinery and equipment		597100.0	78%									
Total inve	0.76	583718.0										
Net income		-583718.0	**24277.2**	**28343.3**	**196240.2**	**207677.8**	**207677.8**	**207677.8**	**376779.8**	**376779.8**	**376779.8**	**376779.8**
Profitability			0.07	0.08	0.55	0.58	0.58	0.58	1.04	1.04	1.04	1.04
Discount rate		**0.12**	**NPV_{10}=**	**535069**	**IRR_{10}=**	**24.8%**						
				7								

3.4 Results of the Policy Analysis Matrix

The PAM assessment reveals that the SMCs will be economically competitive at current levels of technology, input and output prices and policy transfers, achieving. This is confirmed by a private profit of MNT 262.4 thousand to MNT 383.2 thousand per hectare of seed production and PCR values of the SMCs between 0.560 to 0.657.

The positive social profits of the SMCs imply that these centres will efficiently utilise resources in seed production and be able to survive without further government support. Furthermore, the DRC coefficients of all SMCs are less than unity, thereby indicating that the value of domestic resources (i.e. non-tradable inputs) used in production is lower than the value added. This implies efficient use of domestic resources and socially profitable production. The SMC in the Central region, with the lowest DRC value of 0.479, is most profitable in terms of use of domestic resources.

The NPCO value of 0.963 that applies to all three SMCs indicates that the producers are not protected by policy and that substantial output tax applies. The NPCI values that are greater than unity indicate that the input costs are higher than reference prices, thus implying that the government is not providing incentives to the producers. The EPC values of 0.943 to 0.944 further indicate the absence of protection and negative incentive to SMCs (Tables 3.14 and 3.15).

Table 3.14: Results of the Policy Analysis Matrix

Items	Revenues	Tradable inputs	Domestic resources		Profits
			Labour	Capital	
SMC in the Central region					
Private	1158.7	288.5	135.7	351.3	383.2
Social	1203.8	281.5	121.2	321.0	480.1
Divergences	-45.1	7.0	14.5	30.3	-96.9
SMC in the Western region					
Private	1038.3	273.8	135.7	366.3	262.4
Social	1077.8	267.0	121.2	336.8	352.8
Divergences	-39.5	6.8	14.5	29.5	-90.4
SMC in the Eastern region					
Private	1091.0	287.0	136.0	353.9	314.0
Social	1132.3	280.1	121.4	315.5	415.3
Divergences	-41.3	7.0	14.6	38.4	-101.3

Table 3.15: PAM indicators of the hypothetical Seed Multiplication Centres

Indicator	SMC in the Central region	SMC in the Western region	SMC in the Eastern region
Private Cost Ratio (PCR)	0.560	0.657	0.609
Domestic Resource Cost Ratio (DCR)	0.479	0.565	0.513
Nominal Protection Coefficient on outputs (NPCO)	0.963	0.963	0.963
Nominal Protection Coefficient on tradable inputs (NPCI)	1.025	1.026	1.025
Effective Protection Coefficient (EPC)	0.944	0.943	0.943

4. DEMAND AND SUPPLY MODELS OF SEED AND BREAD WHEAT

4.1 Material and methods

Wheat yield function

The wheat yield function is based on the Hydrothermal Coefficient (HTC), which assesses weather conditions for crop vegetation using precipitation and temperature data. Using weather parameters from the period 2000 to 2017, we determined the HTC for the overall period of vegetation and harvest each year (Table 4.1).

Table 4.1: Hydrothermal Coefficient in the Central region during the period 2000 to 2017

HTC	Level of moisture	Frequency of Occurrence
>1.6	Over moisture	0.0%
1.6-1.3	Sufficient moisture	12.5%
1.3-1	Rather insufficient moisture	43.8%
1-0.7	Drought	37.5%
0.7-0.4	Severe drought	6.2%
<0.4	Extremely dry	0.0%

Consequently, we determined separate HTCs for the vegetation period (May to August) and the harvesting period (August to September):

$$\text{Vegetation period HTC} = (\sum \text{Precipitation}_{\text{May-August}})/(0.1\sum \text{Temperature}_{\text{May-August}})$$

$$\text{Harvesting period HTC} = (\sum \text{Precipitation}_{\text{August-September}})/(0.1\sum \text{Temperature}_{\text{August-September}})$$

The wheat yield (per hectare) function (Q) that resulted from our estimation is:

$$Q = 13.579\text{HTC}_{\text{May-August}} + 6.175\text{D}_{2008} - 5.595\text{HTC}_{\text{August-September}} - 1.5702_{2012} \quad (1)$$

Data basis

The demand and supply models of seed and bread wheat are based on the market data provided in Tables 4.2 and 4.3.

