8 Discussion of Model Results – Alternative Parameter Values

In this chapter, results of the stochastic, multi-period, spatial equilibrium model will be discussed. This model, given in (6.44), serves as a tool for answering the third research question which is raised in Section 1.2. This question deals with the quantitative effects of changes in marketing costs or market institutions on cereal trade and cereal prices in Burkina Faso. In Section 3.3, several scenarios are formulated, which indicate the changes that will be analysed. Each scenario implies an alteration of some of the model parameters or constraints. First, the model with the parameter values as discussed in the previous chapter will be dealt with in Section 8.1. This model is called the 'base model'. The results of this model, called the 'base results', reflect the welfare optimising equilibrium quantities and prices for a set of parameter values that are based on the actual situation on the cereal market in Burkina Faso. They serve as a benchmark with which the results of the scenario analyses will be compared. The first four scenarios discussed in Section 3.3 will be studied in the Sections 8.2 to 8.5. They concern developments in the economy resulting in changing transport costs, cereal production levels, consumer income levels, and trade costs. For these scenarios, only some of the parameter values have to be adapted. In Chapter 9, the scenarios will be considered for which also the model formulation has to be adapted. In Chapter 10, the main lessons and conclusions of these scenario analyses are summarised. The non-linear programming models are formulated in GAMS version 2.25 and solved with CONOPT2 (see Brooke et al., 1992). The number of variables and constraints is different for each period. In the model for period 1, the number of variables is 22,657 and the number of constraints 6,625.[1]

8.1 Results of Base Model

The base model is presented in (6.44) in Section 6.2. The values of the model parameters are estimated in Sections 7.2.3, 7.2.4, and 7.3. The results reflect the actual prices and trade flows on the cereal market in Burkina Faso fairly well. I discuss the main results which are presented in the Tables 8.1.a to 8.1.d.

Prices calculated by the model, see Table 8.1.a, are generally a little lower than the observed prices given in Table 2.1. The producer and consumer

[1] The base model in GAMS formulation can be obtained from the author.

Table 8.1.a: Results of the base model: Consumer price levels and supply per person

→ PERIOD ↓ CRPA	Consumer price level (FCFA/kg)[1]					Supply per rural inhabitant (kg/person)				
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Ave-rage	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Total[2]
Centre	110	113	119	128	118	3.7	12.7	3.9	2.1	23
Centre Nord	112	115	123	132	120	3.7	4.6	3.4	1.0	13
Centre Ouest	104	107	112	129	113	6.0	8.7	17.8	3.4	36
Centre Sud	105	107	118	122	113	7.9	11.5	4.9	22.8	47
Sahel	113	121	127	140	125	4.3	5.4	1.2	0.9	12
Mouhoun	98	104	108	115	106	9.7	12.8	10.2	48.6	82
Est	104	103	110	121	109	6.3	9.1	12.5	9.8	38
Centre Est	109	108	115	124	114	5.4	7.7	1.6	17.1	32
Nord	107	111	117	126	115	1.7	5.6	2.5	0.8	11
Sud Ouest	99	98	105	116	104	9.4	12.3	48.7	8.9	80
Hauts Bassins	101	109	115	131	114	51.6	12.8	10.2	9.2	84
Comoé	106	104	118	126	113	9.0	11.9	9.5	34.7	65
Average price	106	108	115	126	114					
Total supply (1000 tonnes)[3]						88.3	88.1	90.4	117.9	385

Note: 1) The producer price is equal to $p_{it} = \pi_{it} - \alpha_{it} = \pi_{it} - 15$, see Sections 6.2 and 7.3; 2) Total supplies per inhabitant are not equal to the annually available quantity, w_{i0}, given in Table 7.4, because of storage losses; 3) Total supply is the sum over all regions of supply per person multiplied with the rural population per region, see Table 7.1.

prices reflect seasonality well. In general, prices increase during the year, from harvest to harvest. Producer price fluctuations during the year are on average somewhat higher than the average observed fluctuations. This was expected, because I deal with a specific year instead of with the average over a number of years. Next, in line with price observations, the results show that prices in the high production areas, from which cereals are transported (Mouhoun, Hauts Bassins, Comoé, Sud Ouest) are below the average of the optimal prices. Prices in the low production and shortage areas (Centre, Sahel, Nord, Centre Nord) are above the average of the optimal prices. The price differences between these regions result from transport costs between the surplus and shortage regions and the market forces of supply and demand. The ordering of regions in those with a high to those with a low equilibrium price corresponds to the ordering according to the average observed consumer prices, which are given in Table

2.1. This ordering only partly corresponds to the ordering according to the observed producer prices. According to the observed prices, the producer prices in the southern regions Centre Ouest, Centre Est, Centre Sud and Comoé are higher than in the other regions. The optimal prices resulting from the equilibrium model do not support this. This difference may be caused by transborder trade with foreign traders, which is neglected in the model, since I concentrate on cereal distribution only within the country.

In Table 8.1.b, the net revenues of the cereal producers are presented. These net revenues are equal to the revenues from sales minus the supply and production costs (see Section 6.1.1). Net revenues seem to be rather low. The main reason is that production costs include a 'valuation' of the land and labour used for production. These are no 'real' costs for the producers, but they make up the largest part of the production costs. In Section 6.1.1, the optimal supply behaviour of the cereal producers has been derived. Producers balance in each period net revenues from selling now and expected net revenues from selling in one of the future periods. It was assumed that they have to supply in each period at least a minimum quantity, and that they determine at the beginning of the first period how much they can supply during that year. In each period, it is optimal for the producers 1) to supply the minimally required quantity if expected future net revenues exceed the current net revenues; 2) to supply the maximum quantity possible if current net revenues exceed expected future net revenues; or 3) to supply no matter what possible quantity if expected future and current net revenues are equal. In the last case, producers are indifferent about the quantity supplied. It follows from this specification that small differences in expectations costs, or prices between two regions, may cause very large differences in the timing of supplies by the producers.

The results show, see Table 8.1.a, that for the region Sahel, the cereal producers only sell the minimally required quantity in the first three periods because they expect to earn more if they sell later. In the last period, they are indifferent about the quantity sold, because profits from sales are zero. For the region Comoé, these 'forced' minimum sales result in net losses. This means that not all production costs can be regained if they sell the minimally required quantity. This does not mean that the farmers make real losses because not all production costs are 'real' costs. It only means that they earn less than the

Table 8.1.b: Producer net revenues[1], consumer utility[2], trader net revenues[3], and level of semi-welfare[4]

→PERIOD ↓CRPA	Revenues per producer (in FCFA)[1]					Utility[2]		
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Total	Per urban cons.	Per rural cons.	Total per region ($\times 10^6$)
Centre	73	219	70	44	391	0.63	0.71	1.20
Cen. Nord	79	83	70	23	247	0.60	0.65	0.65
Cen. Ouest	68	75	149	65	341	0.62	0.73	0.76
Centre Sud	13	-17	13	28	34	0.62	0.73	0.38
Sahel	108	147	33	31	311	0.59	1.09	0.85
Mouhoun	190	256	190	991	1522	0.64	0.62	0.77
Est	70	47	71	109	281	0.63	1.13	1.15
Centre Est	26	-10	-2	29	42	0.62	0.72	0.59
Nord	29	84	39	15	160	0.61	0.67	0.69
Sud Ouest	82	30	143	71	310	0.64	0.52	0.29
Hauts Bass.	1039	289	238	309	1825	0.64	0.59	0.67
Comoé	-17	-117	-17	0	-147	0.62	0.59	0.21
Average	152	113	92	180	512	0.63	0.74	0.72
Total rev. $\times 10^6$ FCFA	1433	1066	873	1703	4840			
Total utility ($\times 10^6$)[2]						1.20	7.02	8.22
Trader Net Revenues ($\times 10^6$ FCFA)[3]			-150	**Level of Semi-Welfare ($\times 10^6$ FCFA)[4]**				26689

Notes: 1) Producer net revenues per period are defined as the revenues from sales minus the costs from production and supply: $(p_{it} - c_{it})x_{it}$, see (5.1), (6.14), and Section 7.2.3. Total net revenues per producer are the discounted sum of the profits per period $\Sigma_t(p_{it} - c_{it})x_{it}\sigma^{t-1}$, see Section 7.2.3. Total net revenues are the sum over all periods of the net revenues per producer multiplied with the size of the rural population;
2) Consumer utility per consumer from cereal consumption is defined as $\Sigma_t\sigma^{t-1}b_{ith}\ln(y_{ith} - \gamma_{ith})$, with discount factor $\sigma = 0.97$, see (7.13) in Section 7.2.4. Total utility per region is equal to the utility per urban consumer multiplied with the urban population plus the utility per rural consumer multiplied with the rural population of that region. Total utility is equal to the sum over all regions of the urban/rural utility multiplied with the urban/rural population size;
3) Trader net revenues are defined as the discounted sum over all periods of the revenues from sales minus the costs from purchasing, transporting, and storing, see Section 6.1.2.
4) Semi-welfare is defined as the discounted sum over all periods of the consumer net revenues plus the producer's net revenues, plus the trader's net revenues, see (6.3.4) in Section 6.2.

intrinsic value of their commodities. In the region Hauts Bassins, producers sell the maximum quantity possible in the first period because they expect to make lower profits if they sell later. In the other periods, they also expect to make the highest profits by selling in that period instead of in one of the later periods. But they can only supply the minimally required quantity, because that is all that is

left from the first period. One may expect that farmers in the surplus region Hauts Bassins are not forced to sell the bulk of their supplies early in the season, because they are, in general, wealthier than the farmers in most other regions. A substantial part of their income is earned from cotton production, which enables them to postpone their cereal sales. A closer look at the observed price data, however, shows that, during the year, prices in Hauts Bassins increase much less than in most other regions. For that reason, it is not expected to be profitable to postpone supplies to later periods.

