

**International price shocks and development:
A general equilibrium approach with applications to Burkina
Faso.**

Part 3:

**International price shocks in Burkina Faso: assessing development impacts
with a Computable General Equilibrium (CGE) approach.**

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Abstract

After sketching the links between development and agriculture, this paper analyses the implications on welfare and growth of recent international price shocks, notably energy and agricultural products, in Burkina Faso, a less industrialised, low-income, food-deficit, net oil-importing country. The socio-economic impacts of the above-mentioned external shocks are analysed by means of a Computable General Equilibrium model (CGE). The results of the analysis show that oil price hikes in recent years had much greater impacts on the welfare of the poorer layers of the population than any other price shifts. The paper discusses also the extent to which technological changes in agriculture, specifically the introduction of “Good Agricultural Practices” (GAP) towards “conservation agriculture”, could mitigate the welfare and growth losses derived by international price shocks. It is shown that the technological changes explored in this paper, in spite of their significant impacts on agricultural productivity, by no means countervail the negative welfare and growth losses brought by international price shocks. The energy dependency, particularly in a context of high oil prices, looks as a channel that systematically siphons out domestic resources, jeopardizing household welfare and seriously hampering domestic primary capital accumulation and related endogenous-growth potential. Policy implications for poverty reduction and food security are that suitable policies should favour not only the adoption of appropriate energy-saving agricultural technologies but also the exploitation of sustainable energy production potential of rural areas. These findings are likely to apply to other less-industrialised energy-importing countries with similar socio-economic structure. Furthermore, by providing and comparing alternative analytical frameworks, notably related to macro-economic model closures and assumptions on factor markets, this paper emphasizes the importance of reading model results in the light of the assumptions made and carrying out appropriate sensitivity tests on most relevant hypotheses.

Table of contents

1	Introduction	4
2	Development and agriculture in open economies	4
3	International price shocks and development: the case of Burkina Faso	8
4	The structure of the national economy	13
5	The CGE of Burkina Faso	19
5.1	Data sources	19
5.2	Macro-economic closures	21
5.3	Closures for factor markets	27
6	Simulations of socio-economic impacts of external shocks.....	29
6.1	Macro economic impacts	30
6.2	Activity levels	33
6.3	Welfare impacts.....	35
6.4	Alternative macro-economic and factor-market closures	39
6.5	Simulations under alternative macro-economic and factor-market closures	42
6.6	Implications of alternative macro and factor market closures	58
7	Technological Changes under “Good Agricultural Practices”	59
8	Some policy implications	65
9	Conclusions	66
10	References	68
11	Appendix A: Detailed data and tables.....	70
12	Appendix B: features of the CGE model adopted.....	74
12.1	The LES demand system.....	74
12.2	Armington functions for imported goods.....	81
12.3	CET functions for Export versus Domestic Supply.....	84

1 Introduction

This paper, aims at analyzing the implications on welfare and growth of recent international price shocks, notably energy and agricultural products, in Burkina Faso, a less industrialised, low-income, food-deficit, net oil-importing country. The socio-economic impacts of the above-mentioned external shocks are analysed by means of a Computable General Equilibrium model (CGE).

The structure of the paper is as follows: in section 3, the links between agriculture and development are highlighted. The analysis of some international price shocks applied to Burkina Faso is carried out in sections 4 to 8. The main socio-economic features of the country are then illustrated in sections 4 and 5. Here, the country's economic structure is analysed using selected macro-economic data, including a Social Accounting Matrix (SAM). A SAM-based Computable General Equilibrium model of the country is presented in section 6. To test the extent to which international price changes affect the socio-economic system, some CGE simulations for different commodities, notably oil, fertilisers, food and cotton, have been carried out and presented in section 7.. In section 8, the socio-economic impacts of introducing technological changes in the agricultural sector are analysed by means of some additional CGE-based simulations. Possible policy implications are discussed in section 9 and concluding remarks are also provided. The paper is complemented by two chapters in appendix. The first one comprises detailed data tables and results of the CGE models. The second one reports the main equations of the model and some technical considerations on its structure.

2 Development and agriculture in open economies

To achieve the first Millennium Development Goal (MDG) “*Eradicate extreme poverty and hunger*”¹, many less-industrialised countries have relied so far on the formulation and implementation of the so-called “Poverty Reduction Strategies” (PRS)². After the first wave of PRS, in the early 2000s, the focus shifted towards a more balanced, inclusive economic and social development, based on a medium-long term vision of the countries' potential³. In this context, the prevailing development paradigm adopted for less-industrialised countries by many bi-lateral and multi-lateral development agencies, including FAO and international banks; focused on the agricultural sector as an engine of growth and poverty reduction⁴.

¹ See the site of the United Nations Development Group, in charge of coordinating the work of the various UN development agencies towards the achievement of the Millennium Development Goals (MDGs): <http://www.undg.org>.

² The Term “Poverty Reduction Strategy Paper” (PRSP), later on generalised as “Poverty Reduction Strategy”, first adopted by the World Bank in 1999, refers to a document “*describing a country's macroeconomic, structural and social policies and programs to promote growth and reduce poverty, as well as associated external financing needs*”. Countries are required to prepare and update PRSPs because “*PRSPs are a requirement for countries in order to receive concessional assistance from the World Bank*” (<http://go.worldbank.org/ZLBKFM2V90>).

³ World Bank (2005): 2005 Review of the PRS Approach: Balancing Accountabilities and Scaling Up Results. World Bank, Washington D.C.

⁴ Indeed, the FAO (FAO, 2003) adopted the so-called “*Twin-Track Approach*”, as the conceptual framework for its “*Anti-Hunger Programme*”. It comprises both programmes aimed at improving the direct and immediate access of food to food-insecure people and interventions aimed at agricultural development and off-farm income generation, on the assumption that there are mutually reinforcing relationships between these components towards food insecurity and poverty reduction. FAO (2003): *Anti-Hunger Programme: A twin-track approach to*

Agricultural development is considered particularly relevant for countries with a large share of agricultural employment in rural areas and the emphasis is put on: 1) direct impacts on farmers' income, especially poor smallholders, 2) indirect impacts via downstream linkages and multiplier effects: distributed income, increased consumption of local goods, etc and 3) its presumed role in slowing down urbanisation and the international migration phenomenon. These arguments are based on findings of a conspicuous mass of studies on agricultural growth and development, carried out in the last sixty years⁵.

However, just after the Second World War, the wisdom of 'agriculture' (broadly intended as a set of traditional, subsistence and rural activities) as an ancillary sector functional to the development of the more 'modern' industrial sector, started consolidating. For instance, the Nobel Prize winner Arthur Lewis, in the fifties pioneered the exploration of the industrialisation process of a dualistic economic system, characterised by two sectors: "subsistence" sector and "capitalistic" sector, with "unlimited" supply of labour, flowing from the first to the second. The existence of this "reserve army", concentrated in rural areas (generically referred to as "agriculture" by many authors) kept inspiring in the sixties the traditional view of the link between agriculture and growth, according to which a "developing" economy is a "dual" system where a "dynamic" industrial sector is associated with a more "traditional" agricultural sector. However, very often, the "traditional sector" was not seen only as a "reservoir" of labour, but more generally as a source of "surpluses" (variously defined as for example, savings, excess labour force, inputs, food etc), to be extracted and put at the service of the "modern" (industrial, urban) sector. Fei and Ranis (1964)⁶ proposed a dual-economy model where technological changes in agriculture improve the marginal productivity of labour so that it becomes positive but less than the real wage. In this case labour flows to the industrial sector with some loss of agricultural output. Jorgenson (1967)⁷, adopting an analytical framework similar to that of Fei and Ranis, added emphasis to the role of the agricultural surplus as a generator of savings, which in turn allowed capital accumulation and consequent expansion of the economic system.

'New dignity' to the 'agricultural' sector, was provided by Dixit (1970)⁸, who perceived the agricultural sector not any more as completely ancillary to the rest of the economic system, rather as a sector whose development, by means of technical progress and capital accumulation, can contribute to productive job creation and overall well-being. 'New dignity' to the agricultural sector, intended as 'rural space', was also provided by the work of Harris and Todaro (1970)⁹. In a different conceptual context, characterised by unemployment in the 'modern' sector, they developed a dualistic labour market model on the basis of which some paradigms of the relationships between the agricultural and the industrial sectors needed to be

hunger reduction: priorities for national and international action Food and Agriculture Organization of the United Nations. Rome.

⁵ For a comprehensive treatment of the theory of the growth of the agricultural sector within the context of a growing economy see e.g. : Mundlak, Y. (2000). *Agriculture and Economic Growth* Theory and Measurement. Harvard University Press

⁶ Fei, J. C. H., and Ranis, G. (1964), *Development of the Labour Surplus Economy*, Homewood: Irwin, 1964

⁷ Jorgenson D., W. (1967) Surplus Agricultural Labour and the Development of a Dual Economy, *Oxford Economic Papers*.1967; 19: 288-312

⁸ Dixit, A., (1970) 'Growth patterns in a dual economy ', *Oxford Economic Papers*, 22 (2) July 1970, pp. 229-33.

⁹ Harris, J. R., and Todaro, (1970) M . P., 'Migration, Unemployment and Development: a two-sector analysis', *The American Economic Review*, 60 (1) , Mar. 1970, pp. 126-42.

revisited. Productivity improvements in the agricultural sector (considered there as the rural space) were no longer seen as devices allowing the release of labour from agriculture towards the industrial sector, but rather as devices to keep labour in rural areas, thus reducing unemployment in industrial (urban) ones. Therefore, a direct policy implication is that promoting the development of activities in rural areas could reduce the wage differentials between rural and urban areas and, by way of consequence, unemployment in the industrial (urban) sector.

More recently, in the line traced by Johnston and Mellor (1961)¹⁰, Anriquez and Stamoulis (2007) revisited the role of agriculture as an engine of growth providing new evidence to the importance of “backward” and “forward” linkages of the sector. They calculate for a sample of 26 low-middle income countries, backward and forward linkage indexes¹¹ and emphasise that, in earlier stages of development, agriculture plays an important developmental role thanks to its backward linkages. This opposes the historical wisdom (see e.g. Hirschman, 1958)¹² that denied agricultural development the role of ‘engine of growth’ due to its weak backward linkages with the rest of the economy.

In addition to the role of agricultural development as an engine of growth, countless authors put a lot of emphasis on its role for poverty reduction and food security (“balanced growth”). The conventional vision on the role of agriculture for poverty reduction is well summarised by Byerlee et al. (2005): *“mass of evidence [is] already available on the central role of increasing agricultural productivity on pro-poor growth, especially in the early stages of development, and especially if productivity growth is transmitted to lower food prices. ... Given widespread household food insecurity, the major challenge in Africa is how to stimulate broad-based productivity growth in food staples and sustain overall productivity gains over decades, if the Asian record of poverty reduction is to be repeated”*.

Also FAO (2009) highlight how poverty is positively affected by agricultural development, specifically by productivity shifts due to investment in infrastructure and R&D; leading to the consequent reduction in prices of staple food consumed by the poor¹³. The various initiatives adopted in 2008 and 2011 by many international organisations to address the so-called “soaring food prices” crisis, readdressed the focus on the agricultural sector as a “supplier” of food, on the assumption that increased agricultural output and productivity favour poor consumers due to a reduction in food prices (FAO, 2011)¹⁴.

¹⁰ Johnston B,F and Mellor J,W. (1961): The role of agriculture in economic development, American Economic Review 51(4): 566-593, 1961. Anriquez, G., Stamoulis, K. 2007. Rural development and poverty reduction: Is Agriculture Still a Key? e-JADE, FAO- Rome.

¹¹ In an Input-Output (I-O) context, as in the one adopted by the authors, “backward linkages” are the relationships of a sector with the other sectors via its input requirements; “forward linkages” instead refer to relationships of a sector with the others by means of the absorption of the sector’s outputs downstream. The authors work out backward and forward linkages of the agricultural sector as first-round multipliers, i.e. “attenuated” Leontief multipliers which rule out second to nth-round effects, on the assumption that these further effects may not be realised due to frictions in the economic system or structural changes occurring during the adjustment process. In addition, these effects are weighted with the relative importance within the economy of the sectors providing the input or adsorbing the output. For more details on these indicators, see Anriquez et al (2003): Anriquez G, Foster, W, Valdéz A (2003): Agricultural Growth linkages and the Sector’s Role as Buffer. Roles of Agriculture Project. FAO. Rome

¹² Hirschman, A., O. (1958): The strategy of Economic Development, Yale University Press, New Haven, Connecticut.

¹³ FAO (2009): State Of Food and Insecurity (SOFI) 2009. FAO Rome.

¹⁴ FAO (2011): FAO initiative on soaring food prices: Guide for policy and programmatic actions at country level to address high food prices, FAO UN Rome.

For all the reasons highlighted above, recent agricultural policies for poverty reduction in many less-industrialised countries have as their aims: crop intensification, mechanisation of production processes, increased transformation processes and increased demand of transport services for distribution. This is also the case for Burkina Faso, a semi-arid land-locked country with no fossil energy resources. With a poverty incidence ranging between 40 and 45% of the population, this country faces enormous difficulties in achieving the MDG 1.

Many proposed policy measures for poverty reduction in Burkina Faso within the context of the “Strategic Framework for Poverty Fighting” for 2006-2008, and the “Strategy for accelerated growth and sustainable development 2011-2015”¹⁵ fall into the above-mentioned set of policies, aimed at inducing increased output and productivity.

The achievement of the first MDG however, lies in its reconciliation with other potentially conflicting objectives included in the MDG package; for example, the attainment of local and global sustainability (goal 7). In Burkina Faso for instance, intensification of imported inputs, notably pesticides used in agriculture, as well as the increasing number of dams located in the same river basins, are currently generating environmental externalities that reflect negatively on other productive sectors such as the fishing industry and presumably, health conditions¹⁶. In addition, substantial financial constraints associated with objective water scarcity are going to be the most limiting factors in the expansion of irrigated land and related yields’ increase.

However, beyond the issues related to potential or actual conflicting development objectives, there is a fundamental problem faced by the panoply of agents involved in policy making for socio-economic development. It consists in the missed recognition of mechanisms that systematically siphon resources out of socio-economic systems, hampering the primary accumulation of capital, which is the basis of any development process. Many of these mechanisms in less industrialised countries are influenced, if not determined, by external factors, by means of direct or indirect control on domestic resources and/or by market-price mechanisms. Among them, the energy dependence in net oil-importing countries is particularly important. In recent years in these countries, the energy sector increasingly acted as a “drain of resources” due to dramatic increases in oil prices, as pointed out by Bellù (2007)¹⁷. Given its magnitude, this external shock is expected to have huge implications in terms of growth, income distribution, poverty reduction and food security. Unless these macro problems are fixed, most interventions for poverty reduction and development, including initiatives and actions of the international cooperation community, are more than likely destined to miss their objectives.

The vulnerability of “small” countries is accentuated when they are “low” or “lower-middle” income countries¹⁸. For example the World Bank (2004)¹⁹ states that: “*Low-income countries*

¹⁵ MEF (2011) Stratégie pour la croissance accélérée et le développement durable 2011-2015 (Unpublished). Ministère de l’Economie et des Finances, Burkina Faso.

¹⁶ MECV (2008). Rapport sur la filière Pêche. Ministère de l’Environnement et du Cadre de Vie. Ouagadougou Burkina Faso.

¹⁷ Bellù L.G. (2007). Windfall Oil Profits and Soaring Oil Bills: Some policy implications for Sustainable Development. EASYPol series. FAO UN. Rome

¹⁸ As classified by the World Bank (Atlas methodology), i.e. countries with a per capita Gross National Income (GNP) less than \$ 3,595 (classification 2008, based on 2006 data). See:

<http://siteresources.worldbank.org/DATASTATISTICS/Resources/OGHIST.xls>

¹⁹ World Bank (2004): Global monitoring report. Policies and Actions for Achieving the Millennium Development Goals and Related Outcomes. World Bank, Washington, D.C.

are particularly vulnerable to natural disasters, terms-of-trade shocks and other adverse shocks". Among these countries, "Low-Income Food Deficit Countries" (LIFDC), as classified by FAO UN²⁰ look even more vulnerable. These countries are considered particularly sensitive on food security grounds as their capacity to access food is directly dependent upon many factors such as: a) prices of food commodities on the international markets; b) prices of main export commodities on the international markets; c) macro-economic stability, including equilibrium of the balance of trade; d) efficiency of logistic facilities (transport, storage, distribution facilities etc); e) flexibility/resilience of domestic food sector to absorb or adapt to external shocks.

Flexibility and resilience of the domestic food sector and medium-long term equilibrium of the trade balance, are more difficult to achieve by those LIFDC which rely on imports for a significant part of their energy needs; particularly in situations where soaring oil bills due to increased oil and gas prices impose additional burden on the trade balance, domestic production costs and household budgets. For LIFDC net energy importers, external shocks on main import-export markets may lead to a significant and sudden worsening of the terms of trade with significant consequences in terms of macro-economic stability and welfare of the population. The international community has recently attributed great importance to external shocks as factors affecting the welfare of populations, due to "soaring food prices" in 2007-2008 and 2010-2011. This crisis was assumed to heavily affect poverty and food security in LIFDC²¹.

Much less emphasis, at least in terms of its impacts on development perspectives and welfare of LIFDC, was put on the soaring prices of energy (oil in particular) from 2003 to 2008. However, while net oil exporting countries experienced huge windfall profits in respect of the 2003 base price, as reported by Bellù (2007), net importing countries had to afford additional oil bills, ranging between 1 % of their GDP in 2006 for most OECD countries up to almost 5% for selected LIFDC²². More than likely, these additional energy bills generated persistent macro-economic instability, decreased overall welfare of the population, increased poverty and hampered their long term development perspectives.

3 International price shocks and development: the case of Burkina Faso

²⁰ FAO UN classifies as "Low-Income Food Deficit Countries (LIFDC)" those countries: a) classified by the World Bank as "International Development Agency (IDA) eligible and 20 years IBRD loans" (Operational Lending Category II, i.e. per capita GNI less than 1,735 US\$. Classification 2008 based on 2006 data); b) net (i.e. gross imports less gross exports) food trade position of a country averaged over the preceding three years. Trade volumes for a broad basket of basic foodstuffs (cereals, roots and tubers, pulses, oilseeds and oils other than tree crop oils, meat and dairy products) are converted and aggregated by the calorie content of individual commodities; c) Self-exclusion criterion (countries that meet the above two criteria but request to be excluded from the LIFDC category. See <http://www.fao.org/countryprofiles/lifdc.asp>

²¹ The FAO UN, in partnership with other organisations, launched in December 2007 the "Initiative for Soaring Food Prices" (ISFP), aimed at reducing food insecurity generated in LIFDC by increasing food prices. See (FAO, 2008), Initiative for Soaring Food Prices: programme document, May 2008 FAO UN –Rome. (<http://www.fao.org/isfp/isfp-home/en/>) The ISFP sustained, among other things, the "Emergency Rice Initiative" in 11 countries in West Africa: Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Liberia, Mali, Mauritania, Nigeria, Senegal, Sierra Leone and Togo, aimed at "significantly increase their rice production as of 2008 and 2009." (see Africa Rice Center (WARDA) www.warda.org.)

²² Bellù (2007) reports that windfall profits in 2006 for example amounted to almost 16 % of GDP for Cameroon, 22% for Nigeria, 25% for Angola, 28% for Chad, up to almost 50% for Equatorial Guinea.

Impacts of sudden and persistent shocks on prices of important import and/or export commodities on growth, income distribution, poverty reduction and, more in general, development perspectives, can be assessed by looking at specific country cases. In the next sections we explore the case of Burkina Faso, a LIFDC which has been recently considered by the international community as being among the “priority” countries for intervention to contrast negative food security consequences of soaring food prices.