Table 4.2: Market data on seed wheat

Year	P_{sw}	P_{imp}	P_{sw}*P_{imp}	V_{crop}	Dummy	T	Q1	Q
2007	831.3	337.5	280536.8	141082.9	1	0.0	708.01	4800.0
2008	739.5	500.5	370080	206677.0	1	1.0	-4317.17	10700.0
2009	781.4	365.2	285373.9	244993.1	1	2.0	2478.45	12900.0
2010	650.0	242.1	157348	140106.9	1	3.0	532.86	6500.0
2011	564.6	247.8	139922.2	85349.8	1	4.0	555.91	6600.0
2012	511.6	254.8	130363.8	105736.2	0	5.0	244.00	2800.0
2013	450.1	588.1	264693.1	169163.2	0	6.0	-402.43	3000.1
2014	554.8	400.3	222070.6	175391.4	0	7.0	2869.39	9213.1
2015	473.7	283.9	134488.8	166866.6	0	8.0	382.58	3757.9
2016	499.5	342.1	170883.2	157321.5	1	9.0	1872.73	12204.0
2017	465.2	350.0	162807.4	151212.3	1	10.0	1048.76	6364.0
Average	592.9	355.7	210779	158536	0.6	5.00	543.01	7167.19

Where: P_{sw} – price of domestic seed wheat; P_{imp} – price of imported seed wheat; Q – seed quantity, V_{crop} - agriculture sector wage income; T – innovation influence, and Dummy – policy impact.

Table 4.3: Market data on bread wheat

Year	Q_w	P_w	P_{imp}	P_w*P_{imp}	Dummy	W_{crop}	T	q1	HTK	R_{ex}
2000	107.9	374.9	124.6	46708.22	0.0	11492.7	0	-70.2	1.09	3950.2
2001	107.9	359.3	131.4	47221.93	0.0	12429.7	1	-74.7	0.78	3648.1
2002	89.7	383.4	141.5	54240.72	0.0	13929.3	2	-58.9	0.63	3466.6
2003	127.9	374.7	153.2	57412.12	0.0	15067.3	3	-81.0	1.00	3249.8
2004	108.8	361.6	158.0	57142.5	0.0	16728.0	4	-85.1	1.00	2890.8
2005	49.0	329.4	147.0	48427.37	0.0	17988.7	5	-87.7	0.73	2436.6
2006	108.8	278.3	203.0	56492.88	0.0	20884.2	6	-129.6	1.07	1954.5
2007	90.9	267.2	194.2	51869.9	0.0	20330.6	7	-223.1	1.10	1738.1
2008	177.6	488.8	351.3	171703.4	0.0	38072.1	8	-111.2	1.30	1424.8
2009	349.2	420.0	211.8	88978.63	1.0	45130.4	9	-572.5	1.25	1724.0
2010	*304.5*	350.0	178.7	62562.31	1.0	25809.2	10	1054.0	1.08	1354.3
2011	391.2	304.0	225.6	68601.17	1.0	28276.0	11	1583.9	0.88	1098.3
2012	414.3	223.4	243.4	54356.25	1.0	24421.3	12	2114.0	1.55	1047.0
2013	325.8	239.5	515.0	123342.6	1.0	33703.4	13	-145.7	1.48	1141.9
2014	442.8	383.1	316.1	121085.5	1.0	33016.5	14	-511.2	0.99	1266.5
2015	145.6	362.3	210.7	76343.9	1.0	30029.1	15	-195.1	0.68	1347.2
2016	410.5	375.2	302.5	113490.4	1.0	30448.1	16	199.7	1.40	1438.8
2017	172.6	347.4	297.0	103174.9	1.0	28277.4	17	84.0	0.64	1514.0

Where: P_w – price of domestic (bread) wheat; P_{imp} – price of imported wheat; Q_w – quantity of bread wheat; W_{crop} - agriculture sector wage income; T – innovation influence; R_{ex} – Exchange rate MNT to USD; MHC – moisture heat coefficient; Time trend, delay Dummy – policy impact.