The model results in Table 8.1.a show that most producers do not supply their largest quantity in the post-harvest period, but in particular in the last two periods. This does not correspond with the common view that farmers in developing countries sell when prices are low and purchase when prices are high (see Section 7.1). It corresponds, however, with observations by Armah (1989) for Ghana, Lutz (1994) for Benin, and Bassolet (2000) for Burkina Faso, that most goods are stored by the producers and that only a few traders store cereals for a longer period. These studies conclude that producers instead of traders have a comparative advantage for storage. On average, their storage costs and losses are lower than those for the traders. Costs for storehouses are very low for producers. For traders it is more difficult to protect their large storehouses against rats and fungus, than it is for farmers to protect their small silos.

In Table 8.1.b, also optimal consumer utility levels are presented. Utility has been defined as the discounted sum of utility per region (see (7.13) in Section 7.2.4). It is related to the quantity consumed. The utility levels are used in the next sections to investigate how changes in the trade sector affect consumers. Cereal consumption levels for urban and rural consumers are shown in Table 8.1.c. Urban consumers consume, next to the quantity of cereals reported in the table, also a large amount of rice (estimated at 90 kg per year for consumers in Ouagadougou and Bobo-Dioulasso and 70 kg for other urban consumers; see Section 7.2.4). Differences between rural consumers are large. Especially, rural consumption in the regions Centre and Centre Est, and in the shortage regions Centre Nord, Nord and Sahel are low. The rural consumption levels in the region Centre may be underestimated. It is well possible that income of the rural

Table 8.1.c: Cereal demand and consumption of rural and urban consumers

	Cereal demand and consumption per rural consumer (kg/person)					Cereal demand (=consumption) per urban consumer (kg/person)				
	Cereal demand per period				Annual cereal cons.[1]	Cereal demand per period				Annual cereal cons.[2]
→ PERIOD ↓ CRPA	Oct-Dec a	Jan-Mar b	Apr-Jun c	Jul-Sept d		Oct-Dec e	Jan-Mar f	Apr-Jun g	Jul-Sept h	
Centre	2.1	3.0	3.8	5.8	123	31	28	28	28	115
Centre Nord	1.8	2.9	3.9	5.4	165	27	25	25	25	101
Centre Ouest	2.2	3.0	4.4	5.7	181	28	25	26	25	104
Centre Sud	2.3	2.9	4.0	6.1	238	28	25	26	25	104
Sahel	3.2	4.9	7.0	9.5	163	26	24	25	24	99
Mouhoun	3.1	4.0	6.4	9.0	221	28	26	27	26	107
Est	2.8	3.9	5.6	8.3	197	28	26	27	26	106
Centre Est	2.2	2.8	4.2	6.0	164	27	25	26	25	104
Nord	2.0	2.9	4.1	5.7	145	27	25	26	25	103
Sud Ouest	2.8	4.2	5.6	7.9	211	28	26	27	26	108
Hauts Bassins	3.2	4.1	6.0	7.6	220	32	28	30	27	118
Comoé	3.1	4.1	5.5	8.3	217	27	26	26	25	104
Average	2.6	3.6	5.0	7.1	180	28	26	27	26	106

Notes: 1) Annual cereal consumption of rural consumers is equal to the cereal production level per person (see Table 7.2), minus the quantity sold (see Table 8.1.a), plus their cereal purchases (column a+b+c+d). The large differences in consumption are especially caused by the large differences in production between the different regions; 2) Annual cereal consumption of urban consumers is equal to the sum of their purchases (column e+f+g+h). Recall that they also consume large quantities of rice.

inhabitants in this region is higher than the levels estimated in Section 7.2.4, because many of them earn an additional income in Ouagadougou.

The results show that traders make losses (see Table 8.1.b), which corresponds to observations from Danagro (1999) that traders have great difficulties regaining their operating costs. A closer look at the results shows that they make losses nor profits from transport or from sales in the purchase region. However, storage is loss-making. In section 6.1.2, it has been discussed that, in a period t, traders base their planning for the next period on a number of prices which may possibly occur in period t+1. From a comparison of the possible price realisations with the optimal equilibrium prices, it follows that for the lower price realisations the difference between the possible price in period t+1 and the optimal price in period t is less than storage costs. If these prices would be established, storage would result in a loss. If the higher price realisations would come about, storage would be profitable. In the regions in which traders store (see Table 8.1.d), they expect to make a profit. This is

especially in the regions in which storage costs are lowest, i.e. in the surplus areas (because capital costs are lower in these regions, see Section 7.2.4). However, the price increase in period t+1 which follows from the optimal model results, is lower than the expected increase on which the storage decisions are based. The price increase is less than storage costs, resulting in a loss. Optimal prices are lower than expected because planned purchases and sales for period t+1 are lower than optimal purchases and sales in that period. The main reason for this is that, for the future planning, the traders' decision model does not consider the future minimum sales of the producers. After all, it is not realistic to assume that a trader is willing to purchase this quantity if he expects it to be loss-making. If optimal supply and demand are higher than expected, equilibrium prices will as a consequence be lower than expected.

Only 4% of the annual supplies are found to be kept in store by the traders for more than three months. No data are available to verify this percentage. The general picture, however, corresponds to observations mentioned above that only a few wholesalers invest in long-term storage, because farmers have a comparative advantage for storage. The results demonstrate that the stocks are generally kept in the surplus zones. This is a trivial result because storage costs are lower in these regions. It is also conform reality, in which most wholesalers are situated in the surplus zones. In the third and fourth period, traders do not store for more than three months. They expect to make losses if they would do so.

The direction of the estimated transport flows (see Table 8.1.d) is in line with the flows observed in reality. About 41% of the marketable surplus is transported to other regions. Unfortunately, no data are available to verify this percentage. In accordance with transport studies from SIM (see Danagro, 1999), the results show that most goods are transported from the largest surplus zones Mouhoun and Hauts Bassins towards the region Centre. Also the shortage regions Sahel, Nord, and Centre Nord receive a large part of the surplus from the regions Mouhoun and Est. Transport to these regions is especially high during the lean season, when the farmer's stocks get depleted (from April to September). In the model results, also the transport flow to Hauts Bassins is important. In the period October – December the region Hauts Bassins has a relatively low price and a large surplus that is transferred to Ouagadougou. As a

Table 8.1.d: Transported and stored quantities

Quantity transported (in 1000 tonnes)						
From	**To**	**Oct-Dec**	**Jan-Mar**	**Apr-Jun**	**Jul-Sept**	**Total**
Cen. Ouest	**Centre**			12.1		12.1
Centre Sud	**Centre**		6.1		2.1	8.1
Centre Sud	**Cen. Nord**				5.8	5.8
Mouhoun	**Centre**	1.5			19.6	21.0
Mouhoun	**Cen. Ouest**				5.1	5.1
Mouhoun	**Sahel**			4.6	7.3	11.9
Mouhoun	**Nord**	3.1		4.1	7.2	14.4
Mouhoun	**Hauts Bass.**				3.4	3.4
Est	**Centre**		4.9	0.1		5.0
Est	**Sahel**		0.3	0.6		1.0
Est	**Centre Est**	0.5		4.6		5.1
Centre Est	**Centre**		1.0		5.5	6.5
Sud Ouest	**Centre**		2.7	11.1		13.7
Sud Ouest	**Cen. Nord**			2.2		2.2
Sud Ouest	**Hauts Bass.**		3.9	8.0	0.0	11.9
Sud Ouest	**Comoé**			0.8		0.8
Hauts Bass.	**Centre**	23.3				23.3
Hauts Bass.	**Comoé**	0.4				0.4
Comoé	**Hauts Bass.**		0.2		5.6	5.8
Total		28.8	19.0	48.3	61.4	157.5

Storage (in 1000 tonnes)		
	Oct-Dec	**Jan-Mar**
Centre	0	0
Centre Nord	0	0
Centre Ouest	0.3	2.6
Centre Sud	2.3	0
Sahel	0	0
Mouhoun	0	7.4
Est	1.4	0
Centre Est	0	0
Nord	0	0
Sud Ouest	2.9	0
Hauts Bassins	0	0
Comoé	0	0
Total	7	10

In period 3 and 4 traders store no cereals

result, the producers in Hauts Bassins are not able to provision the consumers in especially Bobo-Dioulasso during the other periods. For that reason, traders transport cereals from Mouhoun and Sud Ouest to Hauts Bassins.[2] This result is not in contradiction with the observation that large quantities of cereals are transported to Bobo-Dioulasso and from Bobo-Dioulasso to Ouagadougou and the northern regions during the entire year. Bobo-Dioulasso has one of the major cereal redistribution markets of the country. Many cereals produced in the neighbouring regions (including Mouhoun) are sold to traders in Bobo-Dioulasso, who resell to traders elsewhere. The model results do only show the

[2] If the price expectations for Hauts Bassins are higher, producers will not supply the largest quantity in the first period, but spread supplies more equally over the year. In that case, transports to and from Hauts Bassins will be considerably less. The cereals which are transported from Mouhoun or Sud Ouest to Hauts Bassins in the base model will, in that case, be transported to Centre.

starting and destination point of the cereals, not whether cereals which are transported from Sud Ouest to Centre change of ownership in Bobo-Dioulasso.