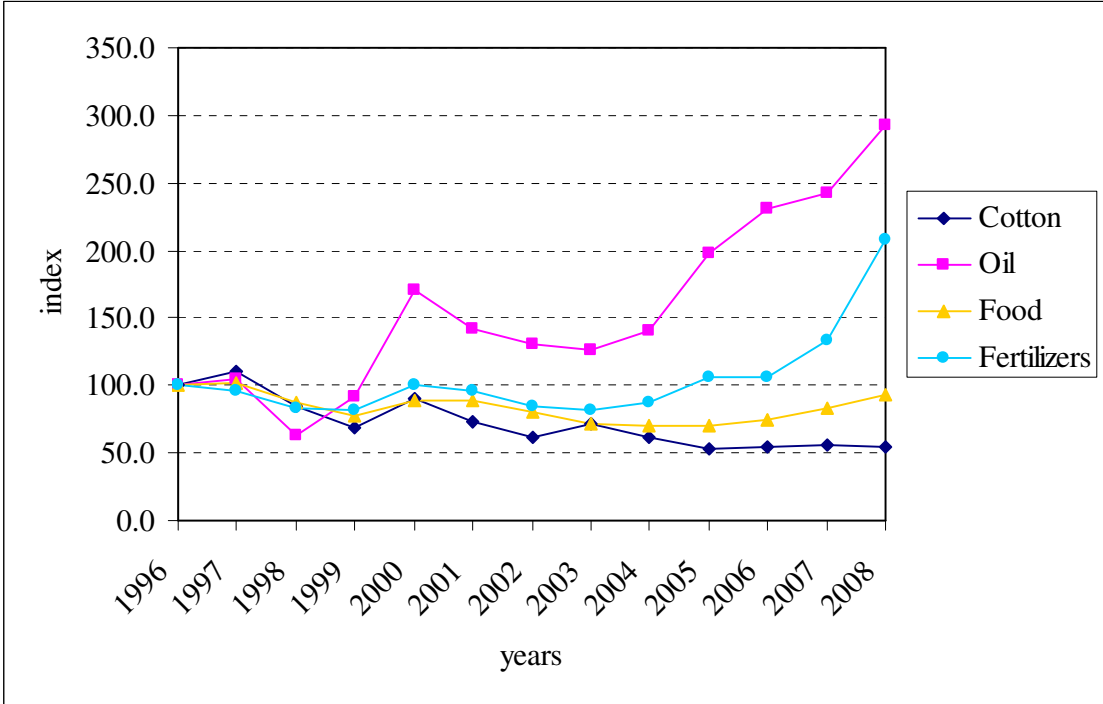
Burkina Faso is a small, low-income food deficit country, a net importer of energy²³. In addition, given its dimensions, Burkina Faso can be considered as a price taker on all the international markets in which it operates. This implies that this country is particularly vulnerable to external shocks.

To see to what extent price shocks on international markets affected Burkina Faso, the prices faced by the country of the main import-export commodities have been analysed. The price indexes in the last twelve years of cotton (for exports) and food, energy and fertilisers for imports are reported in figure 2. These indexes are based on international prices converted in local currency using annual average exchange rates and deflated with domestic GDP deflator (base year 2000). Given the impossibility of getting a complete time series of import and export prices for Burkina Faso, international nominal FOB prices in US dollars for fertilisers, cotton and oil were used as a starting point. The fertiliser price index is country specific, i.e. it was calculated on the basis of the prices of different types of fertilisers weighted with actual imports, derived from Customs data for 2005. Cotton, food and oil indexes are based on international composite prices²⁴.

²³ Burkina Faso is also classified among the Least Developed Countries (LDC) by the UN and a “low-income” country also according to the classification of the World Bank.

²⁴ Adjustments of FOB prices with international freight costs to better reflect CIF prices were attempted on the basis of custom data 2005, reporting CIF prices 25% above FOB prices on average. These adjustments do not substantially change the overall picture and are not reported here.

Figure 2. Constant FOB price indexes for selected import and export commodities



Sources: Author’s calculations based on: Cotton index: “Cotlook A index”, Cotton Outlook (http://www.cotlook.com/information/cotlook_indices.php); Oil index: Composite Crude oil weighted by export volume. US Energy Information Administration <http://tonto.eia.doe.gov/dnav/pet/hist/wtotworldw.htm>; Food and fertilisers Indexes: FAO food price index and FAO (AGPC) indexes for various fertiliser types, UN Food and Agriculture Organization – Rome; GDP deflator and nominal average exchange rate FCFA/US\$: IMF World Outlook Database, <http://www.imf.org/external/pubs/ft/weo/2008/02/weodata/weose1gr.aspx>

In spite of the fact that Burkina Faso was unanimously considered by the international community as a country particularly affected by the food crisis in 2008, having to benefit from immediate international support, there is insubstantial evidence of long term increases of food import prices and domestic prices of main staple food (cereals). The aggregated food import price index, based on the FAO food composite index shows an upward trend only from 2005 onward, which, in any case, always remains below the 1996 level.

However, the weights of the different food commodities in that index may not necessarily reflect the appropriate weights for Burkina Faso. Therefore, in order to better assess the food price changes faced by Burkina Faso, a further investigation of the actual domestic market prices was necessary. A domestic price index of staple food (the four main cereals: millet, sorghum, maize and rice), was built for both urban and rural populations using as weights the shares of actual households’ expenditure, based on the most recent “household living standards survey”, as reported in table 1.

Table 1: Consumption shares (quantities) of staple cereals by household location

	Household		Average (LSMS)	Average (FBS-FAO)
	Urban	Rural		
Rice	30.1%	7.5%	11.0%	6.7%
Millet	12.8%	38.3%	34.3%	32.4%
Sorghum	13.7%	38.6%	34.8%	39.6%
Maize	43.4%	15.6%	19.9%	21.3%
Total	100.0%	100.0%	100.0%	100.0%

Source: “Enquête sur les conditions de vie des ménages-2003” Institut National de la Statistique et Démographie (INSD)- Ouagadougou. Average weights (FBS-FAO) based on Food Balance Sheets (FBS), FAOSTAT, Food and Agriculture Organization of United Nations, Rome.

The price composite indexes of main cereals for rural and urban households in the last twelve years are reported in Figure 3. Their inspection confirms that overall, cereal prices did not substantially grow in the last decade. Nevertheless, the aggregate staple food index is characterised by:

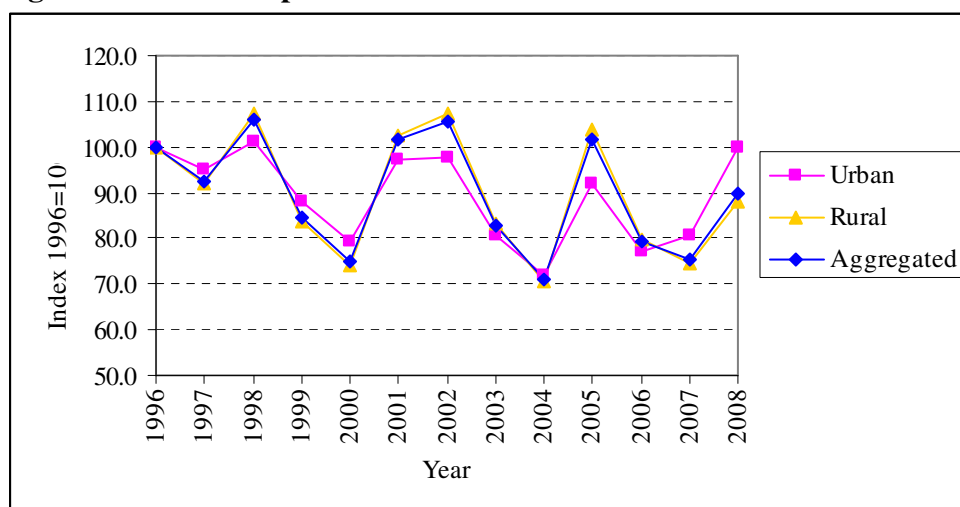
- a) Sharp oscillations, showing higher prices in some periods (1996, 1998, 2001-02, 2005) and lower prices in subsequent ones (1997, 2000, 2004, 2006).
- b) A significant increase (around 25%) from 2006 to 2008.

The absence of substantial shocks to the international food prices in real terms, i.e. at constant domestic prices until 2007, contributed to smooth domestic consumer prices of staple cereals. However on the one hand, rural households have been affected by greater price volatility than urban households, due to the higher share in consumption of domestic crops (more than 92%, comprising millet, sorghum and maize), characterised by more volatile prices (see table 1). On the other hand, since 2007, urban households experienced higher price increases instead due to the significant price increase of the imported component (30%, essentially rice).

Nevertheless, in spite of these oscillations, in 2008, *“the situation of food and nutrition of people is globally satisfactory. Even if prices are higher than those of last year, they are at a lower level than in 2005. The currently tend to stabilise, or even to drop on some markets.”* (Agrialerte, 2008)²⁵

²⁵ Translated from (Agrialerte,2008) Alerte sur la situation de la campagne agricole des régions - Burkina Faso N°023-22/07/2008 Direction Générale des Prévisions et des Statistiques Agricoles (DGPSA), Direction du Système l’Alerte Précoce (DSAP) Ouagadougou. Information System on Food Security (SISA) www.sisa.bf

Figure 3. Consumer price index for cereals in urban and rural households (prices 2000)



Source: Author's calculations on data from the "Direction Générale des Prévisions et Statistiques Agricoles – DGPSA" Ouagadougou, for all prices, except: 1) price of Rice for 2007 (twelve months) and 2008 (period Jan-Mar): FAO report on Soaring food prices, May 2008. 2) Prices of millet, sorghum and white maize period Apr-Jul 2008: USAID, Famine Early Warning Systems Network (FEWSNET). West Africa Monthly bulletin of Cereal Prices, July 2008. 3) Consumer Price Index World Bank Development Indicators Database (2007 and 2008 refer to the GDP deflator). 4) Consumption weights for rural and urban households: Report on "Enquête sur les conditions de vie des ménages-2003" Institut National de la Statistique et Démographie (INSD)-Ouagadougou.

The relative stability of food prices strongly contrasts with the dramatic increase of real energy prices (essentially oil-based products and gas): they more than tripled since 1996. The long term growth of oil prices is associated with the more recent increase of fertiliser prices, which almost doubled in the last two years. On the other hand, the prices of cotton, the main export crop, following an almost steady long-term decline, fell in real terms by around 50%.

In order to assess the magnitude and depth of socio-economic impacts of these external shocks, it is necessary to explore the structure of the socio-economic system and the channels through which external shocks affect the economy. This will be done in two steps: 1) an analysis of selected macro-economic variables that will provide some insights into the importance of the main traded commodities; and 2) some simulations carried out with a Computable General Equilibrium model of the country that will allow assessment of the likely socio-economic impacts of these external shocks.

The following analyses will be based, among others, on the most recent Social Accounting Matrix (SAM) of Burkina Faso.²⁶ The SAM comprises 56 commodities, including 21 agricultural, 55 activities, five factors (agricultural labour, non agricultural labour, family labour, agricultural capital, non agricultural capital) four household groups (rural poor, rural non-poor, urban poor, urban non-poor), financial enterprises, non financial enterprises, plus the government account, the Savings-Investment account and the Rest of The World (RoW). It is based on the year 2000's national accounts data, including input-output data for different

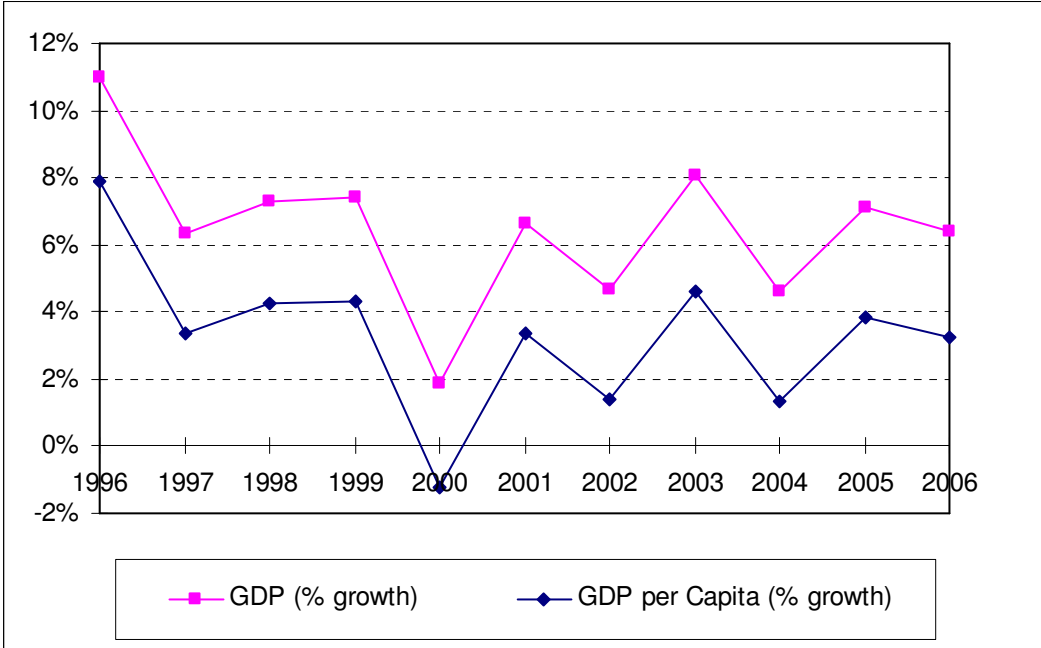
²⁶ Hebie, Mamadou (2007). Social Accounting Matrix of Burkina Faso, year 2000. Unpublished. Direction Générale des Statistiques et Prévisions Agricoles. Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques (MAHRH). Ouagadougou. This is the only SAM available to date and was prepared in the context of a policy assistance project supported by FAO.

sectors, and household expenditures have been calculated based on the Living Standards Survey 2003.

4 The structure of the national economy

In the last decade, Burkina Faso has been characterised by non negligible annual GDP growth rates, ranging from 5% for GDP and 2% for GDP per capita (see figure 1). The fastest growing sector was industry, (9.5% per year) followed by services (5.4%) and agriculture (less than 5%).

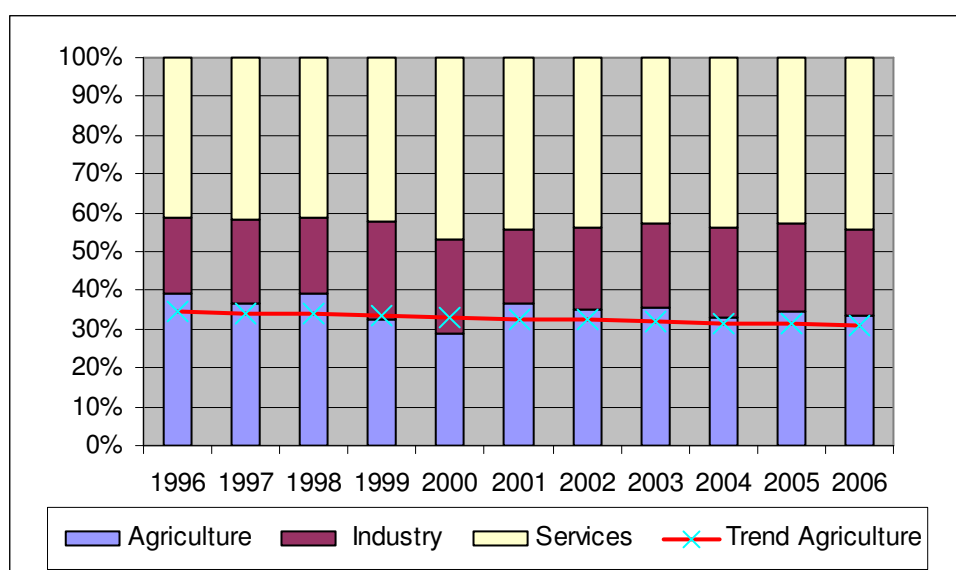
Figure 3: GDP and per capita GDP growth rates (GDP at constant FCFA)



Source: Own elaborations on: World Development Indicators, World Bank

As a consequence of this differentiated growth, Burkina Faso, as well as other countries in West Africa, is changing, little by little, its productive structure, where industry and services have more weight than agriculture.

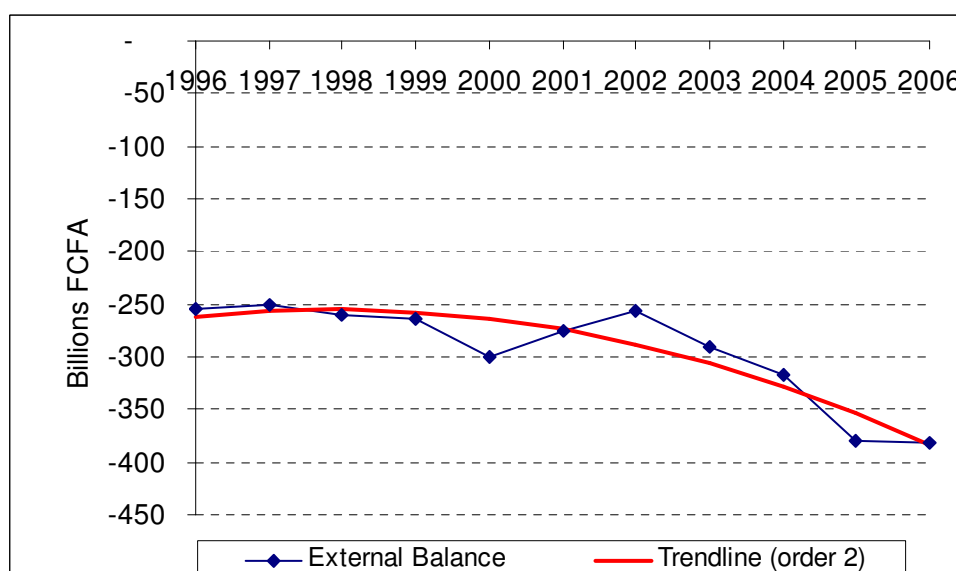
Figure 4: Value added by sector (shares of GDP, nominal).



Source: Author calculations on: World Development Indicators, World Bank.

The sustainability of growth is, however, jeopardised by external macro-economic imbalances. For example, the external balance of goods and services, which started recovering after 2000, significantly deteriorated in 2002, and a further increase of the deficit is expected for 2007.

Figure 2. External Balance of goods and services. Constant billions FCFA (year 2000)



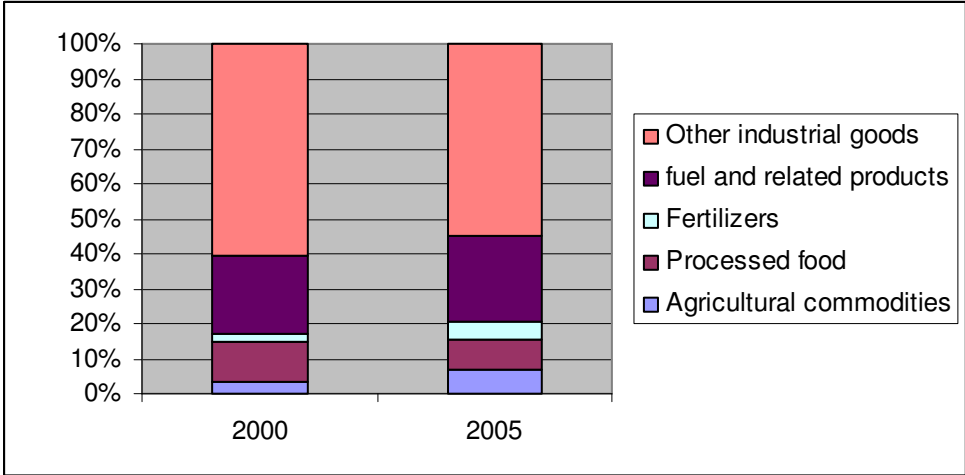
Source: Author's calculations on: World Development Indicators, World Bank (external balance in nominal FCFA) and IMF world outlook (GDP deflator at year 2000 prices).

This increased deficit is essentially due to imports growth no longer being compensated by exports.

The analysis of the structure of imports in the SAM 2000 and an inspection of custom data for 2005 reveals that the bulk of imports in the country comprises industrial goods, with a

growing weight from 2000 to 2005 of chemicals; including fertilisers and pesticides, and oil-related energy products, as reported in figure 3. Agricultural commodities and processed food items do not play a major role as they comprise around 15% of total imports. This situation looks quite stable in different years, as the only significant change between 2000 and 2005 is the increased weight of raw commodities with respect to processed food. This is essentially due to the increased imports of rice.

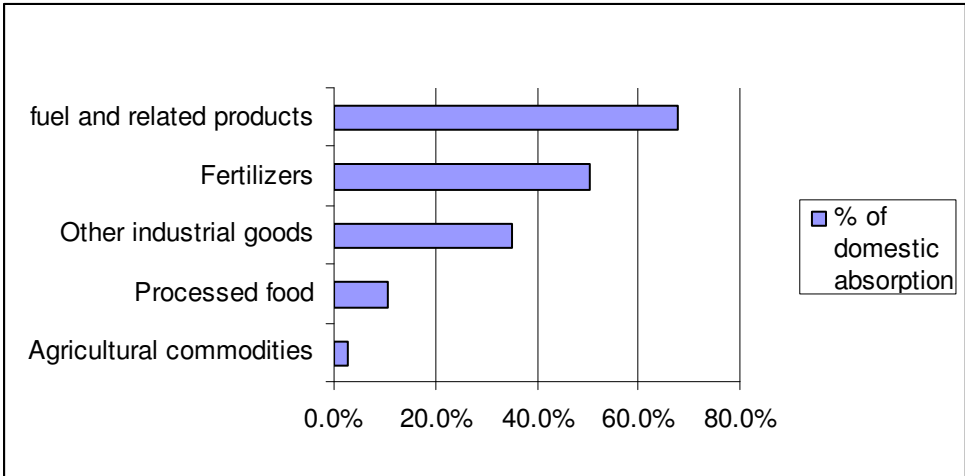
Figure 3: Imports by commodity as % of total imports (years 2000 and 2005)



Sources: Social Accounting Matrix for year 2000 and author elaborations on Customs data for year 2005.