Using the methods developed/suggested by Appelbaum (1982), Bresnahan (1982) and O'Donnell et al. (2004), which relate to the analytic framework of the New Empirical Industrial Organisation (NEIO), we applied the following functions in developing the demand and supply models and determining the market equilibria for seed and bread wheat.

Demand function (represents consumer market conditions):

$$Q = a_0 + a_1P + a_2Y + a_3PS + a_4S + \varepsilon \qquad (2)$$

Where: Q - quantity of product; P - product price; S - price of substitutes and Y - consumers' income.

Using the demand function, we determined the marginal cost function as follows:

$$MC = b_0 + b_1Q + b_2M + b_3N + \eta \qquad (3)$$

Where: MC – marginal costs; Q – quantity of product; M – price of relevant production factors; N – macroeconomic or weather factors.

The marginal revenue was determined using the following function:

$$MR = P + Q\frac{\partial P}{\partial Q} = P + \frac{Q}{a_1 + a_3S} \qquad (4)$$

Marginal revenue, as perceived by farms, were determined as:

$$PMR = \lambda(P + \frac{Q}{a_1 + a_3S}) + (1 - \lambda)P = P + \lambda\frac{Q}{a_1 + a_3S},\ 0 \leq \lambda \leq 1 \qquad (5)$$

Where λ in expresses the degree of market power. In case of free competition λ will be 0 and in the case of monopoly market λ=1, in the case of oligopoly market λ ≈ *0.5*, and in the case of monopolistic competition this measure will be *0* <λ< *0.5*. Using the cost function, we similarly determined the degree of monopsony market power.

Using the PMR=MC equality condition we derived supply function, which represents producer market conditions.

Supply function:

$$P = -Q_1 + b_0 + b_1 Q + b_2 M + b_3 N + \gamma, Q_1 = \frac{Q}{a_1 + a_3 S} \qquad (6)$$

4.2 Demand and supply models of seed wheat

The price elasticity of demand (E_d) was determined at -0.353 (Table 4.4).

Table 4.4: Demand model of seed wheat

	Intercept	P_w	P_{imp}	P_w*P_{imp}	V_{crop}	Dummy	R square	F_{sign}
Qd=	10193.937	-22.6138	-34.3820	0.0516	0.0601	3256.2340		
t_{stat}	0.6780	-0.8605	-0.9284	0.7537	2.6070	1.7210	0.7719	0.1035

The price elasticity of supply (E_s) is 8.71 (Table 4.5).

Table 4.5: Supply model of seed wheat

	Intercept	Q1	Q	T	R square	F_{sign}
P=	703.3565	0.0103	0.0095	-37.7435		
t_{stat}	14.9164	1.1601	1.9543	-7.1211	0.9029	0.0006

The λ is 0.01, hence implying that the degree of market power is perfect competition.

The marginal cost function and average cost function of wheat seed are shown in Tables 4.6 and 4.7. The functions are statistically significant.

Table 4.6: Seed marginal cost function

	Intercept	Q1	T	R square	F_{sign}
MC=	703.3565	0.0095	0.0095		
t_{stat}	14.9164	1.9543	1.9543	0.9029	0.0006

Table 4.7: Seed average cost function

	Intercept	Q1	T	R square	F_{sign}
MC=	703.3565	0.005	-37.7435		
t_{stat}	14.9164	1.9543	-7.1211	0.9029	0.0006

Using these functions, the market equilibrium for seed wheat was determined at constant 2010 prices and current prices. For instance, the average current price of wheat seed is 799.8- 853.7 thousand MNT and at 2010 constant prices is 593.1thousand MNT per ton (Table 4.8).