8.2 Scenario 1: Better Road and Communication Infrastructure

Due to bad road conditions transport costs are high. In Section 2.3.3, it has been argued that transport costs make up 5% to 20% of the consumer price. Better road conditions will lead to lower transport costs, which may result in lower cereal prices and higher transport flows between the different regions. Different studies report on the effects of infrastructural development on economic growth. For example, World Bank (2000b) estimates that a drop of 10% in transport costs increases trade by 25%. The World Development Report 1994 claims that a 1% increase in the stock of infrastructure (including not only roads but also electricity, telecommunication, water supplies, ports, railways, and sewerage) is associated with a 1% increase in GDP (World Bank, 1994). Furthermore, bad road conditions "condemns rural areas to isolation, subsistence production, and high risk" (World Bank, 2000b, p. 139). In this section, I investigate whether these statements are supported by the results of the equilibrium models for cereal trade in Burkina Faso. The effect of infrastructure on the growth of cereal trade is expected to be considerably lower than the effect on transport for export goods because of the inelasticity of cereal supply. That is, cereal supply does hardly react on prices (see also the Sections 6.1.1). Only the timing of supply may change. In other words, the trade effects are basically redistribution effects.

In Section 8.2.1, the influence of an overall decrease or increase of transport cost on cereal prices and transport flows will be analysed. Note that transport costs deal with the costs of transport between the main cities in the different regions. Next, in Section 8.2.2, it is analysed what happens if some routes are asphalted. Finally, I examine the effect of improved road (main and rural roads) and communication (especially telephone and fax) infrastructure on cereal trade in Section 8.2.3. These improvements result in a reduction of the expenses on transport and personnel. I analyse the situation in which transport and transaction costs decrease by 25%. Some conclusions of the parameter adaptations in the equilibrium model will be drawn in Section 8.2.4.

8.2.1 An Overall Decrease of Transport Costs

Consider four cases: a decrease of transport costs by 25%, a decrease by 10%, an increase by 10%, and an increase by 25%. It is interesting to analyse the impact of an increase of transport costs as well because Danagro (1999) concluded that many carriers would have more healthy businesses if they could ask higher transport prices. A reduction of transport costs may be reached by improved road infrastructure, improved management of transport companies, improved truck maintenance, and cheaper fuel and spare parts.

It follows from the results that the impact of a general increase or decrease of transport costs on prices is small. Compared to the base results, if transport costs decrease, producer and consumer prices decrease in the regions to which is transported (Centre, Centre Nord, Sahel), whereas they increase in the surplus regions (Mouhoun, Sud Ouest) (see Table 8.2.a). The picture is the reverse if transport costs increase. Most consumer prices change less than 1%. The maximum changes of average prices per region are an increase of 3.2% in the region Est and an increase of 3.1% in the region Sahel if transport costs increase with 25%. The change in Est is caused by a change in the timing of supplies, and the change in Sahel by a drop in the quantity transported (see below).

Prices increase in one region and decrease in another due to the forces of supply and demand, the scarcity of cereals, and the price inelasticity of cereal supply. For example, if transport costs decline, prices in Sahel decrease. As a result, demand in Sahel increases. To satisfy this extra demand, traders will transport more from Mouhoun and Est. Total demand in these regions rises (demand from consumers and from traders who want to transport to Sahel), whereas producer supply can hardly change. As a consequence, producer prices have to rise in Mouhoun and Est (so that the price difference with Sahel is equal to the transport costs). Also transports from other regions to Sahel can not increase substantially because total annual supply can hardly change. This example shows that if transport costs make up, for example, 20% of the price in Sahel, a fall of the costs with 25% will not result in a decrease of the price with 5%. It will be considerably less. An overall decrease of transport costs can, for that reason, only result in modest changes in producer and consumer prices. Another consequence is that, on average, prices may increase, even if transport costs decline.

Table 8.2.a: Model results if transport costs change: % change of average consumer prices, semi-welfare, consumer utility, and trader net losses

Change of Average Consumer Prices in the different CRPAs[1]									
	Change of Transport costs					Change of Transport costs			
↓ CRPA	-25%	-10%	+10%	+25%	↓ CRPA	-25%	-10%	+10%	+25%
Centre	-0.5%	-0.4%	0.8%	2.1%	**Nord**	0.1%	-0.2%	0.5%	1.1%
Cen. Nord	-0.8%	-0.3%	0.6%	1.4%	**Sud Ouest**	2.0%	0.7%	-0.4%	-0.7%
Cen. Ouest	0.2%	-0.2%	0.8%	1.9%	**Hauts Bass.**	0.3%	0.0%	0.3%	1.1%
Centre Sud	0.8%	0.0%	0.4%	1.5%	**Comoé**	0.5%	0.0%	0.3%	0.8%
Sahel	-1.7%	-0.8%	1.2%	3.1%	**Average[2]**	0.3%	0.0%	0.6%	1.4%
Mouhoun	2.4%	0.7%	-0.4%	-1.1%	**Semi-Welfare**	1.6%	0.7%	-0.9%	-1.8%
Est	0.7%	0.7%	2.3%	3.2%	**Consumer Utility**	0%	0%	-0.5%	-1.0%
Centre Est	-0.1%	-0.1%	0.8%	1.9%	**Trader Net Losses**	-25%	-19%	12%	13%

Notes: 1) Average consumer price over the four periods per CRPA; 2) Average price for Burkina Faso, i.e. the average over all CRPAs and periods.

If transport costs increase, optimal welfare decreases, total consumer utility decreases, and trader losses increase (see Table 8.2.a). The change of welfare and total utility is less than 2%. In the regions in which prices fall, consumers will profit from a fall in transport costs. Consumers in the other regions will experience declining utility levels. For producers, net revenues increase if prices rise, and vice-versa. The impact on trader net profits is large, mainly due to changes in the quantities stored (see below).

Also transport flows hardly change. If transport costs decrease with 25%, the quantity transported only increases by 0.6% (see Table 8.2.b). It is striking that the quantity transported also increases if transport costs increase. The net annual flows from or to the different regions, however, increase if transport costs decrease, and vice versa.[3] The net flows change with +0.8%, +0.5%, -0.9%, and -2.1% for the four scenarios. Total flows change due to changes in the timing of supplies by the producers. Subtle changes in prices may have important consequences for the timing of producer supply, which influences transport flows. For example, in the base scenario and if transport costs decrease, producers in the region Est supply in the periods 3 and 4 about 13 kg and 10 kg per person. If transport costs increase, this changes in 19 and 4 kg in the periods 3 and 4. As a result, transport from Est increases in period 3,

[3] The net annual flow of cereals from a region is defined as the total annual quantity transported from that region to other regions minus the total annual quantity transported towards that region.

Table 8.2.b: Model results if transport costs change: quantities transported (in 1000 tonnes)

		Change of Transport Costs							Change of Transport Costs				
From	**To**	**-25%**	**-10%**	**base**	**10%**	**25%**	**From**	**To**	**-25%**	**-10%**	**base**	**10%**	**25%**
CO	**C**	12.1	12.2	12.1	12.2	12.4	**CE**	**C**	6.5	6.5	6.5	1.0	1.1
CS	**C**	7.3	7.6	8.1	8.2	8.3	**CE**	**Est**	0.0	0.0	0.0	5.5	5.5
CS	**CN**	6.7	6.4	5.8	5.8	5.7	**SO**	**C**	15.3	14.2	13.7	8.1	5.3
Mo	**C**	20.6	21.1	21.0	24.9	27.1	**SO**	**CN**	0.8	1.7	2.2	2.1	2.0
Mo	**CN**	0.7	0.0	0.0	0.0	0.0	**SO**	**CO**	0.0	0.0	0.0	0.4	1.5
Mo	**CO**	5.0	5.1	5.1	4.7	3.5	**SO**	**HB**	11.9	11.9	11.9	17.1	19.6
Mo	**Sa**	11.9	12.0	11.9	11.7	10.7	**SO**	**Com**	0.9	0.9	0.8	0.8	0.0
Mo	**No**	14.4	14.5	14.4	14.3	14.2	**HB**	**C**	23.5	23.3	23.3	23.2	23.2
Mo	**HB**	3.9	3.4	3.4	0.0	0.0	**HB**	**Com**	0.4	0.4	0.4	0.4	0.4
Est	**C**	4.8	5.1	5.0	11.5	10.9	**Com**	**HB**	5.3	5.8	5.8	3.8	0.9
Est	**Sa**	1.3	1.0	1.0	0.8	1.5		**Total**	159	158	158	162	159
Est	**CE**	5.2	5.1	5.1	5.0	4.9							

Note: C = Centre, CN = Centre Nord, CO = Centre Ouest, CS = Centre Sud, Sa = Sahel, Mo = Mouhoun, CE = Centre Est, No = Nord, SO = Sud Ouest, HB = Hauts Bassins, Com = Comoé.

but traders have to transport to Est in period 4 to satisfy consumer demand. Net annual transport from the region Est does, however, not change a lot compared with the base scenario.