Looking at the role of imports in respect of the domestic absorption, as reported in figure 4, it is apparent that, overall, agricultural commodities and processed food imports are marginal related to the domestic output of the same commodities, as they represent less than 3% and 11% respectively of the total supply. In contrast, this is not the case for industrial goods, where imports cover almost 45% of the total supply. Specifically, fuel and fuel-related products are essentially totally imported (68% of the value of supply is imported, while the remaining 32% is due to domestic trade margins, taxes and distribution costs).

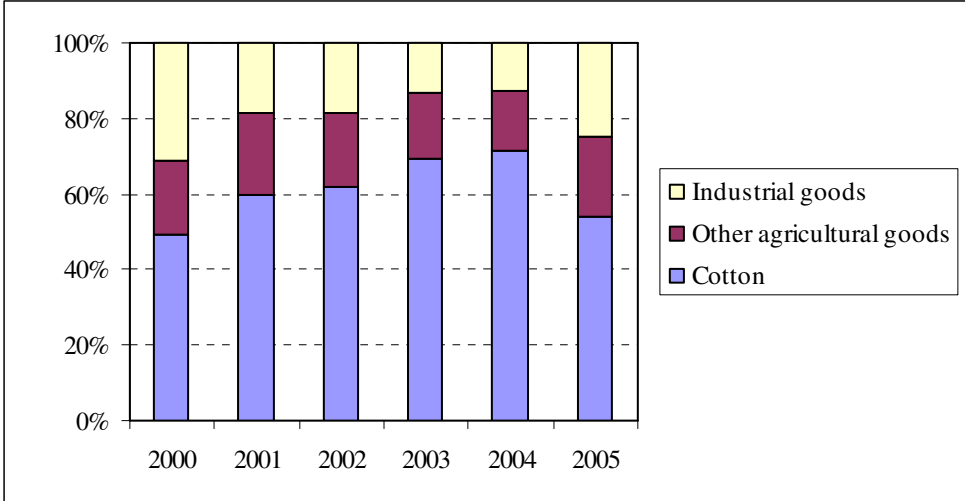
Figure 4: Imports by commodity, as % of domestic absorption, year 2000.



Source: Social Accounting Matrix, year 2000.

On the export side, Burkina Faso is almost a “single-commodity” trader. Cotton covers among 50% and 70% of export revenues in recent years, as reported in figure 5.

Figure 5: Exports by main commodity groups.



Source: Years 2000 and 2005: SAM-Burkina. Years 2001 to 2004: Author’s calculations on data from: International Trade Centre UNCTAD/WTO <http://www.intracen.org/tradstat/>

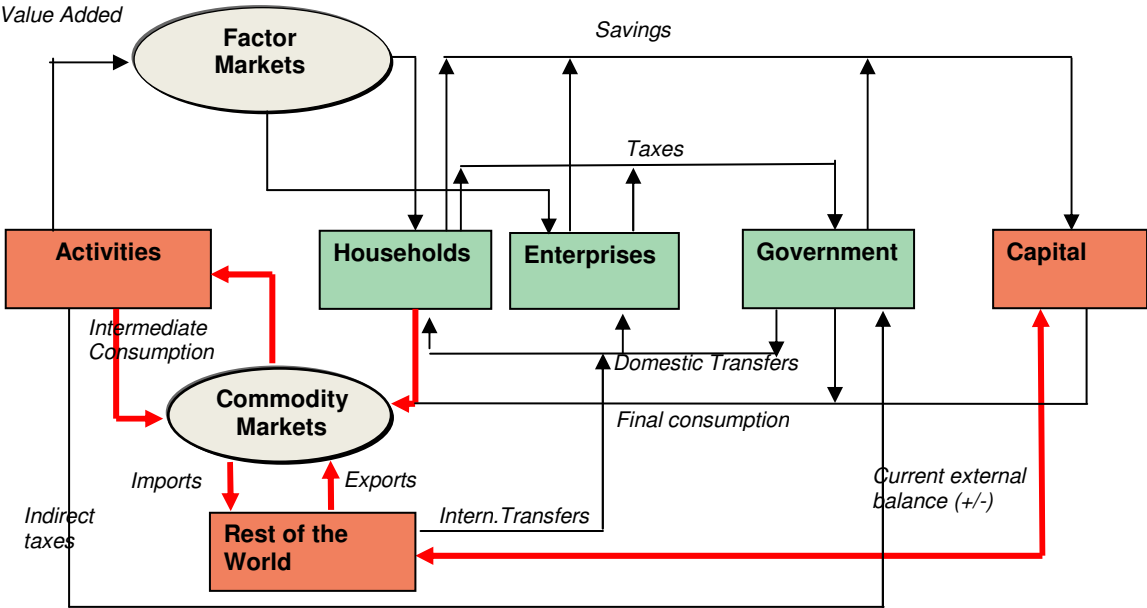
Given the overarching role of cotton in exports, the continuous fall of its real price in recent years (with the exception of 2003) represented a real loss of income to the country.

It is expected that the loss of income from cotton, in addition to the increased energy and fertiliser bills, has very likely negatively affected the growth perspectives and welfare of different social groups in a diversified way, through multiple flows of payments originated by income generation, income distribution and expenditure processes.

Figure 6 provides a schematic view of the flows of payments among the different economic entities through which external shocks are likely to affect the socio-economic system.

Upward shifts in oil prices, for example, other things being equal, lead to increased input costs for the activities utilising those imports as intermediate consumption and for households directly using oil products. This leads to increased prices of outputs produced using oil products, in particular those produced with energy intensive production processes. Increased output prices imply, other things being equal, reduced real income of institutions. In addition, increased import prices lead to a worsening of the balance of trade, particularly if import substitution by means of domestic products is difficult. Furthermore, upward price shifts will activate behavioural reactions such as substitution in consumption towards relatively cheaper goods and services; affecting in turn the output of the activities producing the different types of goods. Upward and downward shifts of activities will then affect the demand of factors and related payments to factors. This will have implications for households’ incomes.

Figure 6. Main flows of payments through which external shocks affect the economic system (in red).



Source: adapted from: Round J. (2003): Social Accounting Matrices and SAM-based multiplier analysis”, chapter 14 in F. Bourguignon and L.A Pereira da Silva (Eds) The impact of economic policies on poverty and income distribution, New York, World Bank and Oxford University Press.

On these grounds, it is most likely that different socio-economic groups are affected differently, according to, for example. their geographic location (rural versus urban) or their welfare status (poor versus non-poor). To analyse the extent to which price changes on the international markets affected the different layers of the populations, and to investigate the distributional impacts of possible countervailing policy measures, it is necessary to dispose of a framework comprising the abovementioned factors and related interlinking channels. The SAM 2000 allows some considerations to be drawn about the distributional impacts of shocks and policies because in the SAM households are classified in Rural-Urban and Poor-Non poor according to their residence and the national per capita annual poverty line²⁷. In the following paragraphs a short description of the household classification is provided.

The SAM 2000 bases its classification of households on the “Survey on the Living Standards of Households” run in 2003 by the INSD²⁸. INSD (2003) adopted an absolute poverty line for the period April-July 2003 The poverty line, calculated on the basis of minimum calories intake and minimum-non food requirements, amounts to 82 672 FCFA per person per year, corresponding to around one fourth of the legal minimum wage and around two fifths of the international poverty line of one dollar per person per day. The INSD survey allows the classification of the population and the households as reported in table 2.

²⁷ The per capita poverty line was estimated by INSD (2003) at 82 672 FCFA for 2003.
²⁸ INSD (2003) Analyse des résultats de l’Enquête sur les Conditions de vie des ménages Burkina Faso. Ministère de l’Economie et du développement. Segretariat General, Insitut National de la Statistique et de la Démographie (INSD)
 INSD (2003) : Profile de la Pauvreté en 2003. Ministère de l’Economie et du développement. Segretariat General, Insitut National de la Statistique et de la Démographie (INSD)

Table 2. Rural-Urban and Poor/Non-Poor Classification of Population and Households

# Population	Poor	Non poor	total	% Population	Poor	Non poor	total
Rural	4,869,012	4,446,348	9,315,360	Rural	52.3%	47.7%	100.0%
Urban	412,010	1,656,435	2,068,445	Urban	19.9%	80.1%	100.0%
total	5,281,022	6,102,783	11,383,805	total	46.4%	53.6%	100.0%

# of Households	Poor	Non poor	total	% Households	Poor	Non poor	total
Rural	612,770	794,670	1,407,441	Rural	43.5%	56.5%	100.0%
Urban	54,155	315,440	369,595	Urban	14.7%	85.3%	100.0%
total	666,925	1,110,111	1,777,035	total	37.5%	62.5%	100.0%

Source: Own calculations on INSD data from "Enquête sur les conditions de vie des Ménages" (2003) And INSD (2003): «La Pauvreté' au 2003»

The survey data also allow the analysis of the expenditure by type of household, as reported in table 3. This analysis reveals that, overall, the urban layer of the society looks more polarized than the rural one, as the difference in the average expenditure between poor and non poor is lower in rural areas than in urban ones. In addition, although much more widespread, rural poverty is on average less deep than urban poverty, as rural poor households spend on average more than their homologues in urban areas (423,000 and 372,000 FCFA per year, respectively). On the other hand, the average expenditure of non poor is higher in urban areas than in rural ones.

Table 3: Average household expenditure by type of household.

Average exp*	Poor	Non poor	total	Average exp*	Poor	Non poor	total
Rural	423	874	678	Rural	52%	108%	84%
Urban	372	1,484	1,321	Urban	46%	183%	163%
total	419	1,047	811	total	52%	129%	100%

* Thousands FCFA per household per year

* % of national average household expend. year 2000

Source: Social Accounting Matrix of Burkina Faso for year 2000.

In addition to the expenditure level, the structure of expenditure may also lead to differentiated impacts of external shocks and related policies on the different types of households.

Table 4. Expenditure shares by type of households

	Rural Poor	Rural non-poor	Urban Poor	Urban non-poor	Notes: SAM code
Agricultural commodities	43.9%	25.2%	30.5%	16.3%	
<i>Fruits and vegetables</i>	13.9%	6.7%	9.0%	5.3%	CAGEX,CAMAR,CAGOT
<i>Cereals</i>	17.5%	10.9%	10.5%	6.5%	CAGFO
<i>Meat and Fish</i>	12.6%	7.5%	10.9%	4.6%	CBOV,CCATF,CCHAS,CFISH
Processed food	26.4%	31.1%	26.5%	21.3%	CNAFO+CABAT
Other Primary commodities	1.8%	2.6%	3.6%	2.1%	CFORE+CMINE
Industrial goods	19.1%	20.3%	23.3%	24.6%	
<i>Fuel, related products and energy</i>	6.7%	6.6%	9.0%	8.3%	CPPTR,CENEG
<i>Other industrial goods</i>	12.5%	13.6%	14.2%	16.4%	CNAOI
Services	8.8%	20.9%	16.1%	35.7%	
<i>Transport</i>	1.4%	2.2%	1.9%	1.5%	CTRANS
<i>Other services</i>	7.4%	18.7%	14.3%	34.1%	CFINAN,CNASM,CNASNM
Total	100.0%	100.0%	100.0%	100.0%	

Source: Social Accounting Matrix of Burkina Faso for year 2000.

Looking at table 4, as expected, the percent of food expenditure on the total expenditure is higher among the poor than among the non-poor. This holds both for rural and urban layers of

the population. Furthermore, the rural poor spend more on raw (unprocessed) food than the other types of households. On the other hand, the share of expenditure on industrial goods is fairly similar across the different households, ranging from the 19.1% of the rural poor to the 24.6% of the urban non-poor. This also applies to the expenditure for fuel and energy. This implies that the difference in the share of food expenditure is complemented by the differences in the expenditure on services. The share of the non-poor, in particular the urban ones, is much higher than the share of the poor (35.7% and 8.8% respectively).

The different structure of expenditure across households, associated with the different expenditure levels and likely diversified behavioural responses of the various social groups described above, should result in differentiated welfare impacts of different external shocks and related policy measures. The CGE model, described in the next section, will be used to shed some light on the cross-sectoral and inter institutional socio-economic impacts of external shocks and possible related policy measures.

5 The CGE of Burkina Faso

The CGE model adopted for Burkina Faso is based on the standard IFPRI CGE (2002)²⁹. This is a single-country, multi-sector, multi-commodity open-economy static model, based on a SAM of the country, essentially used to calculate selected parameters and “calibrate” the model in such a way that its solutions, in absence of shocks, replicate the solutions of the variables at the benchmark. In this section, some important features of the model will be illustrated. A detailed description of the structure and selected blocks of the model is reported in appendix.

5.1 Data sources

The SAM described in the section above has been utilised as the base of macro-economic data for the CGE model. The SAM has been aggregated in larger groups of commodities and macro-production sectors (activities) to rule out small value cells in order to ease the convergence of the model.

In addition, the SAM was modified to highlight the expenses for agricultural chemicals (fertilisers and pesticides), because the original SAM reported only the production and use of an aggregated commodity: “other industrial goods”. The payments of the agricultural sectors to the account of this aggregated commodity were assumed to be payments for agricultural chemicals. This assumption allowed the separation these expenses from the rest of the expenses for other industrial goods. The commodities, activities and institutions comprised in the SAM are reported in table 5.

²⁹ Lofgren H, Lee Harris R, Robinson S. et al.(2002) A standard Computable General Equilibrium (CGE) model in GAMS. International Food Policy Research Institute, Washington D.C.

Table 5. Aggregated SAM elements for the CGE model.

#	Activities	Code	#	Commodities	Code
1	Cotton grains	ACOTN	1	Cotton grains	CCOTN
2	Cash crops	AAGEX	2	Cash crops	CAGEX
3	Vegetables	AAMAR	3	Vegetables	CAMAR
4	Food crops	AAGFO	4	Food crops	CAGFO
5	Other Agriculture	AAGOT	5	Other Agriculture	CAGOT
6	Livestock-bovine	ABOV	6	Livestock-bovine	CBOV
7	Other livestock	ACATF	7	Other livestock	CCATF
8	Hunting	ACHAS	8	Hunting	CCHAS
9	Forestry	AFORE	9	Forestry	CFORE
10	Fisheries	AFISH	10	Fisheries	CFISH
11	Mining	AMINE	11	Mining	CMINE
12	Cotton ginning	AEGRC	12	Cotton ginning	CEGRC
13	Slaughtering	AABAT	13	Slaughtering	CABAT
14	Agro-industry	ANAFO	14	Agro-industry	CNAFO
15	Other industry	ANAOI	15	Other industry	CNAOI
16	Power, water and gas	AENEG	16	Oil and oil products	CPPTR
17	Trade	ACOME	17	Fertilizers and Pesticides	CFERT
18	Transport	ATRANS	18	Power, water and gas	GENEG
19	Financial ervices	AFINAN	19	Trade	CCOME
20	Services to enterprises	ANASM	20	Transport	CTRANS
21	Services to households	ANASNM	21	Financial services	CFINAN
			22	Services to enterprises	CNASM
			23	Services to households	CNASNM

#	Institutions/ other accounts	Code	#	Factors	Code
1	Poor rural households	HLSLOW	1	Agricultural labour	LABAGR
2	Non-poor rural households	HLSUPP	2	Non-agricultural labour	LABNAGR
3	Poor urban households	HURBLOW	3	Family labour	MOF
4	Non-poor urban households	HURBUPP	4	Agricultural capital	CAPSH
5	Financial enterprises	ENTRF	5	Non agricultural Capital	CAPLSC
6	Non-financial Enterprises	ENTRNF			
7	Income taxes on households	YTAX			
8	Indirect taxes on activity incomes	ATAX			
9	VAT and other taxes on goods	TAR			
10	Import taxes	ITAX			
11	Export taxes	ETAX			
12	Government account	GOV			
13	Rest of the World	ROW			
14	Savings-Investment account	S-I			

The SAM was used to obtain share parameters and scale factors for almost all the demand and supply functions included in the model.

In the absence of more detailed information, we adopted a Leontief technology (fixed technical coefficients) based on SAM information, for the following levels of the “technology nest”:

1. determination of the composite intermediate input;
2. determination of the value-added mix.

In addition to information contained in the SAM, different sets of elasticities were used for:

1. substitution of domestic goods versus imports (Armington-type CES function elasticities);
2. transformation of domestic consumption goods into exports (CET function elasticities);
3. own, cross-price and income elasticities for households. (LES demand system, with “subsistence” consumption shares. An estimate of the Frisch parameter was obtained from the literature).

4. determination of the aggregated value added is obtained (CES function allowing for imperfect substitutability among factors).

For more details on the equations of the model regarding the demand system for final consumers the import/domestic substitution and the export/domestic transformation, see the technical appendix at the end of the paper.

Elasticities have been derived from available literature, in the absence of relevant information at country level. Given that the choice of elasticities introduced some degree of subjectivity in determining the behavioural responses of agents to shocks and policy measures; some sensitivity analysis on the most relevant parameters for the specific measures under investigation were carried out, to also take into account the very different estimates identified in literature³⁰.

5.2 Macro-economic closures

The model requires some “macro-economic closures”, i.e. we need specifying the ways by which relevant macro-economic balances are satisfied. More specifically this applies for the following macro-economic balances:

- 1) government account balance;
- 2) Rest Of the World (ROW) account balance;
- 3) Savings/Investment (S-I) account balance.

1) Government account balance (deficit/surplus). The government revenue (YG) has to be equal to the government expenditure (EG) plus the government savings ($GSAV$):

$$YG = EG + GSAV . \quad (6.1)$$

In the model, the income of the government YG comprises taxes on income of institutions and other income:

$$YG = TINS \cdot YI + FTRANSF * EXR + OTHIG \quad (6.2)$$

where:

- $TINS$: Vector of institution-specific tax rates;
 YI : Vector of incomes of non-governmental institutions;
 $FTRANSF$ Foreign transfers to the government (in foreign currency);
 EXR Real exchange rate (expressed in terms of the price numeraire);
 $OTHIG$: Other government income.

The government expenditure EG comprises government consumption and transfers:

$$EG = QG \cdot PQ + Transf \cdot CPI \quad (6.3)$$

where QG is a vector of “real” government consumption (government consumption in physical terms), PQ the vector of commodity prices and $Transf$ are public transfers to non-governmental institutions.

³⁰ To this regard see e.g. Gibson. K. (2003) Armington Elasticities for South Africa. Long and Short Run level Estimates. Trade and Industrial Policy Strategies Working paper 12-2003 University of Natal (South Africa).

The consumption component of the government expenditure $QG \cdot PQ$ is modelled either by fixing QG in real terms (for instance, anchored to the base year), or by fixing it as a given share of the nominal total absorption³¹. Transfers are exogenous but are kept constant in real terms for the consumers through the different simulations by multiplying them by the consumer price index CPI . The government balance adjusts by means of one of the following options:

- a. **Flexible government savings** and fixed tax rates. Government savings adjust to the new level of taxes calculated with new incomes, existing tax rates and new nominal government consumption.
- b. **Fixed government savings** and flexible taxation, by means of fixed adjustments in the tax rates for selected institutions.
- c. **Fixed government savings** and flexible taxation by means of proportional adjustments in the tax rates for selected institutions.³²

2) Rest of the World (RoW) account. The external balance, specifically the current account deficit/surplus, expressed in the model in foreign currency, is as follows:

$$QE \cdot PWE - QM \cdot PWM + tr(F, ROW) - tr(ROW, F) + FTRANSF = - FSAV \quad (6.4)$$

where:

QE :	Vector of exported quantities
PWE :	Vector of world export prices (in foreign currency)
QM :	Vector of imported quantities
PWM :	Vector of world import prices (in foreign currency)
$tr(F, ROW)$:	Transfers from the ROW for the payments of domestic factors
$tr(ROW, F)$:	Transfers to the ROW for the payments of foreign factors
$FTRANSF$	Transfers from ROW to government
$FSAV$:	Foreign savings (deficit/surplus of the current account)

The left-hand side of 6.4 is the “current account balance” as defined in UN (1993)³³. Note that $FSAV > 0$ implies a deficit of the current account balance; vice versa, $FSAV < 0$ implies a surplus of the current account.