Table 4.8: Market equilibrium for seed wheat, MNT 1000 per ton

Deflator	Q	P_{2010}	$P_{nominal}$	AC_{2010}	$AC_{nominal}$
0.6737	7139.4	780.7	525.9	726.2	489.2
0.8182	11092.5	736.5	602.6	716.4	586.2
0.833	12628.0	782.9	652.3	689.1	574.1
1.000	6722.6	660.6	660.6	621.0	621.0

1.151	3808.9	595.5	685.5	583.7	672.0
1.298	2307.9	539.6	700.6	527.9	685.5
1.336	2549.0	497.1	664.2	491.1	656.2
1.436	6095.9	545.2	782.7	482.9	693.3
1.461	6474.2	467.8	683.2	419.3	612.3
1.493	10917.9	492.6	735.4	421.6	629.4
1.612	9037.0	426.1	687.0	356.2	574.2
1.348	5989.2	593.1	799.8	548.7	739.8
1.398		2011-2017	829.3		767.1
1.439		2012-2017	853.7		789.7

4.3 Demand and supply models of bread wheat

The price elasticity of demand (E_d) is -3.428 (Table 4.9).

Table 4.9: Demand model of bread wheat

	Intercept	P_w	P_{imp}	P_w*P_{imp}	Dummy	W_{crop}	T
Q_d=	1000.811	-3.322	-2.056	0.007	320.279	0.003	-8.934
t_{stat}	3.057	-2.999	-2.744	2.923	4.914	1.122	-1.118
Adjusted R-squared		0.816	Akaike info criterion		11.273	DW	stat 2.493

The price elasticity of supply (E_s) is 7.701 (Table 4.10).

Table 4.10: Supply model of bread wheat

	Intercept	Q1	Q	T	R square	F_{sign}	D	T
P_s=	-168.376	0.134	0.046	-120.669	0.127	0.012	-158.143	14.798
t_{stat}	-0.705	0.649	1.524	-2.159	4.086	2.357	-1.975	1.203
Adjusted R-squared		0.604	Akaike info criterion		10.670	DW stat	2.612	

The λ is 0.046, implying that the degree of market power is perfect competition.

The marginal cost function is:

$$MC= -168.376+0.134q-120.669HTK+0.127R_{ex}+0.012W_{crop}-158.143Dummy+14.798T$$

The average cost function is:

$$AC=-168.376+0.067q-120.669HTK+0.127R_{ex}+0.012wcrop-158.143Dummy+14.798T$$

The equilibrium price of bread wheat is MNT 515.4 thousand per ton at 2017 price or, on average, MNT 436.5 thousand per ton at 2010 constant price (Table 4.11).

Table 4.11: Market equilibrium for seed wheat, MNT 1000 per ton

Year	Q	P_{2010}	$P_{nominal}$	AC_{2010}	$AC_{nominal}$
2010	460.2	285.8	285.8	196.4	196.4
2011	286.1	322.3	371.0	238.0	274.0
2012	392.7	241.3	313.2	120.1	155.9
2013	266.6	269.4	360.0	262.1	350.2
2014	380.1	350.0	502.5	351.9	505.3
2015	198.5	365.9	535.3	357.9	523.5
2016	336.0	347.0	518.0	320.3	.478.1

2017	158.6	376.2	606.4	362.7	584.7
Average	309.9	319.7	436.5	276.2	383.5
At 2017 prices			515.4		445.2
Profitability index (PI)			15.8%		

In conclusion, seed and bread wheat markets are shaped by free competition. The price elasticity of demand is -0.353 for seed wheat and -3.428 for bread what. In contrast, the price elasticity of supply is 8.71 for seed wheat and 7.701 for bread wheat. The reverse demand sensitivity implies that the seed wheat and bread wheat markets are closely related.

5. CONCLUSIONS

Estimated costs of wheat and potato breeding

Estimated total costs of a wheat breeding program to result in the release of a new variety, at a program duration of 12 to 16 years, range between MNT 243.1 and 327.3 million at 2010 prices. Costs of labour, capital costs and overheads, and operating costs account for 74, 24 and 2 percent of the total costs, respectively.

Estimated total cost of a potato breeding program with an average duration of 13 years is MNT 163.3 million at 2010 prices. Costs of labour, capital costs and overheads, and operating costs account for 87.4, 11.5 and 1.1 percent of the total costs, respectively.