Compared to the base results, the quantities stored change with respectively -22%, -19%, +19%, and +38%, for the four scenarios. This is especially due to a shift in the timing of producer supply in some regions.

8.2.2 Asphalting Some Routes

If specific routes are asphalted, transport costs between the regions connected by the new roads will decline. These decreases may be considerable. For example, by asphalting the road from Dédougou to Dori, transport costs from Mouhoun to Sahel or Nord will drop by 30%. I consider three different routes, for which I analyse the impact on cereal trade if they are asphalted; (A) from Dédougou (Mouhoun; see Figure 1.1) to Dori (Sahel), (B) from Bobo-Dioulasso (Hauts Bassins) via Dédougou to Ouahigouya (Nord), and (C) from Dédougou to Koudougou (Centre Ouest). All these routes are used intensively for transport from the surplus regions Mouhoun and Hauts Bassins towards the shortage regions Centre, Sahel, and Nord.

As expected, the impact of transport costs on prices and transported quantities is small for all cases. Average prices increase for all cases with less than 1%. For the regions along the newly asphalted route, prices decrease a little in the importing regions and they increase a little in the exporting regions. For the regions not connected by the new road, prices increase. Transporting from and to these regions becomes relatively more expensive, due to the new road. As a result, consumption decreases in the regions in which prices increase. Also transport to these regions declines. For example, by asphalting the road from Dédougou to Dori, prices in the region Sahel decrease by 3.9%, but prices in the region Centre increases by 0.5%. As a result, transports to Sahel increase by 7.6%, but transports to Centre and Centre Nord fall. Also the direction of transports changes. For this case, a part of the cereals which were first transported from Mouhoun to Centre are now transported to Sahel, whereas a part of the cereals which were transported from Est to Sahel are now heading for Centre. Likewise, by asphalting the road from Dédougou to Koudougou, consumer prices in the region Sahel and Nord increase by 1.6% and 0.8%. Consumption in these regions as well as transport towards these regions falls. Transport flows from Mouhoun to Centre increase by 40% (+8,510 tonnes). This is at the expense of transport flows from Mouhoun to Sahel and to Hauts Bassins (-4,630 tonnes and -3,400 tonnes). These flows are partly taken over by transports from other, but more expensive, regions, resulting in higher prices. The deterioration of the consumption situation in the shortage regions not connected by the new road is an unwanted effect of asphalting specific roads.

Another unwanted effect is that some regions may lose their competitive position to the regions connected by the new road. For example, for Case B, the producers in Comoé supply less than in the base scenario. Transports to Hauts Bassins, which came from Comoé in the base scenario, now originate from Mouhoun. Consumption can increase if producers in Comoé supply more. However, the extra utility obtained from a higher consumption does, apparently, not outweigh the extra transport costs if more is transported from Comoé to Hauts Bassins and from Mouhoun to the shortage areas. Cheaper transport costs on one route may price other routes out of the market, resulting in higher prices in all regions if goods are scarce and in a decrease of the transported quantity.

8.2.3 Better Road and Communication Infrastructure

In Section 3.2.3, it was argued that better road and communication (especially telephone and fax) infrastructure may not only lead to lower transport costs, but also to lower costs for personnel and considerably less risk for the traders. If transport costs are lower, especially if rural infrastructure is improved, traders can visit remote regions more easily. Furthermore, if they can rely on telephone and fax lines, they can control their employees working in remote areas and search for information on supply and demand opportunities more easily. As a consequence, transaction costs will decrease. Consider the case in which transport and transaction costs decrease by 25% (transaction costs fall from 15 FCFA/kg in the base scenario to 11.25 FCFA/kg). Due to the fall in transaction costs, the margin between producer and consumer prices will decline. It is possible that the consumer price decreases whereas the producer price increases. In that case, both producers and consumers benefit from the changes. It is, however, also possible that consumer as well as producer prices increase or decrease. Due to the scarcity of cereals and the inelasticity of supply, it is not expected that consumer prices decline a lot.

Compared with the base results, the consumer prices decrease on average by 1.2% and the producer price increases by 2.4%. In the first three periods, consumer prices decrease in almost all regions. Average decreases in the first three periods are respectively 2.4%, 1.8%, and 2.8%. As a result, demand increases in these periods. Due to the higher demand in the first periods, cereals are scarce in the last period, resulting in higher consumer prices compared to the base results (+1.7%). The average decrease of consumer prices is highest in the regions Sahel (-3.4%), Centre Nord (-2.6%), Centre (-2%), and Nord (-1.5%).

Producer prices increase in almost all regions and all periods. Increases are highest in period 4 (on average +5.4%, compared to +1.3%, +1.9%, +0.5% for the other three periods). The increases are highest in the main exporting regions Mouhoun, Est, and Sud Ouest. Due to the price increase, producers in the region Comoé sell their entire annual supply, whereas in the base scenario, they only sell a part of the stock which can be sold during the year. The transported quantity increases by 4.7%. Transport to the region Sahel increases by 5.2%, to Nord by 4.9%, to Hauts Bassins by 2.1%, and to Centre by 1.7%.

A consequence of these changes is that overall welfare increases by 6.6%. Utility increases in the shortage regions Centre, Sahel, Centre Nord, and Nord and the regions Comoé and Hauts Bassins (between 0.8% and 4.8%), i.e. in the regions towards which goods are transported. It remains the same or decreases slightly in the other regions. Net producer revenues increase on average by 25.6%. This is so high because, in this case, net producer revenues are positive in all regions during all periods. For the regions for which revenues per unit of cereals supplied were negative in the base scenario and positive in this case, total revenues change a lot. The losses of the traders decrease by 23.4% due to less storage.

Compared with the scenario in which only transport costs fall by 25% (see Section 8.2.1), the situation is better now for almost all market actors. The few producers and consumers who are worse off, see their net revenues and utility fall only a by small percentage. The others see their situation improve much more. If only the transport costs for the main routes fall, changes in prices and transport flows are small. The changes will be larger and more effective if traders can also save a lot on their personnel costs and if their trade risks drop. More reliable telephone and fax lines and improved rural roads certainly help in achieving such a situation.

8.2.4 Conclusions for Scenario 1

The analysis of the influence of road and communication infrastructure on cereal trade, as discussed in the previous sections, gives some interesting and remarkable results. First, the direct influence of transport costs on cereal prices, quantities, consumer utility, and semi-welfare is small. The main reason is that transport costs only make up 5% to 20% of the price. Due to the forces of supply and demand, lower transport costs will result in lower prices in the regions to which is transported (the importing regions) and higher prices in the regions from where is transported (the exporting regions).

Secondly, due to the inelasticity of supply, the price decrease in the importing regions is expected to be lower than the price increase in the exporting regions. Consumer prices in the importing regions can not fall too much, because the resulting rise in demand can hardly be satisfied by a rising supply of cereals. Only if consumer prices in the importing regions fall by a

small percentage and producer prices in the exporting regions increase more (so that their difference is equal to transport costs), an equilibrium can be reached.

Thirdly, a change in transport cost has positive consequences for some people but negative consequences for others. If prices increase, producer net revenues from supplies will increase but consumer utility will decrease, and vice versa. Especially asphalting specific routes may have unforeseen consequences for the quantities transported to the shortage regions. The consumers in the most vulnerable regions may be affected more than wanted. An example is asphalting the road from Dédougou to Koudougou. A consequence is that the quantity of cereals transported to the regions Sahel and Nord will decrease due to a price increase in these regions. If transport costs for one route decrease, other routes become relatively more expensive, in that way affecting their competitiveness. A result may even be that total cereal supplies decline.

Fourthly, important improvements can be achieved for most market actors, if transaction and transport costs decrease simultaneously due to better telecommunication networks and better main and rural roads. In that case, rural market places can more easily and more cheaply be reached, information can more easily be gathered, and personnel can more easily be monitored. As a result, producer prices may rise and consumers prices fall simultaneously, leading to higher net revenues for the producers, and higher cereal consumption and utility for the consumers.