Options for its equilibrium are:

- a. **Fixed foreign savings and flexible real exchange rate**³⁴. In this case, the equilibrium in the external balance is achieved by depreciating (appreciating) the local currency, i.e. increasing (decreasing) the price of the foreign currency in real terms, to compensate for a deficit (surplus) of the trade balance which exceeds the fixed foreign savings level.

³¹ This implies that the scale factor (variable $GADJ$) which shifts the vector of quantities consumed by the government, and which is exogenously fixed when QG is exogenous, is endogenized. In any case, the proportions among the physical commodities consumed by the government are the same as in the base case.

³² For example, given institution A with a tax rate of 20% and institution B with a tax rate of 15%, under the closure b., a required tax change of e.g. +7% for both institutions leads to new tax rates of 27% and 22% for A and B respectively. Under the closure c. instead, a required tax change of e.g. +40%, leads to new tax rates of 28% and 21% for A and B respectively.

³³ The current account balance, as defined in the Systems of National accounts (1993) includes The *goods and services account* (the overall trade balance) The *primary income account* (factor income such as from labour, loans and investments) The *secondary income account* (transfer payments).

³⁴ Real exchange rate refers here to the price in local currency of one unit of foreign currency expressed at constant domestic prices.

Assuming that world prices are exogenously fixed, the depreciation (appreciation) of the foreign currency implies that imports become more expensive (cheaper) w.r.t. domestic goods and exports are more profitable (less profitable) than domestic sales, entailing an adjustment of quantities imported and exported (via the Armington and CET functions). Fixing the foreign savings in foreign currency, when the balance of transfers from and to abroad is exogenous, implies also fixing the balance of trade in foreign currency. Overall, this closure amounts to:

$$QE \cdot \overline{PWE} - QM \cdot \overline{PWM} + \overline{tr(F, ROW)} - \overline{tr(ROW, F)} + \overline{FTRANSF} = - \overline{FSAV} \quad (6.5)$$

Note however that the variable $FSAV$ represents a “net” flow of foreign financial resources, resulting from the balance of inflows and outflows. While the inflow component may be related to the capacity of the country to attract new capital from abroad, the outflow component is directly linked to the investment choices of domestic investors. On these issues, see e.g. Taylor (2004)³⁵ The assumption of ‘exogeneity’ of $FSAV$ therefore has to be considered only as one possible modelling option in absence of further information regarding the way capital inflows and outflows are determined. For this reason, the level of $FSAV$ may be subject to sensitivity testing.

- b. **Flexible foreign savings and fixed exchange rate.** Under this option the exchange rate is implicitly anchored to the numeraire of the system and the external current account balance is adjusted by means of flexible foreign savings. In this case, the foreign savings adjust to compensate for imbalances in the trade account.

A discussion on the implications of the different types of closure of the external balance is reported in appendix B, section 13.4.

3) Savings/investment account³⁶: The Savings-investment balance is represented by the following relation:

$$YI \cdot (1 - TINS) \cdot MPS + GSAV + FSAV \cdot EXR = QINV \cdot PQ \quad (6.6)$$

where:

- YI a vector of incomes of the different non-governmental institutions;
- $TINS$ a vector of institution-specific tax rates for non-governmental institutions;
- MPS a vector of institution-specific average propensities to save;
- $GSAV$ savings of the government;
- $FSAV$ foreign savings in foreign currency;
- EXR exchange rate;
- $QINV$ vector of physical quantities of investment commodities;
- PQ vector of commodity prices.

This balance adjusts by means of one of these options:

³⁵ Taylor L. (2004). Reconstructing macroeconomics: structuralist proposals and critiques of the mainstream Ch 10. Harvard University Press, 2004.

³⁶ The model adopted allows for two options for the variation of the average propensity to save MPS: a) “uniform fixed points saving rate change”, through the adjustment of the parameter DMPS and b) “proportional saving rates change” through the adjustment of the parameter MPSadj, as follows:
 $MPS = mps0 \cdot (1 + MPSadj) + DMPS$

- a. **Fixed investment (in physical terms) and flexible savings** by means of fixed adjustments of the average propensity to save for selected institutions. For example, given two institutions, A and B, with an average propensity to save 10% and 15% respectively, a required change in the savings is obtained by an additional fixed number of percentage points equal for both the institutions: say 5%, in their propensity to save, leading to 15% and 20% for A and B respectively.
- b. **Fixed investment (in physical terms) and flexible savings** by means of proportional adjustments of the average propensity to save for selected institutions, e.g. given the two institutions A and B above, a required change in the savings is obtained by a proportional change in the average propensities to save equally for both the institutions: say 20%, in their propensity to save, leading to 12% and 18% for A and B respectively.
- c. **Flexible investment and fixed savings** with fixed marginal propensity to save for non-government institutions;
- d. **Fixed investment share of absorption and fixed government consumption share** of absorption. Absorption is expressed in value terms. This implies that quantities for investments and government consumption are flexible. The propensities to save adjust as in case a.
- e. **Fixed shares as above.** The propensities to save adjust as in case b.
- f. **Fixed investment and flexible savings**, by means of adjustments of income. Average propensities to save are fixed, but shifts in income by means of the “Keynesian multiplier” effects allow savings to adjust to investment (“Keynesian-type” closure)³⁷.
- g. **Fixed investment and flexible savings**, by means of adjustments in the income distribution. This closure requires that at least two institutions with different propensities to save. This is a “Postkeynesian-type” adjustment mechanism (Kaldor-Pasinetti).
- h. **Fixed investment and “compulsory” savings.** Government savings adjust to satisfy the S-I balance (this is a “Johansen-type” adjustment mechanism).

Simulations reported in the present study adopted the following macro economic closures (see figure 6):

1. **Government balance:** flexible government savings (fixed direct tax rates), This option is likely to be better at fitting the actual situation of the country. Indeed, analysing the impact of external shocks and policy measures on tax rates, with the aim of identifying appropriate tax rates to enable the maintenance of a fixed budget deficit, would be a pure theoretical exercise, given the context of the country. Adjustments of tax rates and fiscal policies in general would actually be difficult to implement in practice, given the weak institutional structure, including the fiscal administration. In addition, by imposing flexible government saving, it will allow a focus on welfare changes induced by external shocks and policy responses, not “polluted” by fiscal adjustments. In all the simulations carried out in this work government consumption is fixed at the base level. However, changes in relative prices shift the government expenditure
2. **RoW account:** flexible real exchange rate and fixed foreign savings (fixed deficit of the trade balance, expressed in foreign currency) are chosen as the closure rules for the RoW

³⁷ For a discussion on the different types of closure mechanisms, see the appendix B (chapter 13).

account.³⁸. Therefore, real import/export prices will be affected, in addition to shifts due to external shocks, also by shifts of the real exchange rate. This implies that imbalances in the Rest of the World account generated by external shocks are absorbed by adjustments of the real exchange rate and not by foreign savings.

3. Savings-Investment (S-I) account: regarding the Saving-Investment balance, the macro-economic closure rule chosen is “investment-driven”. Investment has been kept fixed in real terms (fixed quantities). Average propensities to save of households adjust to fit investment requirements. This permits looking at the pure impact on welfare of households and comparing it with the base case, after neutralising possible changes in the capital formation. This closure implies that the economic system is not shifting the burden of current shocks in the future, because is not affecting its capital formation.

The above-mentioned macro-closures, on the basis of equations 6.1 to 6.6 can be represented as follows:

$$\text{Ext. bal.: } \overline{QE} \cdot \overline{PWE} - \overline{QM} \cdot \overline{PWM} = \overline{tr(ROW, F)} - \overline{tr(F, ROW)} - \overline{FTRANSF} - \overline{FSAV} \quad (6.7)$$

$$\text{S-I bal.: } \overline{YI} \cdot (1 - \overline{TINS}) \cdot \overline{MPS} + \overline{GSAV} + \overline{FSAV} \cdot \overline{EXR} = \overline{QINV} \cdot \overline{PQ} \quad (6.8)$$

$$\text{Gov. bal.: } \overline{TINS} \cdot \overline{YI} + \overline{FTRANSF} * \overline{EXR} + \overline{OTHIG} = \overline{QG} \cdot \overline{PQ} + \overline{Transf} \cdot \overline{CPI} + \overline{GSAV} \quad (6.9)$$

When exogenous shifts of world prices, either PWE or PWM , are simulated, the equilibrium of the external balance (6.7) is altered. Under this closure, the only endogenous variables in the balance are the physical quantities of imports and exports QE and QM , in the trade balance on the left hand side of equation 6.7. Note that, under this closure, the trade balance is exogenously fixed, as all the components on the right hand side of the 6.7 are exogenous. Therefore, QE and QM have to adjust upward or downward to restore the equilibrium. As explained above, this happens by means of:

- a. shifts of relative domestic prices of commodities whose world prices change;
- b. a shift of the exchange rate EXR , implying a general shift of domestic versus world prices.

The shifts of import-export commodities affect consumer prices and the consumer price index CPI . However, note that, being CPI the numeraire, only relative prices shift up or down. Price shifts lead to changes in the composition of the domestic demand. As a consequence, as the different commodities are produced with technologies which exhibit different factor intensities, shifts of demands lead to shifts activity levels, factor use and/or shifts in factor remunerations (wages) (according to the specific closures of factor markets, as discussed in the section 6.3 here below), which lead to changes in the income of the various institutions YI .

³⁸ Burkina Faso belongs to the “Union Economique et Monetaire de l’Afrique de l’ Ouest” (UEMOA), which adopted the Franc CFA, a common currency anchored in nominal terms to the Euro. Unilateral nominal devaluations of the national currency are not possible. The “currency devaluations” reported in the results of the simulations in the next sections have to be intended as increases of the level of foreign prices with respect to domestic ones or, analogously, reductions of the general level of domestic prices relative to foreign prices that would enable to keep constant the deficit of the trade account expressed in foreign currency with respect to the base case. A more in depth discussion regarding the closure of the RoW account is reported in annex.

An alternative scenario for the real exchange rate could be to introduce some real appreciation, say, around 1.5% per year, to reflect the actual trend of this variable in recent years, as reported in Joufelkit H.D. (2005): Evolution des taux de change effectifs réels (TCER) de la zone franc: 1993-2006. Rapport “Jumbo”, Agence Française de Développement (AFD)-Paris.

On the one hand, the shift of the exchange rate EXR and, probably to a lesser extent, of incomes YI and prices PQ alter the S-I balance (equation 6.8). An upward shift of the exchange rate shifts upward foreign savings in domestic currency (and vice-versa, a downward shift). This implies that, other things equal, either the government savings $GSAV$ or the average propensities to save of private institutions MPS (or both) have to adjust downward to restore the S-I balance.

On the other hand, the shift of EXR described above, in addition to changes of the government savings $GSAV$, of income YI , as well as changes in other government income $OTHIG$, alters the government balance (equation 6.9) by shifting the value of foreign transfers to government expressed in domestic currency. For example, an upward shift of the exchange rate increases the value of (positive) foreign transfers expressed in domestic currency. Other things equal, $GSAV$ should increase to restore the government balance expressed by equation 6.9. The remainder of the burden in the restoration of the government balance is born by changes of the relative prices PQ . However, note that adjustments of $GSAV$ required for satisfying equation 6.8 have to be compatible with adjustments of the same variable to satisfy equation 6.9. In the case of an upward shift of the exchange rate, the shift of $GSAV$ required to satisfy the government balance (equation 6.9) has the opposite sign of the shift required to restore the S-I balance (equation 6.8). The ultimate sign of the change in $GSAV$ depends, other things equal, by the magnitude of $FTRANSF$. In presence of relatively high transfers from abroad, an upward shift of the exchange rate is likely to generate an increase in $GSAV$ to restore the government balance as per equation 6.9, while MPS will decrease to adjust the S-I balance as per equation 6.8.

Figure 7.1 Macro closures for CGE model.

1. Government Balance*	2. RoW Balance	3. Savings-investments
1.a) Flexible government savings and fixed direct tax rates	2.a) Fixed foreign savings and flexible real exchange rate	3.a) Fixed investment and flexible savings (uniform fixed points saving rates changes).
1.b) Fixed government savings and flexible direct tax rates (uniform fixed points tax rates changes).	2.b) Flexible foreign savings and fixed real exchange rate	3.b) Fixed investment and flexible savings (proportional changes of propensities to save).
1.c) Fixed government savings and flexible direct tax rates (Proportional tax rates changes)		3.c) Flexible investment and fixed saving rates for non govt. institutions)
		3.d) Fixed investment and government consumption absorption shares (uniform fixed points saving rates changes).
		3.e) Fixed investment and government consumption absorption shares (proportional saving rates changes).

= Macro closures adopted
 = Other macro closures tested

* The closures for the government account assume exogenous government consumption in real terms (physical quantities) (under investment closures 3a, 3b, 3c) or fixed nominal shares of absorption (under investment closures 3d and 3e)

5.3 Closures for factor markets

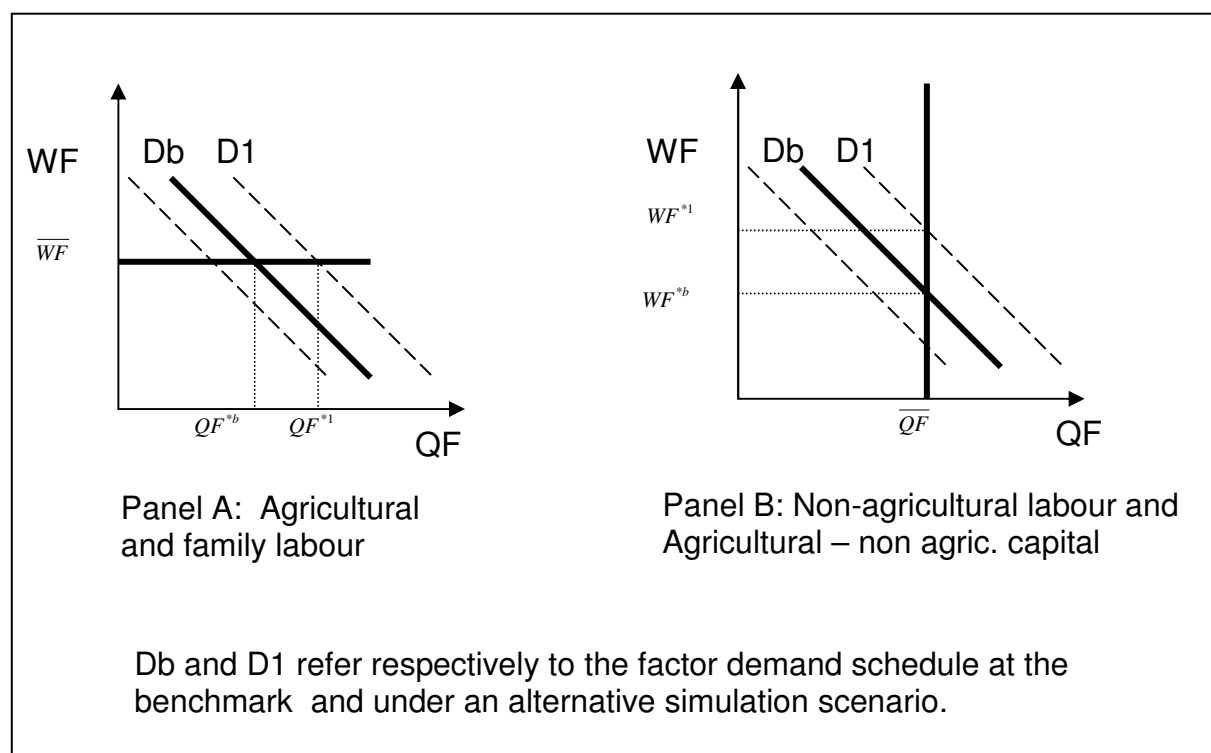
Factors and closures of the factor markets have been dealt with as described below:

1. Non-agricultural labour has been assumed to be mobile across activities and fully employed. Full employment implies assuming for the simulations the same level of employment as the base case but flexible real wage rates (wages adjust across simulations).
2. For agricultural labour and family labour the full-employment option has been relaxed, thus allowing for unemployment, retaining however the possibility to move across activities. Given the structure of the model, this implies that the real wage rate has been fixed.
3. Both agricultural capital and non-agricultural capital have been assumed to be fully employed, but, agricultural capital has been assumed to be mobile across activities within the agricultural sector, while non-agricultural capital has been assumed to be activity-specific.

4. Agricultural and non agricultural factor markets are segmented, i.e. agricultural labour, family labour and agricultural capital employed in the agricultural sector at the benchmark, do not move outside the agricultural sector, as much as non-agricultural labour and non-agricultural capital do not move outside the non-agricultural sector.

These assumptions look quite plausible for Burkina Faso, which is characterized both by labour unemployment and underemployment, as well as lack of capital in many sectors. In addition, the agricultural sector does not look interesting enough to attract capital from the non-agricultural sector. However, the assumption that the agricultural and family labour cannot be employed outside the agricultural sector is quite restrictive. It rests on the implicit hypothesis that non-agricultural activities require a different type of labour (different professional profiles with different skills) with respect to agricultural ones. This also implies assuming that the time-span considered for the simulation scenarios to develop is not enough to permit the re-training or the institutional context is not conducive to that end. Agricultural wages, as well as figurative family wages are assumed to be constant as they are assumed to be quite close to the “subsistence” level but unlikely to rise given the relatively high unemployment rate. Figure 7.2 illustrates the assumptions made for the different factor markets. Note that, on the one hand, for the agricultural and family labour, shifts of the demand schedule under different scenarios lead to shifts in the quantity of labour actually employed at a fixed wage rate. This implies that the agricultural and family labour actually provided is demand-led, in the sense that the supply adjusts to factor demand, i.e. labour is available in any quantity at the given market wage. On the other hand, for non-agricultural labour and capital, which are in fixed supply, shifts of the demand schedule lead to shifts in the factor wage.

Figure 7.2 Closures for factor markets



The macro-closures adopted result from a mix of features of the macro closures described in section 4. More specifically, they reflect a “neo-classical” closure regarding the non-agricultural labour and capital (full-employment of factors), a “Keynesian” closure regarding the agricultural and family labour (exogenous wage, unemployment, exogenous investment) and a “Johansen closure”, (exogenous real investment *QINV* and endogenous government savings *GSAV*). However, regarding the saving-investment balance, the difference with Johansen’s is that here, the saving-investment balance is not achieved through endogenous government savings determined by flexible income tax rates and fixed propensities to save, but by endogenous government savings determined by other tax sources (*OTHIG*) with fixed income tax rates (*TINS*) as well as by shifts in the average propensity to save MPS. In addition, given that different types of households exhibiting different propensities to save are modelled, income distribution changes reflect on the overall savings of institutions. This reflect to a good extent a feature of the Post-Keynesian models (Kaldor-Pasinetti).

As suggested by Lofgren, Robinson et al. (2002), fixed foreign savings (figure 7.1, closure 2.a), fixed real investment (closures 3.a or 3.b) and fixed real government consumption (any of the closures for the government balance), better allow to highlight the total negative (positive) welfare impacts of external shocks or policies on households, as they would not be partially offset (amplified) by decreases (increases) in real investment, real government consumption and increases (decreases) in foreign savings, i.e. injections (drains) of resources from the S-I account, the government account or from the RoW. Note however that welfare effects measured with indicators based on expenditure, such as the Equivalent Variation (*EV*), may be affected by significant changes in the propensities to save *MPS*, as described in the previous paragraph. For example, a downward shift in the *MPS*, other things equal, allows the households consuming more or reducing consumption less than what would happen if *MPS* was kept constant. Therefore, the inspection of shifts in real income is also required to get a full picture of welfare changes. In addition testing alternative macro closures is also advisable. Section 7.3. reports the results of some alternative macro closures.

6 Simulations of socio-economic impacts of external shocks

On the basis of the observed changes in import-export prices in the last twelve years, the price changes reported in table 5 have been retained for simulations. Simulations of external shocks have been carried out and compared with the base case.