The findings suggest that costs of plant breeding programs can be substantially reduced through timely flow of funds and introduction of innovations for shortening the duration of the breeding processes.

Profitability and competitiveness of hypothetical regional seed multiplication centres

The analysis assumed that three regional SMCs (in the Central, Western and Eastern regions) with an annual production capacity of 1745 tons of elite and certified wheat seed will be established with public investments. The investment requirement of each SMC is estimated at MNT 768.1 million, with machinery and equipment accounting for 78% of this amount.

The findings suggest that the SMCs will be financially and economically profitable, hence able to not only recover the investments but also operate without further government support. A financial CBA over a period of 10 years revealed an NPV between MNT 19.2 million and MNT 178.9 and an IRR of 12.5% to 15.9% per SMC. According to an economic CBA, the NPV will be between MNT 629.9 million and an IRR between 24.8% and 28.1% per SMC. The hypothetical SMC in the Central region appears to have the best profitability potential. The initial investments in the SMC can be recovered within 9 to 10 years.

The PAM assessment reveals that the SMCs will be economically competitive at current levels of technology, input and output prices and policy transfers, achieving. This is confirmed by a private profit of MNT 262.4 thousand to MNT 383.2 thousand per hectare of seed production and PCR values of the SMCs between 0.560 to 0.657.

The positive social profits of the SMCs imply that these centres will efficiently utilise resources in seed production and be able to survive without further government support. Furthermore, the DRC coefficients of all SMCs are less than unity, thereby indicating that the value of domestic resources (i.e. non-tradable inputs) used in production is lower than the value added. This implies efficient use of domestic resources and socially profitable production. The SMC in the Central region, with the lowest DRC value of 0.479, is most profitable in terms of use of domestic resources.

The NPCO value of 0.963 that applies to all three SMCs indicates that the producers are not protected by policy and that substantial output tax applies. The NPCI values that are greater than unity indicate that the input costs are higher than reference prices, thus implying that the government is not providing incentives to the producers. The EPC values of 0.943 to 0.944 further indicate the absence of protection and negative incentive to SMCs

Market equilibrium for seed and bread wheat

The market equilibrium for seed wheat was determined at a quantity of 7161 tons and a 2010 constant price of MNT 593.1 thousand per ton.

The market equilibrium for bread wheat was determined at a quantity of 309.9 thousand tons and a 2010 constant price of MNT 319.7 thousand.

Both the seed and bread wheat markets were found to be dominated by free competition ($\lambda \approx 0.01$).

Price elasticities of seed and bread wheat

For seed wheat, the price elasticity of demand (PED) is -0.353 and the price elasticity of supply (PES) is 8.71, implying that a 1% increase in the price would reduce the demand by 0.35 percent while potentially increasing the supply by 8.71 percent. Reversely, it also implies that a 1% decrease in the price would affect a 0.35% increase in the demand and an 8.71% reduction in the supply of seed wheat. In this case, we may conclude that the PED is rather non-elastic while the PES is elastic.

For bread wheat, both the PED (-3.427) and PES (7.7) were found to elastic. A 1% price change would be responded to by a 3.4% reverse change in the demand and a 7.7% corresponding change in the supply of bread wheat.

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7. APPENDIX

Table 7.1: Exemplary technology card for seed wheat cultivation, at an assumed yield of 1.2 t per ha