These results demonstrate that the general statement that a decrease of transport costs will have a considerable influence on the quantity transported must be nuanced. The direct influence on cereal trade and the food situation of the poorer, rural regions is limited, if the transport costs decrease for the main routes only. Furthermore, the influence will not be positive for everybody and one has to be aware of unwanted effects of changes in transport costs. However, if transaction costs decrease due to better (rural) road and communication infrastructure, the market situation may improve considerably for most market actors. The differences in the effects of transport and transaction costs are generally not acknowledged in other studies dealing with the influence of transport costs on trade. It has to be noted that I only deal with the direct impact of transport costs on cereal trade. Spin off effects of improved infrastructure,

which may lead to higher income levels of urban and rural households, are not considered.

8.3 Scenario 2: An Improvement of the Levels of Cereal Production

In section 7.1, it has been argued that in many years annual cereal production is just enough to feed the population. Some regions are in a surplus situation, others in a deficit situation. Some regions are alternately in a deficit or surplus situation, dependent on the whether rainfall was bad or good. An important government objective is to reach a durable increase of cereal production. During the last decades, important improvements have been made in this respect. However, the situation is still critical for a large part of the population. Furthermore, degradation of soil fertility and an increasing pressure on land due to population growth are an impediment for a durable improvement of the national food security situation.

In this section, I analyse the influence of an increased level of cereal production. A number of scenarios are considered. First, in Section 8.3.1, I analyse the influence of a general improvement of the cereal production levels. Also the influence of a deterioration of cereal production is considered to analyse the influence of a bad harvest. I consider the cases in which the cereal production levels decrease in the entire country by 10%, and in which they increase by 10%, 20% or 30%. In Section 8.3.2, I discuss the model results if production improves by 20% in only a part of the country. Next, in Section 8.3.3, I analyse the influence of an improved provision of information on cereal production levels. If traders and producers get more accurate information on the cereal production levels in the different regions, they may adapt their price expectations. In this section, I also analyse the changes if, next to improvements in the provision of information, also transaction costs for the traders and production costs for the producers fall. If traders can purchase larger quantities at once, their transaction costs may increase. Furthermore, if farmers produce more, their costs per unit may fall. Some conclusions of these adaptations of the equilibrium model will be drawn in Section 8.3.4

8.3.1 A Deterioration or Improvement of Cereal Production

Consider four cases: a decrease of cereal production by 10%, an increase of cereal production by 10%, by 20%, or by 30%. The quantity of cereals that producers can supply changes by the same percentages as production. A summary of the results is presented in Table 8.3.a and Table 8.3.b. The results clearly show that prices increase in all regions if production decreases and vice versa (see Table 8.3.a). If production increases, welfare and utility increase (see Table 8.3.a). A remarkable result is that the net revenues of the producers decline if their supplies increase. Their margins fall if prices decrease and production costs remain the same. The production increase is apparently not enough to compensate for the declining margins. Also the situation for the traders deteriorates if prices decrease. If optimal prices are lower but expectations do not change, they expect to make higher profits. As a result, they store substantially more cereals (see Table 8.3.b). However, due to the higher availability of cereals on the market, the prices do not increase as expected, resulting in high losses. In Section 8.3.3, it is analysed to what extent strategies change if they adapt their price expectations.

The change in cereal prices is highest in the last period. This is caused by wrong expectations (see also Section 8.3.3). In the model, the producers and traders do not adapt their price expectations after a change of production. If production increases, they still expect that the prices in each period increase by the same values as in the base scenario (see Section 7.2.3 and 7.4). Consequently, the producers save a large part of their production for the last period. Due to the resulting abundance of cereals, prices fall in period 4. If production decreases, the price increase in the last period is even more explicit. If production decreases by 10%, consumer prices in the first three periods increase on average by only 1.6%, 3.0%, and 3.8%. In the last period, however, it rises by 45.5%. In the model, producers and traders do not expect the price to go up that much, and they do not take into consideration well enough the scarcity of cereals. Not enough cereals are saved for the last period, resulting in sky high cereal prices. This affects especially demand in the last period, which decreases by 24.8%. The rural population is hit even harder, as not only purchases but also the amount of cereals taken from the own stocks decrease. This fall in consumption may pose large problems during the period July-September, which is also called the ‘hunger period’.

Table 8.3.a: Model results if cereal production changes: % change of average consumer prices, semi-welfare, consumer utility, and trader net losses

Change of Average Consumer Prices in the different CRPAs[1]									
	Change of Cereal Production					Change of Cereal Production			
↓ CRPA	-10%	+10%	+20%	+30%	↓ CRPA	-10%	+10%	+20%	+30%
Centre	+14.3%	-2.7%	-4.8%	-7.4%	Sud Ouest	+16.0%	-2.5%	-4.0%	-7.0%
Cen.Nord	+13.2%	-2.8%	-4.2%	-6.0%	Hauts Bassins	+12.2%	-3.4%	-5.8%	-8.6%
Cen.Ouest	+16.0%	-2.3%	-4.1%	-6.7%	Comoé	+12.6%	-1.7%	-4.1%	-7.2%
Cen.Sud	+14.4%	-1.7%	-2.7%	-5.1%	Average[2]	+14.6%	-2.4%	-4.3%	-6.8%
Sahel	+13.0%	-2.7%	-4.3%	-6.6%					
Mouhoun	+15.3%	-3.3%	-5.6%	-8.6%	Semi-Welfare	-4.5%	+1.3%	+2.3%	+2.7%
Est	+18.5%	-1.6%	-4.1%	-5.4%	Consumer Utility	-10.0%	+1.6%	+3%	+5%
Cen. Est	+16.6%	-1.0%	-3.7%	-4.9%	Producer Net Rev	+99.4%	-14.6%	-26.5%	-46.6%
Nord	+14.1%	-3.0%	-4.7%	-8.1%	Trader Net losses	-52.3%	+58.3%	+138.1%	+236.6%

Notes: 1) Average consumer price over the four periods per CRPA; 2) Average price for Burkina Faso, i.e. the average over all CRPAs and periods.

It is logical that prices decrease if production increases. Cereals become less scarce and prices have to fall to be able to sell the extra supply to the consumers. The price changes are most pronounced in the surplus regions Hauts Bassins and Mouhoun (see Table 8.3.a), and smallest in the regions Est, Centre Est, Centre Sud, and Comoé. Total supplies for the entire country increase by 2.2%, 4.0%, and 6.5%, if production increases with 10%, 20%, or 30%, respectively. In Est, Centre Est, Centre Sud, Sud Ouest, and Comoé supply per person does not increase by the same percentage as production. It even decreases in some regions. In the other regions, it increases by 10%. If production decreases by 10%, supply decreases by 9.3%. In that case, supply decreases by 10% in all regions, except for the region Comoé. In the case of a production increase, supplies in the northern and western regions increase more than supplies in the southern and eastern regions for two reasons. First, in the shortage regions, supply increases by the same percentage as production, since this results in a cheap improvement of the food situation (no extra transport costs). Secondly, if prices in Centre Est, Centre Sud, and Comoé would be lower, traders in these regions would be able to compete with traders in the surplus zones. However, producer supplies in these regions will drop to their minimally required levels if traders offer lower prices. On the other hand, producers in the surplus zones Hauts Bassins and Mouhoun will still offer their entire available stock if prices slightly decrease, even if the quantity they can

Table 8.3.b: Model results if cereal production changes: Quantities transported (in 1000 tonnes) and quantities stored

	Change of transport flow from each CRPA					Change of transport flow to each CRPA				
	Change of cereal production					Change of cereal production				
↓ CRPA	-10%	base	10%	20%	30%	-10%	base	10%	20%	30%
Centre	0	0	0	0	0	84.4	89.7	89.6	89.1	89.4
Cen. Nord	0	0	0	0	0	7.2	8.0	7.3	6.5	5.9
Cen. Ouest	9.8	12.1	15.0	12.6	1.0	3.4	5.1	5.2	0	0
Cen. Sud	12.9	14.0	5.7	6.7	7.7	0	0	0	0	0.8
Sahel	0	0	0	0	0	11.2	12.8	12.6	12.1	11.9
Mouhoun	51.0	55.8	64.0	72.3	80.0	0	0	0	0	0
Est	14.4	11.1	14.1	13.7	8.7	3.2	0	0	0	0
Cen. Est	7.6	11.5	1.5	0.2	0.7	6.0	10.1	6.2	7.3	6.7
Nord	0	0	0	0	0	13.1	14.4	14.0	13.4	13.4
Sud Ouest	26.2	28.6	29.2	11.7	13.3	0	0	0	0	0
Hauts Bass	20.4	23.7	25.5	27.9	32.1	20.1	21.0	18.2	15.6	15.1
Comoé	7.1	5.8	0.5	0.4	1.1	0.7	1.3	2.5	1.5	1.5
Total	149.2	162.5	155.5	145.5	144.6	Changes of the quantity stored				
Change[1]	-5.3%		-1.3%	-7.6%	-8.2%	-36.8%		+103%	+199%	+239%

Notes: 1) changes with the base results, see Table 8.1.d; 2) the quantity stored in the base scenario was 16,970 tonnes, see Table 8.1.d.

sell increases. Producers in the southern and eastern regions can not sell to the traders at prices which can compete with prices from the main surplus regions.