Table 5: Price changes by commodity for simulations of external shocks with the CGE model

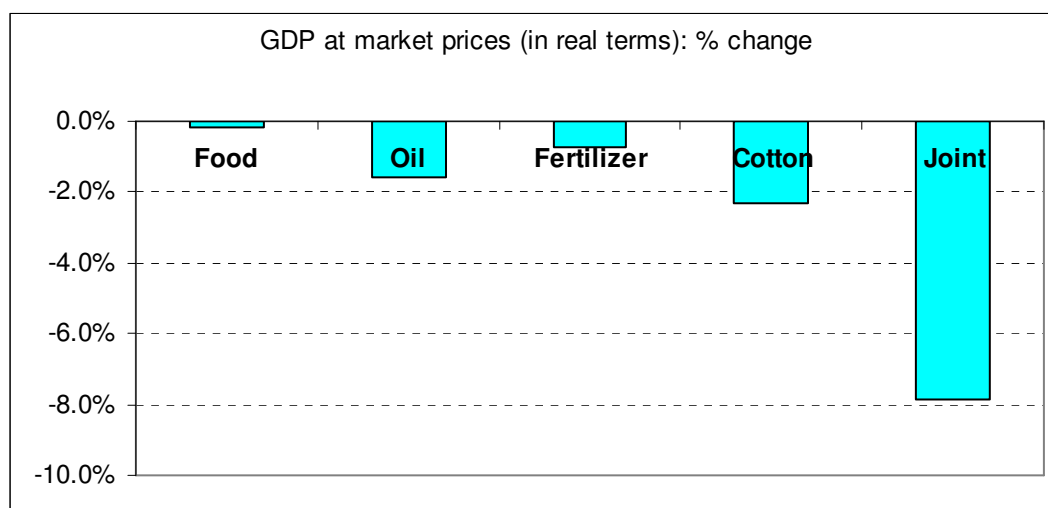
	Food	Oil/oil products	Fertilizers	Cotton
Average index 1997-2004	85.3	118.9	90.0	80.5
Average index 2005-2008	80.5	240.8	138.7	54.4
Index 2008	93.5	292.3	208.4	54.3
% change 05-08/97-04	-5.6%	102.6%	54.2%	-32.4%
% change 08/97-04	9.6%	146.0%	131.7%	-32.6%

The focus will be put on the change registered in 2008 with respect to the average index of the periods 1997-2004.

6.1 Macro economic impacts

All the four exogenous shocks considered have negative effects on GDP, as reported in figure 7.3³⁹.

Figure 7.3 GDP at market prices (at constant prices, % changes)



Source: CGE model results.

Table 6. Macro-economic impacts of external price shocks (at constant prices)

		Base	Food	Oil	Fertilizer	Cotton	Joint shocks
		<i>Million FCFA</i>	<i>% variation w.r.t. the base</i>				
a=b+c+d	Total Absorption	2,119,964	-0.4%	-6.6%	-1.6%	-2.3%	-12.9%
b	Private consumption	1,441,816	-0.6%	-9.8%	-2.4%	-3.4%	-19.0%
c	Investment	279,655	0.0%	0.0%	0.0%	0.0%	0.0%
d	Government cons.	398,493	0.0%	0.0%	0.0%	0.0%	0.0%
e	Exports	149,849	-1.5%	32.3%	3.9%	-29.7%	-11.4%
f	Imports	458,157	-1.7%	-13.8%	-3.2%	-11.0%	-32.7%
g=e-f	Trade balance	-308,308	-1.8%	-36.2%	-6.6%	-1.9%	-43.0%
g=a+g	GDP at market prices	1,811,656	-0.2%	-1.6%	-0.8%	-2.3%	-7.8%

Source: CGE model results.

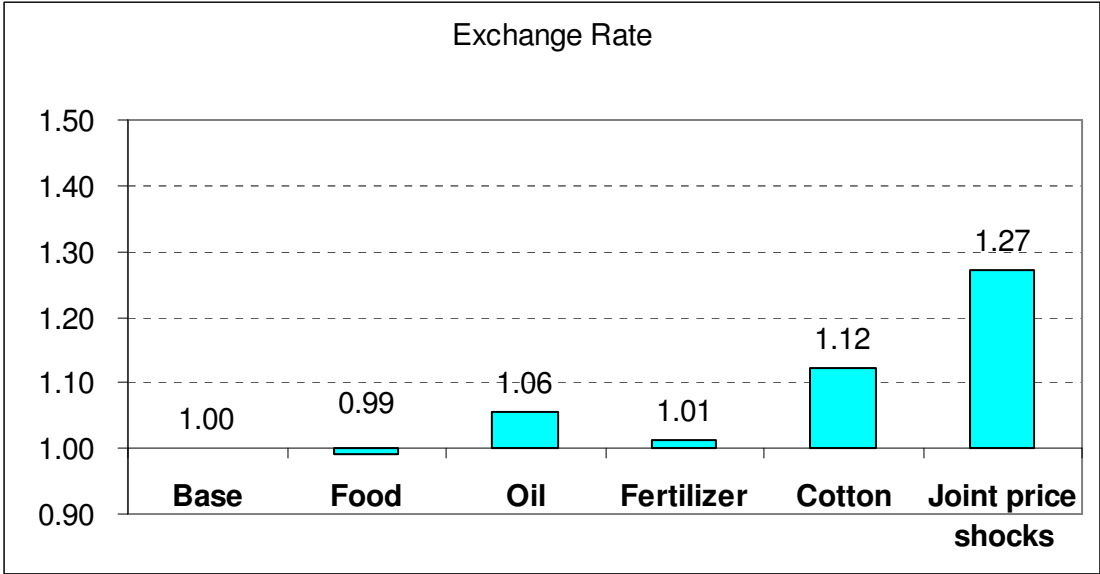
However, while the food shock has marginal impacts (around - 0.2 % of GDP) and fertiliser shows a moderate impact (-0.8%), the price shocks on oil and cotton have significant impacts (around 2% each). When considered jointly, the four price shocks show a very strong impact on GDP, of almost 8%. For the “Joint” scenario, table 6 (rows b, e and f) show that private consumption falls more proportionally than GDP, at around 20%, due to a significant contraction of imports. It also happens to exports.

Shifts in prices of imports and exports change the prices of internationally traded commodities compared to domestically produced substitutes, impacting on the balance of trade. Given that in chosen macro-economic closure for the Rest-Of-the-World account the foreign savings (*FSAV*) are kept constant in real terms (in foreign currency), for all the four

³⁹ . GDP data reported here are in “real” terms, i.e. new quantities calculated in different scenarios are evaluated at “base” prices. Data in tabular format are reported in the appendix.

external shocks the balance of trade is adjusted by means of a devaluation of the (real) Exchange Rate (*EXR*); expressed as the amount of local currency at constant (base) consumer prices required to buy one unit of foreign currency. As reported in figure 7.4, significant depreciation of local currency occurs due to oil price increase (6%) and cotton price decrease (12%) in order to avoid increasing the external deficit. The joint impact of external shocks amounts to a depreciation of 27% on the local currency.

Figure 7.4 Local currency devaluation (Real Exchange Rate: local currency at constant base consumer prices per unit of foreign currency)



Source: CGE model results

Given the fixed nominal exchange regime of the Franc CFA with respect to the Euro, the real exchange rate has to adjust via adjustments in the ratio of the international versus domestic prices. A depreciation of the real exchange rate of 27% can also be read as a reduction of the level of domestic prices relative to the international prices of around 20% (i.e. $1/1.27$)⁴⁰, implying a generalized reduction of domestic purchasing power with respect to foreign goods and assets (see the appendix for a detailed explanation of the adjustment of the real exchange rate).

As expected, oil and fertilizer price increases (simulations 2 and 3), leading to upward shifts of the real exchange rate, increase export quantities and decrease imports (table 6, rows e and f) in order to re-equilibrate the external balance. The international food price increase instead (simulation 1), leads to a substitution of imported food with domestic products, entailing the substitution of export crops with food crops which implies a reduction of both exports and imports. Also the fall of the price of cotton, lads to a reduction of both exports and imports although here the magnitude of the reduction is much higher.

Fixing investment in real terms (row c of table 6), implies assuming that the economic system does not slow down the process of capital formation in response to external shocks. However,

⁴⁰ This may happen in practice by means of open market operations by the central bank to absorb domestic money. The absorption can be generated by sales of foreign currency against domestic currency. The reduced money supply entails a reduction of the general level of domestic prices. See section 13.4 for a detailed explanation of implications of real exchange rate adjustments under a fixed nominal exchange rate regime.

this implies also that the investment bill shifts in nominal terms, i.e. by means of shifts in relative prices. Indeed, relative prices, as well as the other endogenous components in the left-hand side of the S-I balance (equation 6.8), adjust to the exogenous investment quantities.

In particular, the rise of the exchange rate for the oil, fertilizer, cotton and joint price simulations, increases the value in domestic currency of foreign savings. This implies that, being the investment fixed in real terms, the endogenous components of the S-I balance have to adjust downward to satisfy the balance. The burden of the adjustment is born by the private savings which shrink for a reduction of the income of the institutions YI (see table 7), associated to a reduction of the propensity to save MPS , as reported in table 8.

Table 7. Income of different household groups.

	Base	Food	Oil	Fertilizer	Cotton	Joint
Rural poor	271,356	-0.5%	-6.4%	-2.3%	-3.6%	-16.9%
Rural non-poor	793,400	-0.6%	-12.3%	-3.1%	-5.2%	-26.2%
Urban poor	25,357	-0.7%	-13.3%	-3.0%	-5.2%	-26.9%
Urban non-poor	657,493	-0.8%	-16.0%	-3.3%	-5.6%	-30.4%

Source: CGE model results

Table 8. Average propensity to save of selected non-governmental institutions

	Base	Food	Oil	Fertilizer	Cotton	Joint price shocks
Rural poor	3.7%	3.7%	3.2%	3.5%	3.2%	1.6%
Rural non-poor	5.1%	5.1%	4.5%	4.9%	4.5%	2.2%
Urban poor	9.2%	9.2%	8.0%	8.8%	8.0%	4.0%
Urban non-poor	21.1%	21.1%	18.3%	20.0%	18.4%	9.1%

Source: CGE model results

One would expect that the increase in the domestic value of foreign savings reduce the government savings $GSAV$. However, no room for downward adjustments of $GSAV$ is left, as the currency devaluation increases also the amount of foreign transfers to government in local currency (table 9, first row). Given the importance of foreign transfers in the government balance (they amount to almost 45% of the government income), this countervails the reduction of income taxes. This leads, together with increases in the export and import taxes to an increase of $GSAV$ (reduces the deficit, table 8, last row). Note that the increase of $GSAV$, is also supported by a reduction of the government expenditure for consumption (the expenditure for services to households reduces by slightly less than 22% in the joint price change simulation). This decrease is due to a reduction in the relative prices of the two service commodities purchased by the government, as the government consumption is fixed in real terms (see the table A1 on price changes, in appendix).

Table 9. Government budget (% variation w.r.t. the base, unless otherwise stated)

	Base	Food	Oil	Fertilizer	Cotton	Joint
Transfers from ROW	160,368	-0.9%	5.5%	1.3%	12.3%	27.2%
Income taxes	61,345	-0.7%	-16.0%	-3.4%	-5.7%	-30.9%
Import taxes	37,890	-1.8%	43.7%	2.4%	0.6%	52.9%
Export taxes	276	-1.7%	9.2%	2.2%	22.9%	50.6%
Taxes on activities	3,611	0.1%	-10.5%	-3.0%	-2.8%	-20.2%
Taxes on commodities	99,737	-0.6%	-7.9%	-2.1%	0.2%	-12.8%
Total gov.t income (var %)	363,228	-0.9%	2.0%	-0.3%	4.6%	8.6%
Total gov.t income (M.Fcfa)	363,228	360,028	370,547	362,030	379,755	394,586
Services to enterprises	10,372	-0.9%	-16.0%	-3.4%	-4.7%	-30.2%
Services to households	388,121	-0.9%	-9.0%	-3.0%	-5.5%	-21.7%
Transfers to households	46,305	0.0%	0.0%	0.0%	0.0%	0.0%
Total gov.t. expenditure (var %)	444,798	-0.8%	-8.2%	-2.7%	-4.9%	-19.6%
Total expenditure (M.Fcfa)	444,798	441,177	408,330	432,944	422,822	357,461
Gov. savings var %(+/-)	- 81,570	-0.5%	-53.7%	-13.1%	-47.2%	-145.5%
Gov. savings (+/-) M.Fcfa	- 81,570	- 81,149	- 37,782	- 70,914	- 43,067	37,125

Source: CGE model results

6.2 Activity levels

The level of the different activities shifts under the various simulation scenarios (figure 7.5). International food price shocks slightly stimulate domestic agriculture, due to partial substitution of imported food with domestic produces, as well as domestic agro-industry. As the resource base (notably land and agricultural capital) constitutes a binding constraint, non food agriculture, specifically cotton grain and related cotton ginning activities, shrink (figure 7.5, simulation “Food”).

Oil price shocks have strong impacts on the import bill, due to the negligible possibilities to substitute imports with domestic energy products. This leads to a pressure on the balance of trade. However, under this scenario, the deficit of the balance of trade is exogenously fixed, therefore the adjustment on the foreign currency market occurs via an upward shift of the real exchange rate (see figure 7.4). This in turn leads to an increase of the exports of cotton, (+56%, figure 9, “Oil” simulation) which become more competitive. However this implies a diversion of the constrained resources (land and capital) from the other agricultural activities, generating a quite significant reduction of all the other agricultural and agro-industrial activities of -9% and -4% respectively. In spite of the significant increase of the cost of energy, largely used in the industrial sector, the upward shift of the exchange rate leads also to a 3% increase of the other industrial activities. This is due to import substitution of imported industrial items with domestically produced ones.

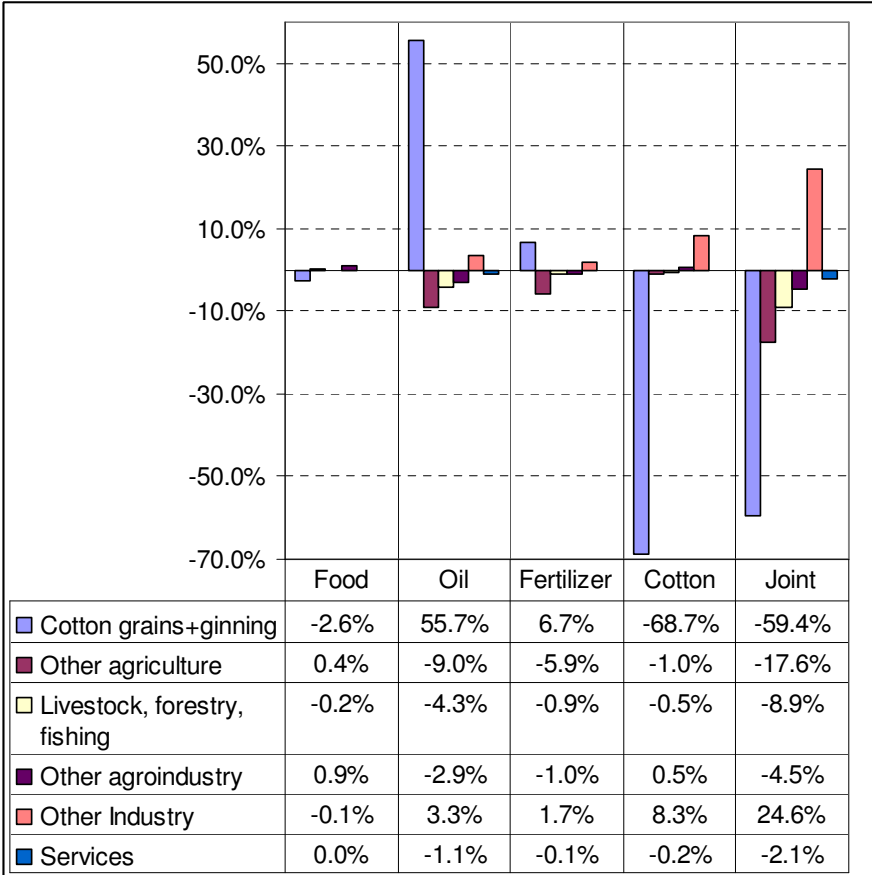
The price shock of fertilizers (figure 7.5, simulation “Fertilizers”) leads to quite similar impacts as the oil price shock, although their magnitude is less important. In spite of the fact that the cotton activity is one of the largest consumers of fertilizer, its activity level increases (+6.7%), due to the pressure on the external balance of trade, as cotton is also the largest export commodity. This in turn, leads to a reallocation of agricultural factors towards the cotton activity, leading to a reduction of all the other agricultural activities as well as the associated agro-industrial activities.

Regarding the impacts of the shrinking international cotton prices, as expected, this leads to a very large contraction of the cotton grain production and ginning activities (almost -70%, figure 7.5, simulation “Cotton”). The significant depreciation of the real exchange rate makes more competitive domestic industrial products vis à vis imported ones, thus leading to an increase of the activity level of the industrial sectors (+8).

When all the price shocks are jointly considered, the reduction of the cotton activity due to the reduction of cotton prices is only partially compensated by the stimulus received by the cotton sector due to the increased demand of foreign currency associated to the oil price rise. This leads to a substantial decrease of the cotton activity (around -60%), an overall contraction of agricultural activities (-18%) and livestock (-9%), justified by the downturn of the whole economic system, as well as to a significant increase of the industrial activities, due to import substitution.

While the separated impacts of shocks on the imports side (oil) and on the export side (cotton) do not generate substantial shrinking of the whole economic activity, the joint impacts international shocks generate a general slow down of all the economic activities (excluded the industrial ones which, however, account for less that 10% of the total output of the system).

Figure 7.5 Activity levels (percent changes w.r.t. the base)



Source: CGE model results. Aggregated activity levels measured at base prices. Detailed activity levels are reported in appendix.

Downward turns in most activity levels affect the effective demand of factors.

Table 10. Factor demands

	Base	Food	Oil	Fertilizer	Cotton	Joint
Agricultural labour	14,355	-0.4%	0.7%	-3.0%	-12.0%	-24.8%
Non-agricultural labour	308,282	0.0%	0.0%	0.0%	0.0%	0.0%
Family labour	301,027	-0.3%	-2.9%	-3.5%	-8.6%	-23.5%
Agricultural capital	169,155	0.0%	0.0%	0.0%	0.0%	0.0%
Non-agricultural capital	877,322	0.0%	0.0%	0.0%	0.0%	0.0%

Source: CGE model results.

6.3 Welfare impacts

The relative shift of one activity with respect to the others, as well as the general downturn of the whole economic activities have significant impacts on the income generation and distribution, as well as on relative prices of final consumption goods and services. Income and price variations, in turn, affect the level of welfare of the various layers of the population.

In order to highlight the distributional effects of the external shocks, an analysis of the Equivalent Variation (*EV*) of the expenditure for different household groups was carried out.