№	Technological operation	Size of work, Wo,hra; т; т.km	Calendars dates	Working days, Др	Working day rate, nсм	Type of mashine		Working day productivity, Wч, ha/ work day	Worker		Fuel requirements, q, kg/ha	Productivity in standard unit, l, ethra	Total requirements fo whole operation						Economic indicators		Reduced costs, thous.tog.	of which		
						Tractor, lorry	Agricultural mashine		Mashine operator, mм	Assistant worker, mв			Number of mashine unit, nв	Number of working days, Дф	Mashine operatots, nм	Assistant workers, nв	Fuel, Q, кg	Standard working days, Nсм	Tractor operation, Wэ, equivalhra	Labour use, Зт, man.hour		Fuel, lubricant costs, thous.tog.	Salary, thous.togr.	Other costs, thous.costs.
A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			Previous processing: fallow				Planting																	
	S=	500	ha;		Qfert	100	кg/ha			Qseed=	160	кg/ha				Qherb=	3	кg/ha						
1	Spring harrowing	500	15-27/IY	12	1.5	John Deer 1204	БИГ-3	19.6	1		6.5	1	1	17.007	1.5	0	3250	25.51	204.08	204.08	17611	6338	416	10858
2	Cultivation before planting (6-8)	500	18/Y-1/YI	12	1.5	John Deer 1204	Кроунд 8/450	20.7	1		12.5	1	1	16.103	1.5	0	6250	24.15	193.24	193.24	29418	12188	394	16837
3	Seed dressing	80	25-28/Y	3	1.5		ПСШ-5	70	1				1	0.762	1.5	0	0	1.14	0.00	9.14	196	8	19	169
4	seed loading	80	25/Y-1/YI	6	1.5		ЗПС-100	82	1				1	0.650	1.5	0	0	0.98	0.00	7.80	119	11	16	92
5	Seed transport (5 km)	400	25/Y-1/YI	7	1.5	John Deer 1204	2ПТС-4	160	1		1.3	0.65	1	1.667	1.5	0	520	2.50	13.00	20.00	2064	1014	41	1009
6	Fertilizer loading	50	25/Y-1/YI	7	1.5	John Deer 1204	loader	110	1		1.1	0.65	1	0.303	1.5	0	55	0.45	2.36	3.64	306	107	7	191
7	Fertilizer transport(5	250	25/Y-1/YI	7	1.5	John Deer	2ПТС-4	160	1		0.42	0.65	1	1.042	1.5	0	104	1.56	8.13	12.50	858	202	25	631
8	Sowing+ fert+ rolling	500	25/Y-1/YI	7	1.5	John Deer 1204	Компакт-солитэр 9/300	36.9	1	3	15.5	1	1	9.033	1.5	4.5	7750	13.55	108.40	433.60	26509	15113	773	10624
9	Harrowing before germination	500	1-15/YI	15	1.5	John Deer 1204	ТЅ-300	15.12	1		3.5	0.65	1	22.046	1.5	0	1750	33.07	171.96	264.55	22257	3413	539	18306
10	Harrowing after germination	500	15-30/YI	15	1.5	John Deer 1204	ТЅ-300	15.12	1		3.5	0.65	1	22.046	1.5	0	1750	33.07	171.96	264.55	22257	3413	539	18306
12	Spraying herbicide	500	15-20/YI	8	1.5	John Deer 1204	Eurolux 1000 TM	28.3	1		3	0.65	1	11.779	1.5	0	1500	17.67	91.87	141.34	15404	2925	288	12191
	Subtotal																				136998	44729	3055	89213
			Harvest, after harvest processing																					
	S=	500	ha		Yield=	1.2	t/ha																	
1	Harvest+straw spreading	500	15-22/IX	10	1.5	Sampo 2025	жатка	14	1		2.7		2	11.905	3	0	1350	35.71	0.00	285.71	12929	2633	582	9714
2	Weat transport	600	10-22/IX	12	1.5	Lorry		200	1		1.1		1	2.000	1.5	0	660	3.00	0.00	24.00	1373	1287	49	37
3	Seed cleaning	600	10-25/IX	15	1.5		ОВС-25	49	1	2			1	8.163	1.5	3	0	12.24	0.00	293.88	3419	170	532	2717
4	Seed grading	600	10-25/IX	18	1.5		СМ-4	20	1	2			1	20.000	1.5	3	0	30.00	0.00	720.00	6890	261	1303	5326
	Subtotal																				24611	4350	2466	17794
																					161608	49080	5521	107007
1	Seed,t	80				850					8869										68000			
2	Fertilizer,t	50				1500					3620										75000			
3	Herbicide,t	1.5				12000					12489										18000			
																					322608	49080	5521	107007
1	Total cost, thous. tog																				384959		67872	
2	Cost per ha, thous tog																				769.9			
3	Average cost, thous tog																				641.6			