If production decreases, transported quantities decrease due to a lower availability of cereals (see Table 8.3.b). If production increases, total transported quantities also decrease. Total flows fall because supplies from within the region increase, due to which transports are less necessary. Net transport flows behave differently. Net flows are 125,000, 130,000, 129,000, 127,000 tonnes for the base scenario and the scenarios in which production increases by 10%, 20%, and 30%, respectively. Transport flows from Mouhoun and Hauts Bassins increase if production rises. For the regions Centre Ouest, Est, and Sud Ouest it depends on the scenario whether exports increase or decrease. If production increases more, it is more efficient (in terms of semi-welfare) to transport more from Mouhoun and Hauts Bassins, and to transport less from Centre Ouest, Est, and Sud Ouest. Since prices in Mouhoun and Hauts Bassins are lower, the traders in the regions Centre Ouest and Sud Ouest can no longer compete with the traders from the largest surplus zones. So, an overall

increase of production may be positive for the traders in the largest surplus zones (they transport more), and negative for the traders in the regions which export moderate quantities (they transport less). Transported quantities to the shortage regions decrease. But due to the increase of production, the cereal availability in these regions rises. The increase of cereal demand, is, however, less than the increase of production in these regions.

The quantities stored are also sensitive to changes in the cereal production levels (see Table 8.3.b). If production increases, traders expect to make higher profits from storage, and consequently, they store more and in more regions. If production falls, the picture is the reverse.

8.3.2 Increased Cereal Production Only in Some Parts of the Country

If cereal production does not increase by 20% in all regions but only in some parts of the country, the changes of the results are smaller. Consider two cases. In Case A, cereal production increases by 20% in the major supply regions Hauts Bassins, Mouhoun, Sud Ouest, and Comoé. In Case B, cereal production increases by 20% in the shortage regions Sahel, Nord, Centre Nord, and Centre. Prices decrease in both cases; on average by 2.7% in Case A, and by 0.6% in Case B.

In Case A, prices decrease the most in the regions in which production increases. Supply increases by 20% in the regions Mouhoun and Hauts Bassins, by only 9.4% in the region Sud Ouest, and it decreases by 30% in the region Comoé. In Comoé, the price drop resulted in larger losses for the producers, due to which they sell less. It is, apparently, more efficient for traders in Comoé to import the cereals from Hauts Bassins and Sud Ouest, instead of offering the producers in Comoé higher prices to urge them to offer more. This is an example in which producers can no longer compete with producers from other regions due to changes in market prices. The quantity transported increases by 2%. Especially transports from Mouhoun, Hauts Bassins, and Sud Ouest increase. Consumption increases in all regions.

In Case B, supplies increase by 20% in the four regions in which production increases. Prices in Sahel decrease more than in the other regions (in Sahel -1.8%). Despite of the price decreases, producer revenues increase substantially for these regions. This differs from the results in the previous section. The total supplied quantity falls by 2.8%, because supplies fall in

Comoé and Centre Sud. The producers in these regions have difficulties competing with cereal imports from other regions. Transport flows decrease by 2%. Especially transports to the northern regions and Centre decrease. Total demand increases in the four shortage regions in which production increases, although much less than the increase of their supplies. In these regions, producer supplies increased by 10,690 tonnes, but consumer demand only by 1,210 tonnes (an increase of only 0.7%). So, an improvement of production does lead to an improvement of the food security situation. The largest improvement is, however, for the cereal producers, because both their revenues and their consumption (taken from own stocks) increase. Urban households hardly benefit from the production increase because it is less interesting for traders to transport cereals to these regions.

8.3.3 A Change in Cereal Production and Price Expectations

In the cases discussed in the previous two sections, producers and traders did not adapt their expectations on price developments. In the first period, the expectations for future prices were the same in each of the cases discussed. In the other periods, they expected the prices to increase like they had expected in the base scenario, independent of the quantity produced.[4] If they have better information on the cereal production levels, they can better anticipate on expected price changes. If production is good, producers and traders expect lower than average future market prices; if production is bad, they expect higher than average future market prices. In this section, I discuss changes in the model results if not only production increases or decreases, but if producers and traders also know about these changes and, as a consequence, adapt their price expectations. I consider three cases. In Case A, production decreases by 10%, producers and traders expect in period 1 that future prices are 10% above the average observed prices, and they expect in the other periods that the predetermined margins with which prices are expected to change in each period,

[4] Recall that producers and traders expect the price in each period to increase with a predetermined value. In period 1, they expect prices in period 2, 3, and 4, to be equal to average observed prices. In period 2, they expect prices in period 3 and 4 to be equal to the realised optimal prices for period 1 plus a predetermined margin. In period 3, they expect prices in period 4 to be equal to the realised optimal price in period 2 plus a predetermined margin, see Sections 7.2.3 and 7.3.

increase by 10% (see also Footnote 4). In Case B, production increases by 20%, and the future prices which are expected in period 1 and the predetermined margins which are expected in the other periods, decrease by 10%. These cases are compared with the situations in which production decreases by 10% or increases by 20%, but price expectations are not adapted. Call these Case A' and B'. Finally, I consider a Case B", in which, like in Case B, production increases by 20% and price expectations fall by 10%, and in which also transaction and production costs fall by 20% and 10%, respectively. In Section 3.3, it has been argued that these costs may fall if larger quantities are produced and supplied.

For the case of a bad harvest (Case A), having correct information on the effect of supplied quantities on prices is important. In Case A', consumer prices increase in the last period on average by 45.5% (see Table 8.3.a). If producers and traders know about the production fall and expect prices to increase by 10%, the average price will increase by 13.7% (was 14.5% in Case A'), and the increase in period 4 will only be 25.7%. As a result, demand, semi-welfare, and utility will decline less. On the other hand, producer revenues will increase a little less. If the producers and traders have more accurate information on production, they can better predict future prices, and they can better spread their activities over the year. As a consequence, shortages will be less dramatic and will be spread more equally over the year, instead of culminating in period four (as was observed in Case A').

The results for Case B show that, if traders and producers expect lower prices if production increases, optimal prices decrease more than if they do not adapt their expectations. For Case B' prices decrease on average by 4.3% compared to the base results (see Table 8.3.a). For Case B, they decrease by 8.6%. Furthermore, total supplies are 3% higher than for Case B' and the prices in the last period do not show such a sharp decline. If producers have better price expectations, they can better spread their supplies over the year.

Finally, consider Case B". The influence of the fall in production and transaction costs is large. Compared to Case B, semi-welfare is 14.8% higher. Compared to the base scenario this is even +17.9%. Consumers benefit from the declining consumer prices. Producers benefit from the fall in their production costs. Producer prices do decrease, but less than the production costs. As a result, the margins increase for the producers. Due to the falling transaction

costs, consumer prices decrease more than producer prices. These changes lead to an increase of demand and supply by 4% compared to Case B (compared to the base scenario this changes by +11.4%). Due to the change in the margins, producers in the regions Centre Sud, Centre Est, and Comoé supply more. Did transport flows in Case B decrease compared to the base scenario, in the current situation it increases. Now, the extra demand in the shortage regions can not be satisfied from the extra supplies in the own region, but partly comes from the surplus regions.

8.3.4 Conclusions for Scenario 2

The analysis of the influence of the level of cereal production gives some interesting results. First, as expected, prices decrease if the cereal producers succeed in increasing their production. If this increase is not accompanied by a decrease of the production costs, this does not automatically mean that the producers benefit from their higher supplies. Their consumption will increase, but their net revenues may fall. If also production costs decrease, the margins for the producers may increase, and supplies may increase more than in the situation without these cost cuts. If also transaction cost decrease, producers can benefit even more from their production increase. In that case consumer prices will fall more than producer prices. The lower consumer prices result in an increased consumption of cereals by the rural as well as the urban population.

Secondly, a production increase in a certain region does lead to higher cereal consumption levels by the consumers in that region. However, demand increases much less than supplies. Especially for the urban consumers, cereal consumption will increase with only a small percentage. In the case of a surplus region, a part of the extra supplies will be transported to other regions. In the case of a deficit region, less cereals will be transported towards that region. Also for the rural consumers, demand will increase with only a small percentage, but consumption levels will improve more because rural consumers can take a larger amount of cereals from their own stocks.

Thirdly, a production increase and the resulting price drop may price traders and producers in other regions out of the market. If production in a neighbouring region increases, it is possible that producers can not compete with cheaply imported cereals. As a result, their supplies and revenues may decrease. Likewise, consider a situation in which traders from a region A and B

transport cereals to a region C. If the price in region A decreases, it is possible that also prices in region C decrease. A result may be that traders in region B have to stop their transports to region C because they can not compete anymore with the traders in region A.

Fourthly, it is important for traders and producers to have correct information on the cereal production levels. If they can make better price forecasts, producers can spread their supplies more equally over the year, and traders can make better storage decisions. A likely result is an increase of the quantity supplied. If producers do not have correct information on production increases, they run the risk to save too large stocks, which have to be dumped for low prices in the last period. If they have wrong information on a fall in production, they run the risk to sell too much during the first periods, leading to sky high prices and a large shortage in the last period. Dramatic situations may be prevented by transmitting on time the correct information on cereal production levels and expected price developments.