The Equivalent Variation (*EV*) of household expenditure, by type of household, is:

$$EV_h = (TotExp_{h,1} - SubsExp_{h,1}) \left(\frac{P_0}{P_1} \right) - (TotExp_{h,0} - SubsExp_{h,0})$$

where h is the index of the type of household, 0 and 1 are respectively the indexes referring to the benchmark case and the shock/policy scenario, $TotExp_{h,1}$ and $TotExp_{h,0}$ are respectively the total expenditure of the household for final consumption under the shock/policy scenario and in the benchmark case, $SubsExp_{h,1}$ and $SubsExp_{h,0}$ are the “subsistence” expenditures of the household, i.e. the minimum consumption required for survival, P_1 and P_0 are price indexes built as geometric means of prices using consumption shares of the different consumption goods as powers of prices⁴¹. Therefore, the *EV* is the difference between the “supernumerary” expenditure of each type of household, i.e. the expenditure in excess over the subsistence expenditure, in the policy scenario, and the supernumerary expenditure at the benchmark,; both expressed in monetary terms at the benchmark price level. In addition, the total *EV* is the sum of the *EV* across the household types. A percentage indicator *EVP* will also be worked out to compare the *EV* with the base total expenditure. Calling the “supernumerary” expenditure $SupExp_h = TotExp_h - SubsExp_h$ and dividing the *EV* by the total expenditure at the benchmark, the *EVP* results:

$$EVP_h = \frac{SupExp_{h,1} \left(\frac{P_0}{P_1} \right) - SupExp_{h,0}}{TotExp_{h,0}}$$

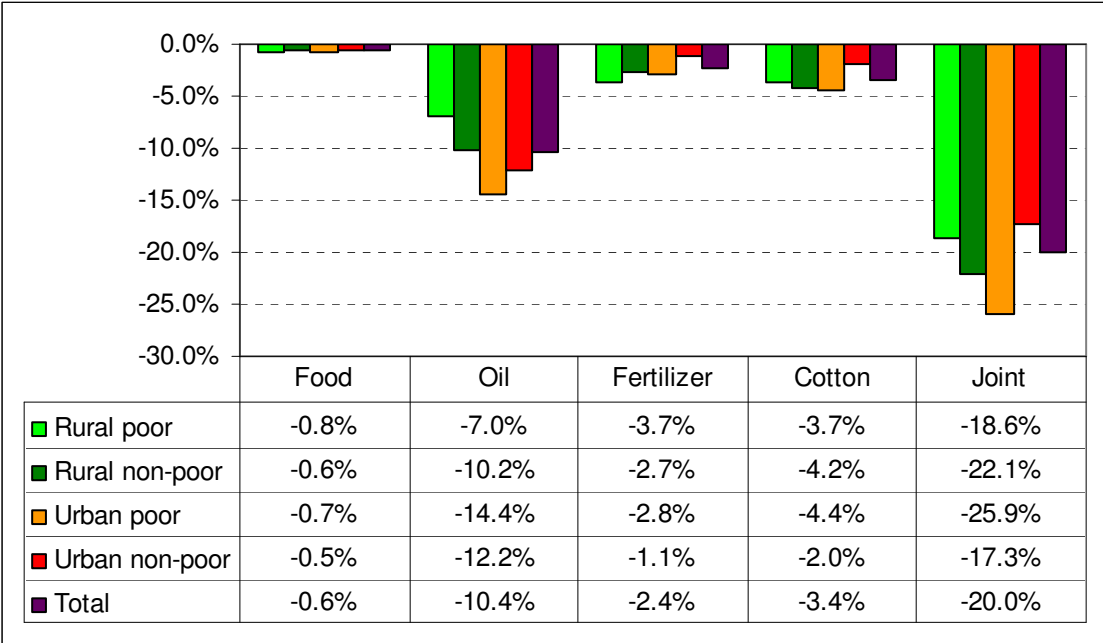
⁴¹ The *EV* can be interpreted as the variation of income of the household equivalent to the shock/policy change. More specifically, it is the minimum amount that the households are ready to accept as compensation if the policy change does not occur, in case of *EV* positive, (also referred to as minimum Willingness To Accept - min WTA) or the maximum amount that the households would be willing to give up to avoid the shock/policy change, in case of *EV* negative (referred also as maximum Willingness To Pay – max WTP to avoid the change). The model adopts formulas for *CV* and *EV* reported in: Blonigen, Bruce A., Joseph E. Flynn, and Kenneth A. Reinert (1997): Sector-Focused General Equilibrium Modelling, pp. 189-230 in eds. Joseph F. Francois and Kenneth A. Reinert, Applied Methods for Trade Policy Analysis. Cambridge, MA: Cambridge University Press.

To ease the direct comparison of the income changes of households with the base case, the Consumer Price Index (CPI) has been chosen as the numeraire of the system.

Results of the EV under different scenarios are reported in figure 7.6⁴².

As expected, all the shocks have negative welfare impacts on all the household groups. However, note that the impacts of the different shocks do not only differ in magnitude, but also on distributional grounds.

Figure 7.6 Impacts of price shocks on welfare (EV) of different household groups.



Source: CGE model results

While the shift in the international price of food items affects household welfare only marginally, oil price increases have a very strong impact on the welfare of all household categories (-10.4%) with negative impacts ranging from 7% to more than 14% respectively for rural and urban poor. This diversification in the magnitude of welfare impacts across the households depends on:

1. **Factor income variations:** the different income sources of the different household groups. Total non-agricultural wages fall more than agricultural wages and remuneration of family work (15.8%, 0.73% and 2.88/%, respectively) thus affecting more significantly the urban segment of the population (table 11)⁴³. Analogously, rents of non-agricultural capital also shrink more than rents of agricultural capital;
2. **Domestic price changes and expenditure allocation.** Under the simulation with international oil price shift, the domestic price of energy products increases by around 116%. (see table A2 in appendix). In addition, table 4 shows different expenditure shares across household groups on energy (oil) intensive items: urban poor allocate more

⁴² Detailed tables are reported in appendix.

⁴³ Note that the factor income is the product of the quantity of each factor absorbed times the specific factor wage.

expenditure on energy products and transport than rural poor (9% and 1.9% against 6.7% and 1.4% respectively).

Table 11. Factor income by type of factor (FCFA for the base, and % change)

	Base	Food	Oil	Fertilizer	Cotton	Joint
Agricultural labour	14,355	-0.39%	0.73%	-3.00%	-11.95%	-24.80%
Non-agricultural labour	308,282	-0.89%	-15.83%	-3.20%	-6.93%	-32.41%
Family labour	301,027	-0.31%	-2.88%	-3.49%	-8.63%	-23.50%
Agricultural capital	169,155	-0.55%	-8.98%	-2.00%	-1.27%	-16.59%
Non-agricultural capital	877,322	-0.78%	-20.04%	-4.19%	-6.89%	-37.61%

Source: CGE model results

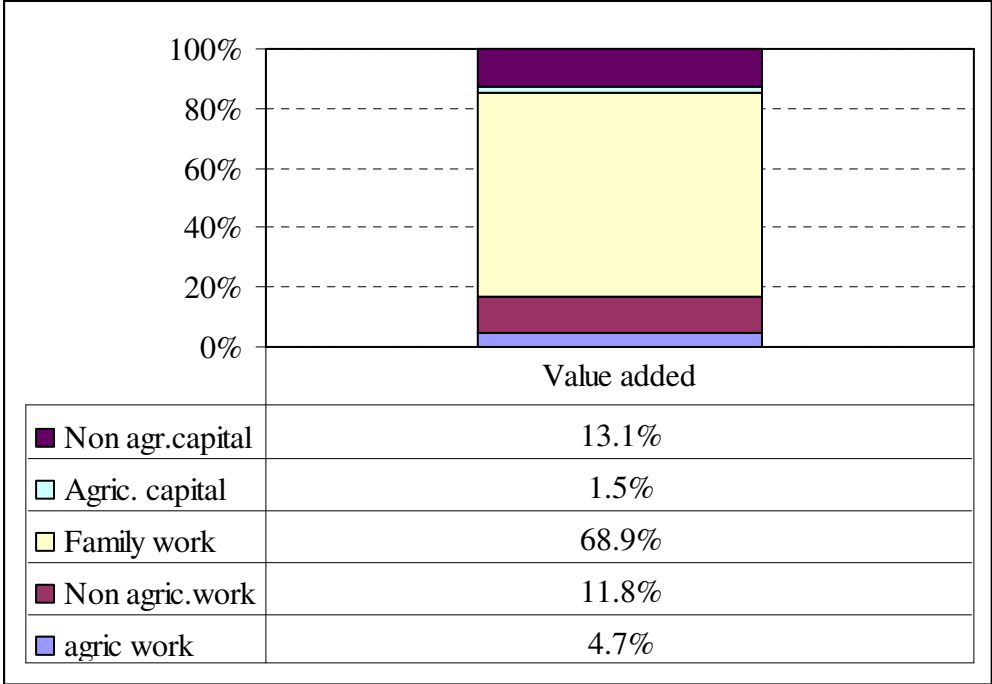
Regarding the shock on fertiliser's price, the magnitude of its impacts on welfare is lower than that of oil, affecting overall household expenditure by -2.4%. Nevertheless, it is not negligible, as it ranges from 1.1% for urban non-poor households to 3.7% for rural poor ones, shown to be particularly adverse to this layer of the population. Again, this can be explained by:

1. **Factor income variations:** the inspection of factor income variations highlights a negative impact (-3.5%) on family labour, by far the most used factor in agriculture.
2. **Domestic price changes and expenditure allocation:** the analysis of domestic price changes highlights that domestic prices of agricultural goods, and in particular, food crops and vegetables are more affected than other goods, with price increases ranging between 6.5% and 11% (see table A2). In addition, as reported in table 4, the expenditure of rural (and urban) poor concentrates on these items (44% and 30% respectively) proportionally more than the expenditure of rural and urban non-poor (25% and 16% respectively). That is why welfare impacts of the fertiliser's price increase are stronger on the poor layers of the population.

The welfare impact of the shock on cotton export price is stronger in magnitude than the shock on fertilisers (-3.4% overall). This affects in particular rural people and urban poor people. This impact can be explained considering the sharp reduction in the activity levels in the cotton value chain. Both primary production and ginning, other things being equal, shrink at around 70% (see table A4 in appendix). As shown in figure 7.7, the cotton value chain makes wide use of family labour (more than 67% of the value added is allocated to remunerate this factor) and to a lesser extent of non agricultural capital⁴⁴. It is mainly through these factor channels that the reduction in the cotton value chain output affects welfare.

⁴⁴ The larger impact on urban poor could be due to the fact that more than 50% of their income is represented by the remuneration of non-agricultural capital services (micro-enterprise, self employed income).

Figure 7.7 Value added repartition in the cotton value chain (% of total value added)



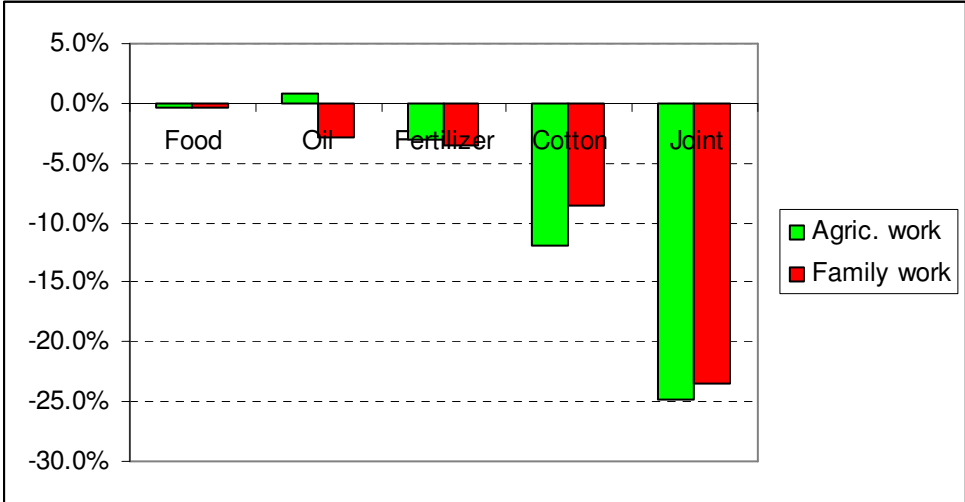
Source: SAM year 2000 Burkina Faso

The joint welfare effects of the different international price shocks amount to -20%, affecting in particular urban poor (-25.9%) and rural segments (-22.1% rural non-poor and 18.6% rural poor population). The rural poor households are shown to be, to some extent, more resilient to external shocks than urban poor ones, probably due to their lower degree of integration with the economic system, in particular through the energy sector, and the possibility of adjusting their income sources by shifting their cropping patterns to some extent.

Beyond price, income and expenditure impacts, all directly affecting the welfare of households, it is important to look at the way international price shocks affect factor uses. Figure 7.8 reports shifts in the use of agricultural (wage) work and family work⁴⁵. Note that all the price shocks have negative impacts on employment, particularly strong for fertiliser and cotton price shocks. The joint effect amounts to a loss of around 25% of job units for these factors, generating significant further unemployment in a context already characterised by few job opportunities.

⁴⁵ Note that agricultural (wage) work and family labour are the only factors assumed to be flexible, i.e. showing unemployment at the base case. The assumptions of full employment of non-agricultural work, agricultural and non agricultural capital imply no changes in the use of these factors.

Figure 7.8 Factor use (% changes) under different international price shocks scenarios.



Source: CGE model results

The analysis of international price shocks reported above highlights the importance of decoupling income generating activities, specifically of the poorer layers of the population, from international price fluctuations, in particular energy and fertilisers. This implies, among other things, the adoption of policy measures favouring less energy intensive technologies and the exploitation of comparative advantages in domestic energy and fertiliser production.

6.4 Alternative macro-economic and factor-market closures

The above-reported macro closures (i.e. flexible government savings with fixed real government consumption, flexible exchange rate, and fixed investment in real terms), associated to unemployment of agricultural and family labour, have been chosen with the aim of highlighting the welfare impacts of external shocks. Under these assumptions, the economic system adjusts to following this likely path:

1. Shifts of international prices (expressed in foreign currency) *PWE* and *PWM* alter the external balance.
2. Imported and exported quantities *QE* and *QM* have to adjust. Changes of relative prices of exported and imported goods respectively : PE/PD and PM/PD occur due to shifts of the exchange rate *EXR* which alter $PE=PWE*EXR$ and $PM=PWM*EXR$.
3. QD/QM and QD/QE adjust and shift activity levels and factor demands *QF* or wages.
4. Factor income $YF=WF*QF$ adjusts via changes of *QF* (for agricultural and family labour) or *WF* (for non-agricultural labour and capital).
5. Household income *Y* adjusts via changes of factor income, leading to changes in household demands.
6. *EXR* shifts both *FSAV* in S-I and *FTRANSF* in government balance account and, as a consequence, the government savings *GSAV* adjust.
7. *MPS* adjusts to restore the S-I balance and the domestic prices *PQ* further adjust.
8. The other government income *OTHIG* adjusts to satisfy the government balance.

An alternative closure for the family-labour market has been also tested, associated to an alternative closure of the Savings-Investment balance. The following assumptions have been chosen as alternative closure rules:

1. The Family labour wage WF is made flexible (keeping flexible also the supply of labour);
2. The propensity to save MPS is fixed (see the modified S-I balance, equation 6.8a below).

This closure mimics a “Keynesian”-type closure, where external shocks, affecting the saving-investment balance, are absorbed by a passive adaptation of savings not generated by adjustments of the propensities to save but by changes in output and incomes.

Note that it is assumed that the agricultural and family labour market is demand-led, in the sense that the supply adjusts to factor demand. This implies that labour is available in any quantity at the prevailing market wage. However, the prevailing market wage, for any quantity of labour, still corresponds to the marginal value product of the specific quantity of labour employed. This is assured by the fact that any equilibrium point, i.e. any combination of wage-quantity lies on the factor demand schedule.

Changing assumptions regarding the way factor markets work and the way savings adjust to exogenous investment shifts is likely to alter the transmission mechanism through which shifts in international prices reflect on the economic system.

Under this closure the economic system is likely to adjust to following this path:

1. Shifts of international prices (expressed in foreign currency) PWE and PWM alter the external balance.
2. Imported and exported quantities QE and QM have to adjust. Changes of relative prices of exported and imported goods respectively : PE/PD and PM/PD occur due to shifts of the exchange rate EXR which alter $PE=PWE*EXR$ and $PM=PWM*EXR$.
3. QD/QM and QD/QE adjust and shift activity levels and factor demands QF or wages.
4. Factor income $YF=WF*QF$ adjusts via changes of BOTH QF AND WF . The possibility to lower WF enables the entrepreneurs to hire more labour with respect to the case where WF is fixed.
5. Household income Y adjusts via changes of factor income, leading to changes in household demands.
6. EXR shifts both $FSAV$ in S-I and $FTRANSF$ in government balance account and, as a consequence, the government savings $GSAV$ adjust.
7. MPS is fixed, so the Saving–Investment balance (S-I) is restored through changes of income YI .
8. The other government income $OTHIG$ adjusts to satisfy the government balance.

As a further alternative, it is of interest testing a “minimum-wage” or “Lower-bounded” labour wage closure. This implies imposing a lower bound on the family labour wage in order to ensure that the wage does not fall below a given “subsistence” level for rural households. Negative external shocks reduce the level of domestic prices with respect to foreign ones. Producers reduce their production costs by lowering the remuneration of factors, including labour. When the family-labour wage reaches the lower bound, other variables in the system have to bear the cost of the adjustment. A simulation is run where foreign transfers to the government, which were modelled as exogenous in the other simulations, are endogenized. Adjustments of foreign transfers would allow the system to fill the competitiveness gap generated when the wage is not allowed to reduce below its lower bound.

To endogenize the foreign transfers when the lower bound for the family labour wage is reached, an endogenous multiplier of the base foreign transfers (variable $LAMBDA$) was created. This implies allowing for a conditional “solve statement” in the solution of the

model, where the equation fixing the wage level at its lower bound operates only if this lower bound is actually binding under the new equilibrium. When this occurs the equation fixing the wage at its lower bound replaces the equation fixing the multiplier of foreign transfers (variable *LAMBDA*) at its benchmark value (say, the unity). The macro-economic closures after this modification result as follows:

External balance:

$$QE \cdot \overline{PWE} - QM \cdot \overline{PWM} = \overline{tr(ROW, F)} - \overline{tr(F, ROW)} - LAMBDA \cdot \overline{FTRANSF} - \overline{FSAV} \quad (6.7a)$$

S-I balance:

$$YI \cdot (1 - \overline{TINS}) \cdot \overline{MPS} + \overline{GSAV} + \overline{FSAV} \cdot \overline{EXR} = \overline{QINV} \cdot \overline{PQ} \quad (6.8a)$$

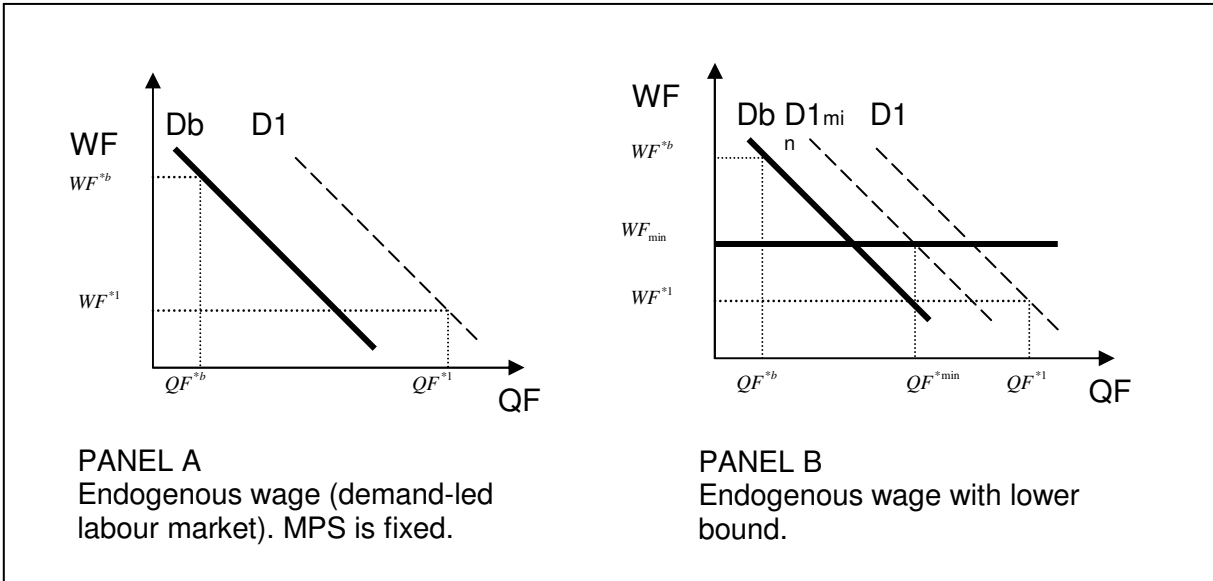
Government balance:

$$\overline{TINS} \cdot YI + LAMBDA \cdot \overline{FTRANSF} \cdot \overline{EXR} + \overline{OTHIG} = \overline{QG} \cdot \overline{PQ} + \overline{Transf} \cdot \overline{CPI} + \overline{GSAV} \quad (6.9a)$$

Note that, when *LAMBDA* is endogenized, the trade balance is no longer exogenous, as it occurred under equation (6.7), as the component $LAMBDA \cdot \overline{FTRANSF}$ on the right hand side of equation (6.7a) is simultaneously determined together with the endogenous components of the left hand side of the same equation, say, the quantities *QE* and *QM*. Endogenizing the trade balance (in foreign currency) is expected to have also an impact on the exchange rate, which is no longer the only variable bearing the burden of adjusting the external balance by shifting the ratio of foreign to domestic prices. In addition, impacts on the structure of the government account, specifically on the income side are expected, as $LAMBDA \cdot \overline{FTRANSF}$ enters as an income component on the left hand side of equation (6.9a).

Figure 8.1 represents the assumptions related to of the family labour factor under these alternative closures.

Figure 8.1 Alternative factor closures for the family-labour market.



In figure 8.1, panel A, the endogenous wage *WF* is still determined by its marginal value product (represented as a point along the factor demand schedule) as in the case of figure 7.2,

but the actual level of labour supplied and its related wage level is determined by other factors within the economic system, such as the activity levels, the income level required to generate the savings to satisfy the saving-investment balance as well as the government balance. In panel B, a lower bound WF_{min} is imposed. A shift of the labour demand schedule due to exogenous shocks (simulations), in absence of a lower bound on the wage would determine a wage WF^*I and a quantity demanded. However, in presence of a lower bound, a quantity WF^*min is determined, corresponding to the wage level WF_{min} . It has to be noted however, that, even in presence of a lower-bounded wage, the equality of the wage level to its marginal value product is still assured, as the lower-bounded equilibrium of the factor market lies on the factor demand schedule $D1min$.