Table 7.1 continued

		Wheat seed costs			Cw,тог./man.hour	Cw ass.w, тог/man hour		Cfl,тог./кг		Celect ,tog./кВт			Cfert,thous.тов./т		Cherb,thous.tog/t		Cseed ,thous.тов./т	
					2054.5	1712.1		1950		181			1500		12000		850	
№	Technological operation	Calendars dates	Working days, Др	Working day rate, nсм	Types of mashine: Tractor, lorry	Types of mashine: Agricultural mashine	Working day productivity, Wн, ha/work day	Fuel requirements, q, кg/ha	counting price, thous.to: Power mashines	counting price, thous.to: Agricultural mashine	counting price, thous.to: Connection	Unit cost, thous.tog./ha; thous.tog./т; thous.tog./т.км: Fuel, lubri. And electri. Costs	Salary	Repair, maintanence costs	Overhaul mashinery and equipment	Depreciation	Investment premium	Reduced costs, thous.cost./ha; thous.cost./т; thous.cost./т.км
A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Previous processing: fallow																	
S=	500	га;		Qб=	100	кг/га		Qy=	160	кг/га				Qr=	3	кг/га		
1	Spring harrowing	15-27/IY	12	1.5	John Deer 1204	БИГ-3	19.6	6.5	110000	6600	636	12.68	0.83	8.38	1.38	4.85	7.10	35.22
2	Cultivation before planting (6-8)	18/Y-1/Y	12	1.5	John Deer 1204	Кроунд 8/450	20.7	12.5	110000	40000		24.38	0.79	12.19	1.31	8.76	11.42	58.84
3	Seed dressing	25-28/Y	3	1.5	0	ПСШ-5	70	0		12500		0.10	0.23	0.68	0.00	0.68	0.76	2.44
4	seed loading	25/Y-1/Y	6	1.5	0	ЗПС-100	82	0		8500		0.13	0.20	0.37	0.00	0.37	0.41	1.48
5	Seed transport (5 km)	25/Y-1/Y	7	1.5	John Deer 1204	2ПТС-4	160	1.3	110000	7500		2.54	0.10	1.01	0.18	0.52	0.81	5.16
6	Fertilizer loading	25/Y-1/Y	7	1.5	John Deer 1204	loader	110	1.1	110000	8500		2.15	0.15	1.51	0.27	0.81	1.23	6.12
7	Fertilizer transport(5	25/Y-1/Y	7	1.5	JD 1204	2ПТС-4	160	0.415	110000	7500		0.81	0.10	1.01	0.18	0.52	0.81	3.43
8	Sowing+ fert+ rolling	25/Y-1/Y	7	1.5	John Deer 1204	Компакт-солитэр 9/300	36.9	15.5	110000	50000	636	30.23	1.55	6.25	0.73	6.30	7.96	53.02
9	Harrowing before germination	1-15/YI	15	1.5	John Deer 1204	TS-300	15.12	3.5	110000	15000	636	6.83	1.08	13.73	1.94	8.77	12.17	44.51
10	Harrowing after germination	15-30/YI	15	1.5	John Deer 1204	TS-300	15.12	3.5	110000	15000	636	6.83	1.08	13.73	1.94	8.77	12.17	44.51
12	Spraying herbicide	15-20/YI	8	1.5	John Deer 1204	Eurolux 1000 TM	28.3	3	110000	27000		5.85	0.58	8.92	1.04	6.20	8.22	30.81
	After harvest processing																	
S=	500	ha		Yield=	1.4	t/ha												
1	Harvest+straw spreading	15-22/IX	10	1.5	Sampo 2025	жатка	14	2.7	120000			5.27	1.16	2.57	2.00	5.71	9.14	25.86
2	Weat transport	10-22/IX	12	1.5	Lorry	0	200	1.1	6000			2.15	0.08	0.02	0.01	0.01	0.02	2.29
3	Seed cleaning	10-25/IX	15	1.5	0	ОВС-25	49	0		34500		0.28	0.89	1.60	0.00	1.13	1.80	5.70
4	Seed grading	10-25/IX	18	1.5	0	СМ-4	20	0		27600		0.43	2.17	3.14	0.00	2.21	3.53	11.48