8.4 Scenario 3: An Improvement of Consumer Income Levels

An important determinant of cereal purchases is the income level. In this section, I analyse the influence of income levels on cereal prices and cereal trade. First, I investigate the influence of a general increase of income by 10% in Section 8.4.1.[5] Also the influence of a change of price expectations and of transaction costs is considered. Transaction costs may decrease because uncertainty decreases for the traders. In Section 8.4.2, the influence of a change of income only in some regions due to specific economic developments is considered. In Section 8.4.3, I summarise the main conclusions from these analyses.

8.4.1 A General Increase of Income

Consider four cases. In all cases income increases by 10%. In Case A, price expectations do not change, in Case B price expectations increase by 5%, and in Case C they increase by 10%. In Case D, income and price expectations

[5] In fact, I assume that the supernumerary income increases by 10%, i.e. the income which remains after all minimal consumption requirements are satisfied, see Section 7.2.4.

increase by 10%, and transaction costs decrease by 10% to 13.5 FCFA/kg (see Section 7.3). Due to the higher income levels and better information availability, uncertainties for the traders decrease, which may result in lower transaction costs.

The results show, as expected, that prices increase if income increases. Due to the higher income, consumers want to purchase more if prices remain the same. Since supply can hardly change, cereal prices rise. As a consequence, producer net revenues increase considerably. Price expectations do matter (see Table 8.4.a). On average, consumer prices increase more, if price expectations change more. If price expectations do not change, prices in the first three periods increase only by a small percentage, whereas prices in the period July-September increase, on average, by 23%. If expectations increase, the periodical price increase is more gradual. In comparison to Case A, the increase in the first three periods is higher, but the increase in the last period is considerably lower, see Table 8.4.a. In these cases, producers and traders anticipate better the augmented scarcity of cereals. This confirms once again the importance of having access to correct information on the factors influencing prices.

If income changes by 10%, total cereal demand increases by almost 1%, see Table 8.4.b. Considering the estimates of the income elasticities of demand, cereal demand would increase with 7% to 9% if income would increase by 10% and prices would remain the same, see Section 7.2.4. However, an increase exceeding 1% is not possible, because the producers already supply their maximum quantity in these cases. Demand also depends on price expectations. In Case A, demand in the first three periods increases, but demand in the last period decreases compared to the base scenario. Such unwanted changes will less frequently arise if producers and traders have more information on which they can base their price expectations. The percentage changes are higher for rural than for urban consumers, because they spend a larger part of their income on cereal purchases. The changes in kilograms are, of course, smaller for the rural consumers, because they purchase only small amounts of cereals.

Due to the increased demand, the transport flows increase (+4% for the Cases A, B, and C). Especially the flows from Comoé increase. Transports to Centre, Sahel, Nord, and Centre Nord, increase for the Cases A, B, and C, on average by 1.7%, 2.9%, 1.6%, and 3.1%. Due to price changes, traders store less cereals if they do not adapt their expectations. If they do adapt their

Table 8.4.a: Model results if consumer income increases by 10% and price expectations change: Consumer prices

↓ CRPA	Changes in Av. Consumer prices[2]				↓ CRPA	Changes in Av. Consumer prices[2]			
	Cons. Price Base Scen.[1]	Price Exp. +0%	Price Exp. +5%	Price Exp. +10%		Cons. Price Base Scen.[1]	Price Exp. +0%	Price Exp. +5%	Price Exp. +10%
Centre	118	8.1%	7.8%	8.2%	**Hauts Bass.**	114	8.2%	8.1%	8.5%
Cen. Nord	120	6.8%	7.6%	8.7%	**Comoé**	113	7.7%	7.9%	7.5%
Cen. Ouest	113	8.4%	7.8%	7.2%	**Average Price**	114	8.2%	8.5%	8.8%
Centre Sud	113	7.5%	8.3%	8.2%	**Changes in Cons. Price per Period**	**Oct-Dec**	**Jan-Mar**	**Apr-Jun**	**Jul-Sept**
Sahel	125	7.2%	7.2%	7.8%					
Mouhoun	106	8.4%	9.1%	9.6%					
Est	109	11.4%	11.8%	12.3%	**Base Scen.[3]**	106	108	115	126
Cen. Est	114	9.3%	10.1%	10.6%	**Price exp.+0%[4]**	1.1%	2.7%	3.8%	23.1%
Nord	115	7.7%	8.3%	8.7%	**Price exp. 5%[4]**	5.6%	5.4%	3.6%	18.1%
Sud Ouest	104	8.7%	8.5%	9.2%	**Price exp.+10%[4]**	9.3%	8.8%	7.1%	10.1%

Notes: 1) Average annual consumer prices in the base scenario per region in FCFA/kg, see Table 8.1.a; 2) Percentage changes in average annual consumer prices compared to consumer prices in the base scenario, if income increases by 10% and if price expectations remain the same, increase by 5%, or increase by 10%; 3) Average national consumer price in the base scenario per period, in FCFA/kg, see Table 8.1.a; 4) Percentage changes in average national consumer prices compared to consumer prices in the base scenario, if income increases by 10% and if price expectations remain the same, increase by 5%, or increase by 10%.

expectations, they expect to make higher profits. Consequently, they store larger quantities. However, still prices increase less than expected, so they lose from their storage activities, due to which their losses are higher than in the base scenario.

The results of Case D do not differ a lot from those of Case C. The average consumer price is only 0.2% lower than in Case C. Almost the entire decrease of transaction costs goes to an increase of the producer prices. Compared to Case C, they increase on average by 1.2% (for the Cases C and D, the average producer prices are 108.8 and 110.2 FCFA/kg, respectively, and the average consumer prices are 123.8 and 123.7 FCFA/kg, respectively). As a consequence, consumer utility levels do hardly change, but producer net revenues increase. Because the producers already supply their maximum quantity, the fall in transaction costs can not lead to lower consumer prices (in Section 8.2.3 the fall in transaction costs resulted in lower consumer prices and higher supply from the producers in Comoé). It results, however, in an

Table 8.4.b. Model results if consumer income increases by 10% and price expectations change: Annual cereal demand and national cereal demand per period

Cereal Demand	Total Demand (in 1000 tonnes)[1]	Change in Cereal Demand[2]	Changes in Cereal Demand per Period[3]			
			Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept
Base Scen.	384.2		81.33	84.8	100.13	117.92
Exp.+0%	387.7	0.9%	6.02%	5.02%	4.38%	-8.48%
Exp. 5%	387.5	0.9%	2.78%	3.13%	4.64%	-5.33%
Exp.+10%	387.2	0.8%	0.43%	0.88%	1.81%	0.07%

Notes: 1) Total consumer demand level for the entire country (in 1000 tonnes); 2) Change in total consumer demand compared to the demand in the base scenario; 3) Total consumer demand per period for the base scenario (in 1000 tonnes), and percentage change in national consumer demand per period compared to consumer demand in the base scenario, if income increases by 10% and if price expectations remain the same, increase by 5%, or increase by 10%.

improvement of the net producer revenues, without influencing cereal consumption. It can be concluded that the influence of the transaction costs is very small in this case.

8.4.2 An Increase of Income in Only Some Regions of the Country

A general increase of income for all inhabitants of Burkina Faso is not very likely. It is more likely that specific groups of inhabitants experience a growth of their income due to specific developments. I consider three possible changes. First, I consider an income growth of 10% for the urban inhabitants of the regions Centre and Hauts Bassins (especially the inhabitants of Ouagadougou and Bobo-Dioulasso). The inhabitants of these cities will benefit most from developments in the industrial and services sector. Secondly, rural inhabitants of the three northern regions (Sahel, Nord, and Centre Nord) are likely to benefit most from developments in the livestock sector. I analyse changes in cereal trade if their income increases by 20%. Finally, rural inhabitants from the four south-western surplus regions (Comoé, Hauts Bassins, Sud Ouest, and Mouhoun) benefit the most from changes in the cotton sector. I analyse the influence of a rise of their income by 20%.

If the income of the urban consumers of the regions Centre and Hauts Bassins increases, their level of utility will increase by 3%. The utility levels of all other consumers decrease, because consumer prices increase on average by 1.6%. Price changes in the regions Centre and Hauts Bassins are not very

different from the average price increase (+1.6% and +1.7%). Due to the price and income changes, cereal demand of the urban consumers in Centre and Hauts Bassins increases by 5%. Demand of the other urban consumers decreases between 0.4% and 1.2%. The demand of the rural consumers decreases on average by 1.9%. So, the improved situation of the households in the main urban centres, results in an improvement of their levels of consumption. However, it leads to a deterioration of the consumption levels of the other consumers. The higher prices, however, have a positive effect on the income levels of the producers in all regions. Transport flows to the region Centre increase by 5%. The flows to the other shortage regions decrease by 2%. Total supplies increase a little bit due to the extra supply from the region Comoé.