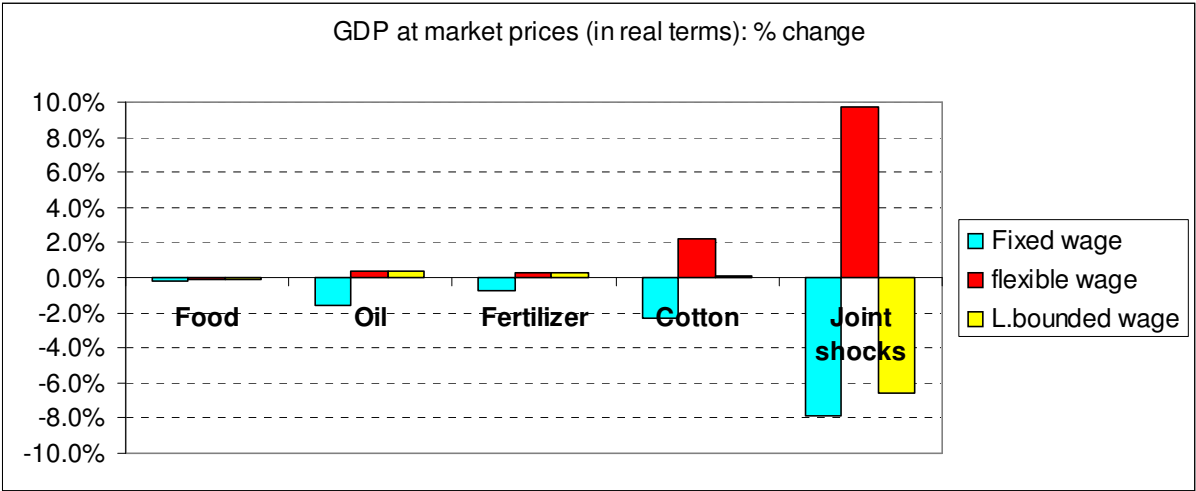
6.5 Simulations under alternative macro-economic and factor-market closures

The same international price shocks simulations reported in section 7 were run under the alternative factor market closures illustrated in figure 8.1 panels A and B.

When running the set of simulations with flexible Lower-bounded family labour wage, shocks on prices of food, oil, and fertilizer don't lead reductions of the wage below the lower bound, i.e. the lower bound wage is non-binding. This implies that for these shocks the results obtained imposing a lower-bound to the family-labour wage are the same as the results of the simulations with unbounded flexible wages. For simulations on cotton price and joint prices shocks the lower bound becomes binding. In these cases the wage is set at the lower bound and foreign transfers adjust to achieve the equilibrium of all the markets.

For all the simulated price shocks, the flexibility of family-labour wage allows the system to expand. Figure 8.2 reports the GDP in real terms (at base prices) for the various simulations under the three wage-regimes. While with fixed family-labour wage GDP substantially shrinks, the opposite occurs with flexible family labour wage. This is particularly evident for the cotton price and the joint price shocks simulations, where the GDP shifts from -2% to +2% and -8% to almost +10% respectively. Under the lower-bounded wage regime the differences with the fixed-wage regime are definitely less important (from -2% to 0.1% and from -8% to -6% for cotton and joint shocks respectively).

Figure 8.2 GDP at constant prices with fixed, flexible and lower bounded family labour wage.



The comparison between the GDP components with fixed wage (table 12 panel A), and the GDP components with flexible wage (table 12 panel B) shows significant differences in the total absorption (row a). While fixed wages lead to important negative changes of the absorption, flexible wages lead to almost zero or positive shifts for most simulations (except the oil price shock which implies a substantial negative change in absorption under both wage regimes). Differences in the changes of total absorption under the two wage regimes are due to important differences in the shifts of the private consumption component, as both the government and investment components are anchored to the base case in real terms (fixed quantities) by assumption (see the macro-economic closure rules above). Under the fixed-wage regime the private consumption (row b) substantially shrinks due to price shocks, down to a -19% for the “joint price” simulation, while under the flexible-wage regime the private consumption remains closer to the base case (except for the oil price simulation) and even increases for the “cotton” and “joint prices” simulations. This difference is due to the fact that with flexible wage, more labour is absorbed by the economic system at a lower cost, allowing to maintain the competitiveness of the system and expanding the GDP even in presence of worsening international prices.

Under the lower-bounded wage regime, for the cotton price simulation, the absorption, as well as the private consumption fall less than under the fixed wage regime. Conversely, for the “joint price” shocks simulation, the absorption falls more than under the fixed wage regime, and the flexible unbounded wage regime (table 12, panel C, row a), negatively affecting private consumption (panel C, row b).

Variations of the GDP at base prices are also due to variations in physical terms of imports and exports. Shocks on import prices (oil and fertilizers) stimulate exports and depress imports. Shocks on export prices (cotton) as well as joint price shocks depress both exports and imports. In all cases these shocks lead to a reduction of the net imports measured at base domestic prices, particularly strong with lower bounded wages for the simulation “Joint price”.

Figure 8.2a reports percentage variations of main import and export commodities for the various price shocks under the different wage regimes.

Upward price shocks on imports (food, oil and fertilizers) reduce quantities of imported items and increase quantities of exported items. This is due to the fact that: 1) there is limited substitutability of imported items with domestically produced ones; 2) the trade balance is constrained as the foreign savings are fixed in foreign currency, implying that any increase in the import bill in foreign currency has to be compensated by increases in export incomes. Point 1) above however does not hold for the simulation on food prices as food items exhibit a higher elasticity of substitution with domestically produced food than other commodities. Under this simulation, there is a slight increase of fertilizer imports, due to the expansion of selected domestic agricultural activities producing food items and a slight decrease of the exports of cotton, due to the shifts of factors from the cotton to the food sectors. Downward shifts of imported commodities and upward shifts of exported ones are stronger with flexible wages rather than fixed wages, signaling a greater capacity of the economic system to react to external shocks and restore its relative competitiveness thanks to the possibility to lower wages and inject additional factors to sustain the output.

Table 12. GDP components in real terms (at base prices). Simulations with fixed, flexible and lower-bounded family-labour wage*

A. Fixed family-labour wage

		Base	Food	Oil	Fertilizer	Cotton	Joint shocks
		Million FCFA	% variation w.r.t.the base				
a=b+c+d	Total Absorbption	2,119,964	-0.4%	-6.6%	-1.6%	-2.3%	-12.9%
b	Private consumption	1,441,816	-0.6%	-9.8%	-2.4%	-3.4%	-19.0%
c	Investment	279,655	0.0%	0.0%	0.0%	0.0%	0.0%
d	Government cons.	398,493	0.0%	0.0%	0.0%	0.0%	0.0%
e	Exports	149,849	-1.5%	32.3%	3.9%	-29.7%	-11.4%
f	Imports	458,157	-1.7%	-13.8%	-3.2%	-11.0%	-32.7%
g=e-f	Trade balance**	- 308,308	1.8%	36.2%	6.6%	1.9%	43.0%
g=a+g	GDP at market prices	1,811,656	-0.2%	-1.6%	-0.8%	-2.3%	-7.8%

B. Flexible family-labour wage

		Base	Food	Oil	Fertilizer	Cotton	Joint shocks
		Million FCFA	% variation w.r.t.the base				
a=b+c+d	Total Absorbption	2,119,964	-0.3%	-5.0%	-0.8%	1.3%	0.5%
b	Private consumption	1,441,816	-0.5%	-7.4%	-1.1%	2.0%	0.7%
c	Investment	279,655	0.0%	0.0%	0.0%	0.0%	0.0%
d	Government cons.	398,493	0.0%	0.0%	0.0%	0.0%	0.0%
e	Exports	149,849	-0.9%	46.3%	11.3%	-10.7%	71.5%
f	Imports	458,157	-1.5%	-9.5%	-0.9%	-6.0%	-13.0%
g=e-f	Trade Balance**	- 308,308	1.8%	36.6%	6.9%	3.6%	54.1%
h=a+g	GDP at market prices	1,811,656	-0.1%	0.3%	0.3%	2.2%	9.7%

C. Lower bounded family-labour wage

		Base	Food	Oil	Fertilizer	Cotton	Joint shocks
		Million FCFA	% variation w.r.t.the base				
a=b+c+d	Total Absorbption	2,119,964	-0.3%	-5.0%	-0.8%	-1.3%	-16.3%
b	Private consumption	1,441,816	-0.5%	-7.4%	-1.1%	-1.9%	-24.0%
c	Investment	279,655	0.0%	0.0%	0.0%	0.0%	0.0%
d	Government cons.	398,493	0.0%	0.0%	0.0%	0.0%	0.0%
e	Exports	149,849	-0.9%	46.3%	11.3%	-14.7%	41.8%
f	Imports	458,157	-1.5%	-9.5%	-0.9%	-10.9%	-35.7%
g=e-f	Trade balance**	- 308,308	1.8%	36.6%	6.9%	9.1%	73.3%
g=a+g	GDP at market prices	1,811,656	-0.1%	0.3%	0.3%	0.1%	-6.6%

* Variations of GDP and GDP components are rates of change calculated on the Laspeyres index of physical quantities (volumes) weighted with base prices.

** Variations of the trade balance at domestic base prices (rows g in the tables above) are calculated on the absolute value of the trade balance at the base. This implies that positive variations signal either a reduction of the deficit measured at domestic base prices (as in all the cases above) or an increase of the surplus.

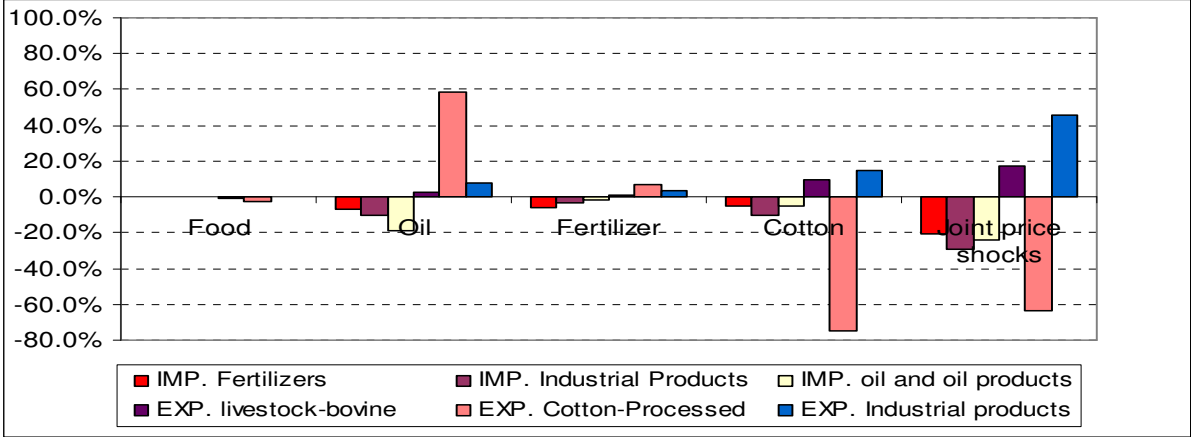
Downward price shocks on exports, (cotton), sharply reduce the export of cotton and, by way of consequence, limit the possibility to import (figure 8.2a, simulations “Cotton”). Conversely, other exports are stimulated, such as the livestock-bovine products and the industrial ones.

When simulating the impact of cotton price reductions under the flexible-wage regime, as in the case of import shocks, the system shows a greater capacity to adsorb the shock than with fixed wages: cotton exports reduce less than in the fixed wage case (-53% with respect to -75% respectively) and the other export sectors expand more, in particular the livestock-bovine sector (+66% with respect to +10% respectively). The sharp expansion of this sector pulls also up the imports of fertilizers (+16%), which showed a negative sign (-5%) under the fixed wage regime.

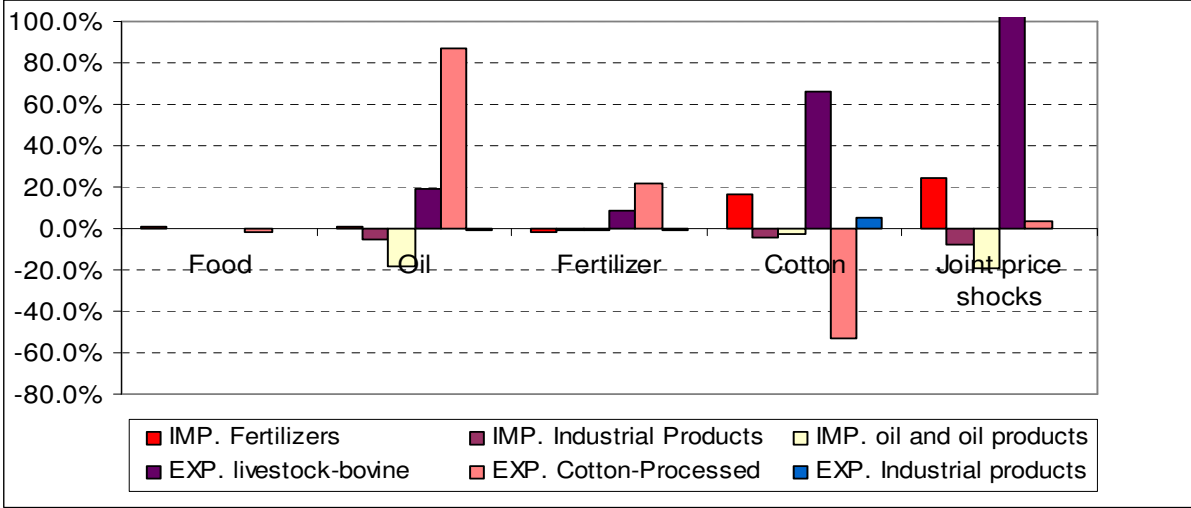
Under the flexible lower-bounded wage regime, the differences with the fixed wage regime are slightly less pronounced than in absence of the lower bound.

Figure 8.2a Variation of main import and export commodities. Simulations with fixed, flexible and lower-bounded family-labour wage.

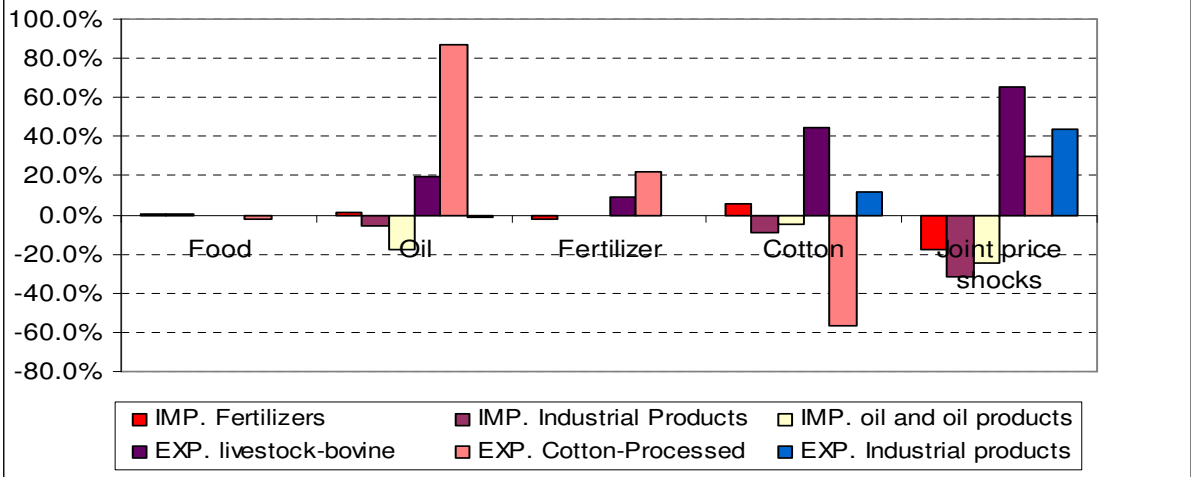
A. Fixed family-labour wage



B. Flexible family-labour wage



C. Lower bounded family-labour wage



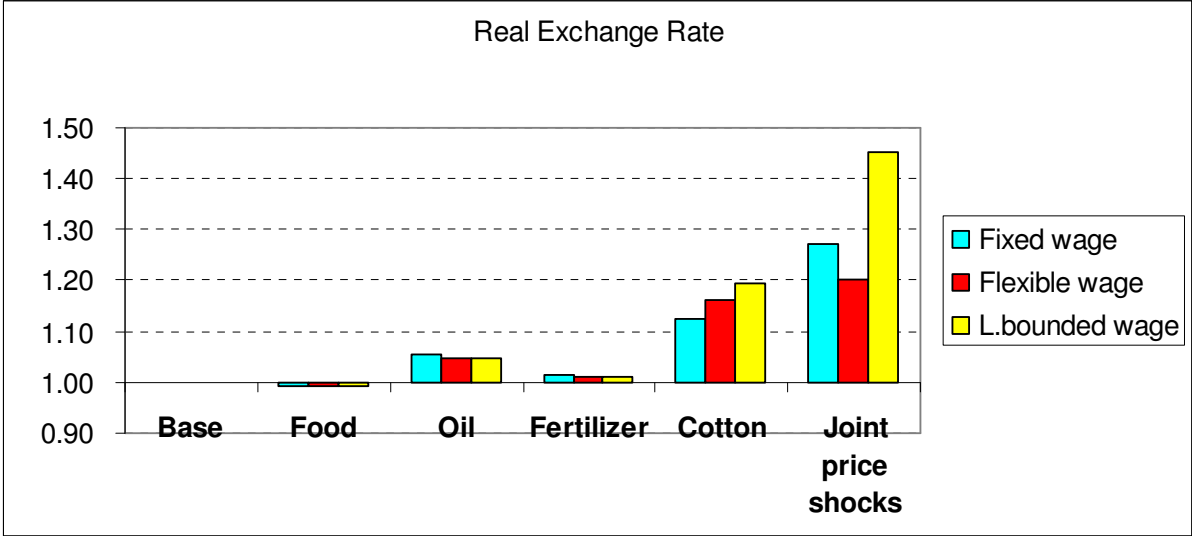
The “Joint price shocks” simulation shows different pictures depending on the different wage regimes. With fixed wage, all the main import items (oil, fertilizers and industrial products) shrink (between -20% and -25%), cotton exports significantly drop (-64%). On the other hand, the agents shift factors from the cotton to the livestock sector as this becomes relatively more competitive. In addition also the export of industrial products significantly increases (+17% and +45% respectively) (figure 8.2a panel A, “Joint price shocks”).

With flexible labour wage, the economic system adjusts to shocks quite differently. Cotton exports in physical terms remain substantially unchanged, as labour wage reductions absorb the negative impacts of the international price downturn. In addition, the increased absorption of labour at a reduced wage generates the drastic expansion of the livestock sector (+632%), which in turn pulls also the increase of imports of fertilizers and pesticides (+22%).

The lower-bounded wage regime generates a more “balanced” adjustment on the export side, as all the three main export commodities (cotton, livestock and industrial products) expand at rates between 30% and 66%, while all the main import products (oil, fertilizers and industrial products) reduce at rates between -17% and -32%.

All the price shocks under any wage regime, except the increase of food prices, imply a currency devaluation in real terms, as shown in figure 8.3. While at the base one unit of foreign currency costs one unit of the composite basket of consumer goods (the CPI index, which is the numeraire), under the different scenarios one unit of foreign currency costs more than one unit of the composite consumer good basket. On the one hand, through the devaluation of the domestic currency, which implies a reduction of the general level of domestic prices including the factor wages, with respect to foreign ones, the economic system restores its relative competitiveness towards the international markets, allowing the country to keep exporting. On the other hand, the reduced purchasing power allows for a reduction of imports, thus enabling the economic system to respect the constraint on the balance of trade. A comparison of the different wage regimes highlights that a larger devaluation occurs the cotton price simulation under the flexible wage regime (1.15) and an even larger when the lower bound applies (1.19). Under the flexible wage regime this is probably due to the higher pressure on imports coming from increased private consumption (+2%). Furthermore, when the lower bound applies, further devaluation allows on one side, restoring the competitiveness of the system no longer achievable through further reductions of wages and, on the other side, achieving a new balance of trade in foreign currency, no longer exogenously fixed.