Secondly, if the rural consumers in the shortage regions Sahel, Nord, and Centre Nord earn 20% more income, their utility levels increase by 9.2%, 11.9%, and 12.3%, respectively. Also their net revenues increase due to the rise of producer and consumer prices. Utility levels for all other consumers decrease between 0% and 3.5%. Consumer prices increase on average by 1.8%. Urban demand falls on average by 0.7%, demand of rural households in three northern regions increases by 17%, and demand in the other rural regions decreases on average by 2.1%. The rise of cereal demand in the shortage regions, results in an increase of cereal consumption by 2%, which looks small, but which may be important. Transport to the northern regions increases with 7,820 tonnes (+22%). Transport to Centre decreases only by 1,250 tonnes (-1.4%).

Finally, consider the case in which the income of the rural consumers in the cotton regions increases by 20%. In that case, the consumption situation improves for the farmers in these regions, but deteriorates for the rest of the population. Utility for the consumers in Comoé, Hauts Bassins, Sud Ouest, and Mouhoun increases by 8.5%, 8.5%, 7.7%, and 8.1%, respectively, but for all other consumers it decreases. The net revenues of the producers increase in all regions because the prices are higher. Consumer prices increase on average by 2.7%. Demand of rural consumers in the four cotton areas increases by 16%. Demand in the other rural areas, however, decreases by 2.8%, and urban demand decreases by 1.2%. Transport to the shortage regions decrease by 2,940 tonnes (-2.4%).

8.4.3 Conclusions for Scenario 3

A few interesting conclusions can be drawn from the analysis of the influence of income levels on cereal trade in Burkina Faso. First, demand increases only with a small percentage if income levels increase. Due to the inelasticity of cereal supply, the quantities transacted on the market can hardly increase if the purchasing power of the consumers increases. As a result prices have to increase. Furthermore, price expectations play an important role on market prices. If producers and traders have better price information, they can better spread their supplies over the year. If they have incorrect information on cereal demand, it is possible that, in spite of the higher income levels, consumption in the last period falls considerably. Transaction costs do, in this case, not have a large influence on consumption. Due to the inelasticity of supply, there is no scope for increasing cereal demand. Declining transaction costs will result especially in higher producer prices and consequently in higher producer revenues.

Secondly, changes in the income levels in certain regions affects all consumers in the country. Due to the scarcity of cereals, a consumption rise in one region will result in a fall of consumption in another region. Especially, if urban incomes grow, rural consumption falls. An improvement of the income position of the rural producers in the northern regions has a positive influence on their consumption levels. The negative effects for the other regions are limited. Promotion of cotton production in the cotton areas may result in lower consumption levels in the other regions. It has to be noted, however, that the effects may even be worse for the consumers in the shortage areas, if the promotion of cotton activities would also result in lower cereal production levels in the cotton areas. In that case prices would increase even more and shortages would augment. Note that it is also possible that the promotion of cotton production results in higher cereal production due to a wider adoption of chemical fertilisers and animal traction. More research is needed to analyse the impact of such policies on cereal production levels.

8.5 Scenario 4: More Efficient Trade

In the fourth scenario, the effect of an improvement of the efficiency of the cereal traders is investigated. Three ways to improve efficiency are considered.

First, due to training and education, traders may organise trade with less costs and less uncertainties. The influence of better training on cereal trade is investigated in Section 8.5.1. In Section 8.5.2, the influence of a better implementation of laws and regulations related to cereal trade and a better protection of agreements is analysed. If these laws and regulations are better followed and agreements can legally be enforced, time and money previously used for negotiations with employees, government officials and police officers may decrease. Finally, in Section 8.5.3, I consider the case in which traders purchase more from farmer co-operatives instead of from individual farmers.

8.5.1 Training and Education

If traders are taught better and develop more trading skills, they may better manage their businesses. They may be able to store their merchandise with less losses, need less personnel, make less transport costs, and negotiate for lower interest rates on loans. I assume that due to better training, storage losses decrease from 3% per quarter to 2%, personnel costs decrease by 15%, transport costs decrease by 15%, and the interest rate for borrowed money decreases from 14% per year to 12% per year (3% per quarter). As a result, storage losses are δ = 0.98, transaction costs are α = 1320 FCFA per bag, transport costs are 85% of the estimates in Section 7.3, and storage costs are estimated as $k_{it} = 0.03p_{it} + 270$, with p_{it} the average producer price given in Table 2.1.

As is already shown in Section 8.2.3, the result of such changes is that consumer prices increase in the exporting and decrease in the importing regions. Due to the gain of efficiency, the margin between consumer and producer prices decreases. In this case, the average consumer price remains the same, and the average producer price increases by 1.8%. On average, producer prices increase in all regions except in the region Sahel (-0.3%). The gain of efficiency can hardly result in more trade, because of the inelasticity of supply. Due to the price changes, demand increases a bit in the shortage regions (+1.7% in Sahel, +1.3% in Centre Nord, +0.5% in Centre, +0.4% in Nord), and decreases in the surplus regions (-0.9% in Mouhoun, -1% in Sud Ouest, -2.8% in Est). Quantities transported to the shortage regions increase by 0.9% (+1,160 tonnes). Quantities stored increase if efficiency improves. In this case, they increase by 49%. Note that the storage costs for the traders are still higher than the storage

costs for the producers. If storage costs for traders would be lower than for producers, they will store even more. This does not mean that in that case producers will supply everything in the first period. Their price expectations play a major role in their supply decisions. If they do not adapt their expectations, they will still supply large quantities in later periods.

8.5.2 Better Implementation of Laws

In Section 3.3 it has been argued that, if laws and regulations related to cereal trade are better implemented and agreements can legally be enforced, traders may experience less problems with government officials and police officers regarding market taxes, documents, road toll, and they can more easily close contracts with unacquainted employees. This may lead to lower personnel costs, market taxes, and transport costs. I assume that these costs and taxes may decrease by 25%. As a result transaction costs are $\alpha = 1175$, storage costs are $0.035p_{it} + 250$, and transport costs are 75% of the estimates in Section 7.3.

The results resemble those in the previous section. Average producer prices increase by 2.0%, due to which net revenues increase for most producers. In this case, transport and transaction costs are lower than in the previous section. Due to the resulting price changes, cereals from Comoé can compete now with cereals from other regions. As a result, the producers in Comoé supply their maximum quantity. This leads to lower consumer prices and more demand. The average consumer price over all regions decreases by 1.1%. Consumer prices in the main exporting regions increase (especially in Mouhoun and Sud Ouest). They decrease in the other regions. Cereal demand increases on average by 0.8%. Especially in the regions Sahel, Centre Nord, and Centre, the consumers profit from the price drop (in these regions consumption increases by 3%, 2%, and 1.3%). As a result, transport flows towards these regions increase. Due to the changes in transport costs and the changes in the prices, transport from Comoé to Hauts Bassins can compete now with transports from Mouhoun. As a consequence, less is transported from Mouhoun to Hauts Bassins. These cereals are redirected especially towards the region Centre. This example demonstrates that a higher efficiency may lead to an improvement of the level of competition.

8.5.3 Trade with Farmer Co-operatives

If traders can purchase more cereals from farmer co-operatives instead of from individual farmers, personnel costs will decrease considerably. In that case, they purchase larger quantities at once and they do not have to set up an assembly network. Also transport costs may fall. If producers are organised in co-operatives they may experience important efficiency gains. Their production, storage, and transaction costs may fall if the co-operative organises trade, purchases of inputs, and training. Consider the case in which transport costs of the traders fall by 10% and their personnel costs fall by 50% from 1,200 FCFA to 600 FCFA per 100 kg bag (so that transaction costs are α_{it} = 900 FCFA/bag). Production costs decrease by 10% (from 75% to 67.5% of the average producer price, see Section 7.2.3). Furthermore, the producers' storage costs halve to 2 FCFA per bag and the supply activities are carried out by the co-operative so that the supply costs for the individual producers are 0 FCFA per bag.

These changes result in a considerable increase of semi-welfare with 25% (this was 3.2% and 6% in the Sections 8.5.1 and 8.5.2). Especially the decline of the production costs of the cereal producers has a large influence on the results. The situation improves for all market actors due to a fall of the consumer prices and a rise of the producer prices. Consumer prices decrease in the first three periods and increase in the fourth period (on average price changes per period are -2.2%, -2.6%, -3.9%, and +2.7%). The effect on producer prices is more distinct. The co-operative has a better negotiation position than the individual farmers, resulting in a price increase in all periods. The increase in the last period is highest (average producer prices increase by 4.1%, 3,5%, 1.5%, and 8.5% for the periods 1 to 4). The margin between the consumer and producer price decreases due to the fall of the transaction costs. Because of the higher producer prices, producers supply more during the first three periods. The result is a scarcity in the last period, leading to an increase of the consumer and producer prices. The timing of cereal supplies changes due to the changes in producer prices and producer costs. The producers in Comoé supply their maximum quantity. As a result, total consumption increases by 0.8%. The total transported quantity decreases by 0.9%. This is especially due to a more efficient spread of cereal supplies over the year due to which the transports to the regions that also export decrease. The quantities transported to the shortage regions increase by 1.5%.