Figure 8.3. Real exchange rate for fixed, flexible and lower bounded family labour wage



The quantities of exports required to obtain the foreign currency necessary to buy the imports that the system requires, are based on the price of exports in terms of imports, the so called “**terms of trade**”, which tell how much the country can import per unit of export. Changes of international prices alter the terms of trade of the country, i.e., the quantity of import one unit of export can buy. Terms of trade indexes are calculated as the ratio between an index of international prices of exports and an index of international prices of imports. As imports and exports are bundles of goods, the change in price of each good alter the price of the bundle in relation to the magnitude of the change and the weight of the specific good in the bundle. Therefore simulated price shocks alter the terms of trade of the country, i.e. its “purchasing power” with respect to the rest of the world both through: 1) the exogenous changes in international prices; and 2) the endogenous changes in the composition of bundles of imported and exported goods.

If the price index of exports increase, other things equal, the terms of trade “improve”, i.e. the country can import more with the same quantity of exports, vice-versa if the price index of exports decreases. The opposite occurs if the price index of imports increases other things equal (worsening of the terms of trade), and, vice-versa, if the price index of imports decreases (improving terms of trade).

Two sets of indexes of the terms of trade have been calculated (see figure 8.3a). The first set of terms of trade indexes is based on the Laspeyres price indexes of exports and imports. The Laspeyres-based terms of trade indexes change through to the various price shock simulations, but are not sensitive to the different wage regimes, because the price changes are the same for all the wage regimes considered and the quantities used to weight the prices are those of the baseline:

Laspeyres-based $TT_{SB(L)}$ and Paasche-based terms of trade indexes $TT_{SB(L)}$ are respectively:

$$TT_{SB(L)} = \frac{\frac{\sum_{i=1}^e PWE_{S_i} QE_{B_i}}{\sum_{i=1}^e PWE_{B_i} QE_{B_i}}}{\frac{\sum_{j=1}^m PWM_{S_j} QM_{B_j}}{\sum_{j=1}^m PWM_{B_j} QM_{B_j}}}$$

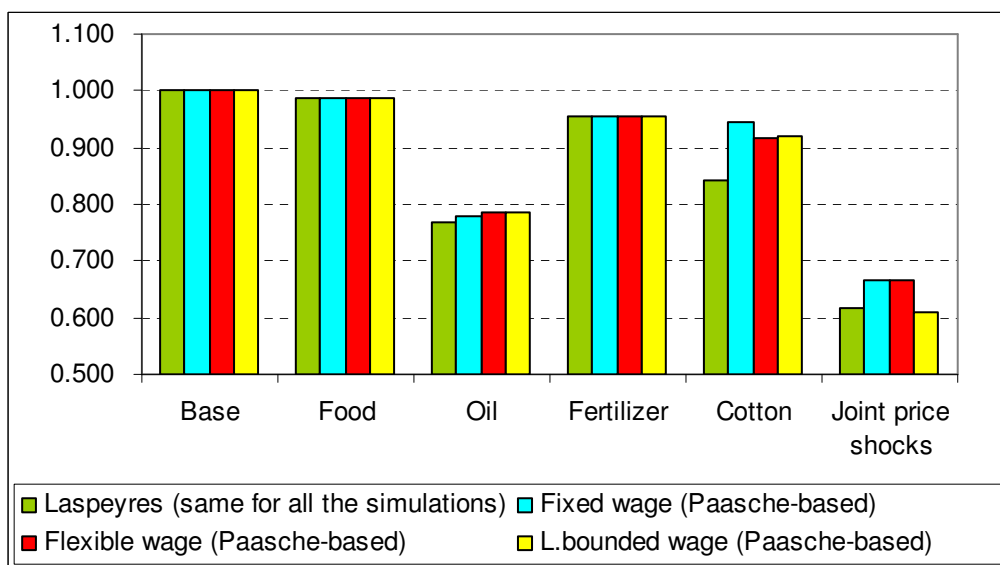
$$TT_{SB(P)} = \frac{\frac{\sum_{i=1}^e PWE_{S_i} QE_{S_i}}{\sum_{i=1}^e PWE_{B_i} QE_{S_i}}}{\frac{\sum_{j=1}^m PWM_{S_j} QM_{S_j}}{\sum_{j=1}^m PWM_{B_i} QM_{S_i}}}$$

Where: PWE and PWM are the international prices of imports and exports respectively; QE and QM are the quantities of exports and imports respectively; i and j are indices for the exported and imported commodities respectively; and S and B are indices referring to a given simulation and to the baseline respectively. The Laspeyre-based Terms of Trade index $TT_{SB(L)}$ is the same for all the wage regimes as under all the regimes the exogenous simulated price changes are the same and the weighting quantities are those of the baseline, thus not related to the specific simulations, while the Paasche-based Terms of Trade index changes under the different wage regimes as the weighting quantities are simulation-specific.

When the terms of trade worsen, more exports have to be devoted to import the same quantity of goods, reducing the quantities available for domestic absorption, other things equal. Therefore, an increase of GDP in real terms, associated to a degradation of the terms of trade, does not necessarily implies that the quantities of goods and services available to the country increase at the same rate.

The larger degradation of the terms of trade occurs for the Oil price shock and the Joint price shock simulations, under all the wage regimes (see figure 8.3a). That is why, for those simulations, there is a large divergence between the variations of the real GDP (moderately negative or slightly positive, depending on the different wage regimes) and the variation of the private consumption, strongly negative for both simulations under any wage regime (compare rows g and by in the panels A, B and C of table 12).

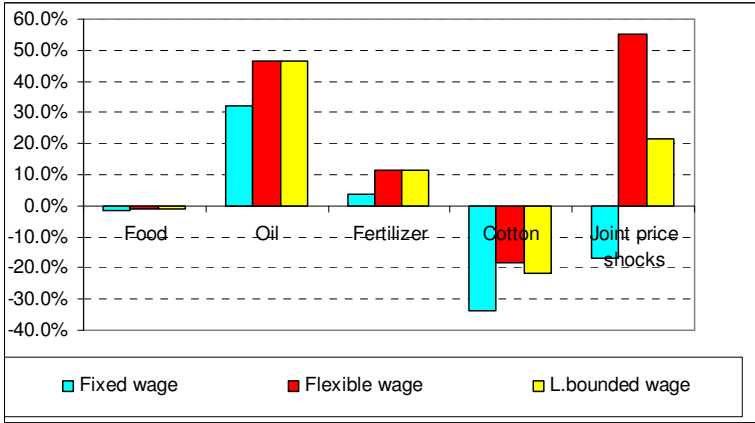
Figure 8.3a Terms of trade for fixed, flexible and lower bounded family labour wage



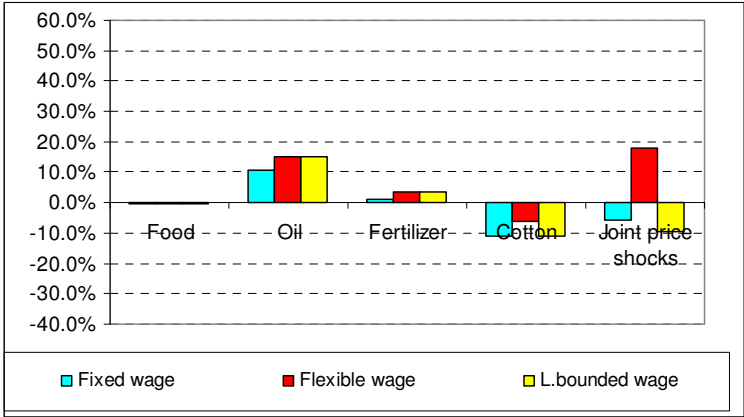
The variations of quantities of exports and imports affect the export income and the import bill in foreign currency. Upward shocks on import prices of oil and fertilizers raise the import bill under all the wage regimes (see figure 8.3 part B).

Figure 8.3b. Balance of trade: Export income, import bill and balance of trade in foreign currency.

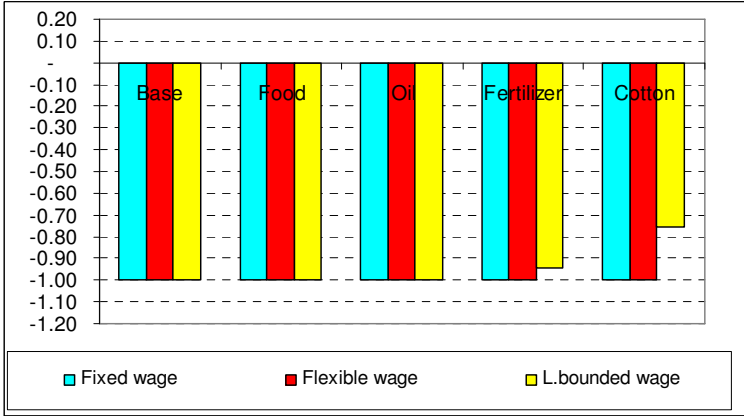
A. Export income in foreign currency (% variation with respect to the base)



B. Import bill in foreign currency (% variation with respect to the base)



C. Balance of trade in foreign currency (index: absolute value at base =1)

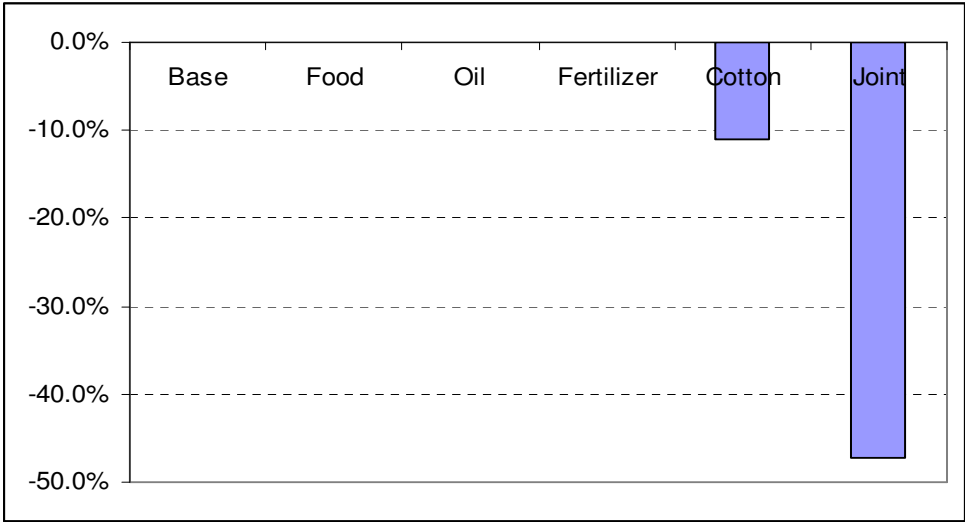


By way of consequence, due to the fact that the balance of trade in foreign currency is fixed (see figure 3, part C), also exports increase. Variations are stronger with flexible wages due to an overall expansion of the economic system under this wage regime.

Conversely, the shock of cotton price reduces both exports and imports. Reductions however are more contained under the flexible wage regime as the increased availability of labour and its reduced cost allows better reacting to the price shock. The lower bound on wages partially reduces this capacity of reaction. The Joint price shock has different impacts on imports and exports according to the wage regime. While with fixed wages imports and exports shrink, with flexible wages they significantly expand. Again, this is due to the possibility of the system to activate the export some commodities, e.g. livestock products (see figure 8.2a, panel B) otherwise not competitive.

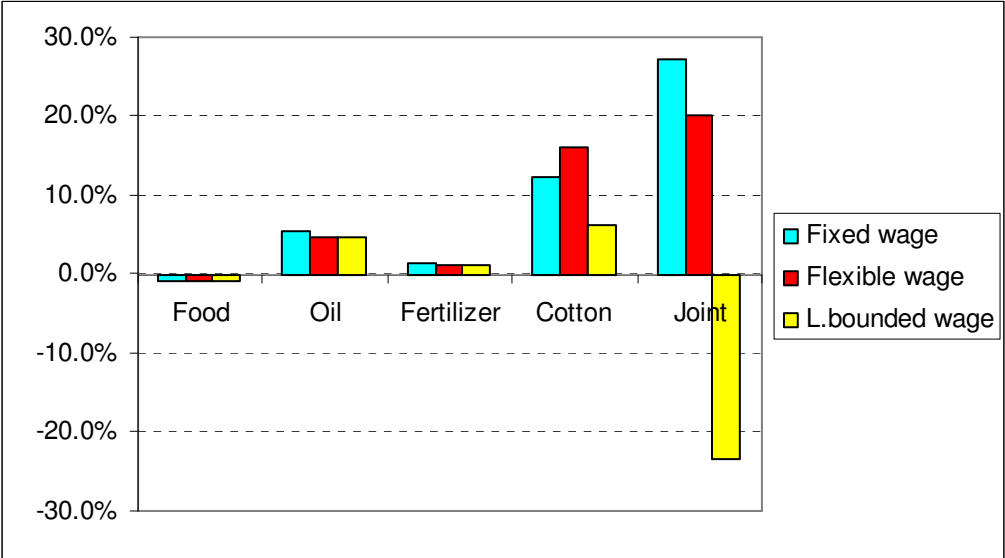
The issue of restoring the competitiveness of the economic system facing international price shocks can be better understood looking at the results of the simulations run under the lower bounded wage regime. Under this regime, not only the wages cannot fall below the 20% of their initial level, but the foreign transfers adapt to allow the system to respect this constraint. Therefore, to restore its competitiveness the system simultaneously adjusts the exchange rate and the required transfers from abroad to achieve the equilibrium of the current account. In addition, the exchange rate must be such that the net external trade be compatible with the level of output where the marginal value product of the family labour corresponds to the lower bound wage. When the lower bound applies, i.e. for the cotton and joint price simulations, the foreign transfers to the government budget have to reduce of more than 10% and almost 50% respectively in foreign currency (figure 8.3a). A reduced inflow of foreign currency leads to a stronger devaluation of the domestic currency than under both the fixed and flexible wage regimes (see figure 8.3). This devaluation allows the economic system to restore its competitiveness and even expand the traditional cotton export. Furthermore, it allows for the expansion of the exports of livestock and industrial products (see figure 8.2a, part C). Overall, the reduction of the foreign transfers to the government leads to an improvement of the balance of trade (say, a reduction of the trade deficit), particularly important for the joint price shock simulation (figure 8.3c, part C).

Figure 8.3c Transfers from ROW to the government budget in foreign currency: (% changes)



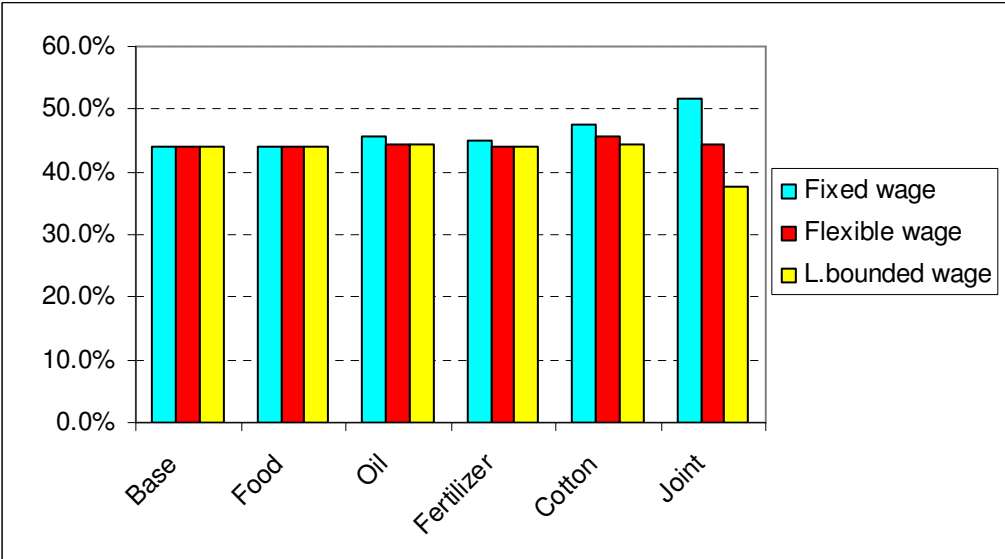
Foreign transfers in domestic currency (figure 8.3 d) for the cotton price simulation, increase in spite of their reduction in foreign currency, due to the increase of the exchange rate. However, for the Joint price simulation, the upward shift of the exchange rate is not large enough to countervail the sharp decrease of the foreign transfers, resulting in a drastic reduction of foreign transfers in domestic currency (-23%).

Figure 8.3d Transfers from ROW to the government budget (domestic currency)



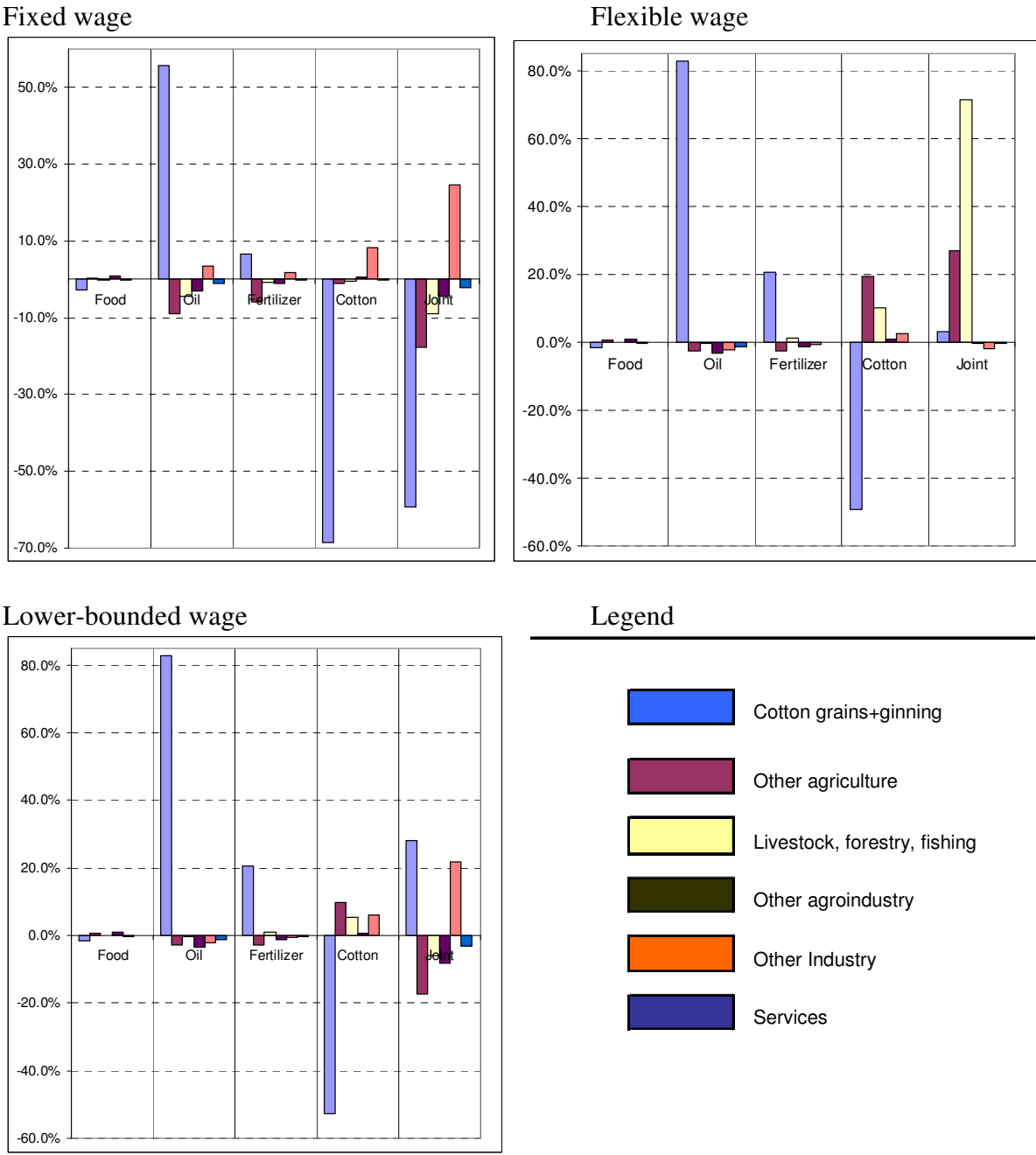
Downward shifts of foreign transfers in domestic currency modify the “dependency ratio” i.e. the share of the budget income funded by foreign agencies (figure 8.3e). This particularly applies to the Joint price simulation, for which, the dependency ratio reduces from 43% at the baseline to 38%.

Figure 8.3e Transfers from ROW to the government budget as % of budget income



The impacts of shifts of international prices on activity levels reflect to a good extent the changes in import and export commodities described above. Under all the wage regimes, the activity level of cotton (grain production and ginning) increases for the upward Oil and Fertilizers price simulations and decreases for the downward cotton price simulation (figure 8.3f). However, the wage regime strongly affects the activity level of cotton for the Joint price shock simulation. With fixed wages, the cotton activity shows a -60% reduction. With flexible and lower bounded wages it increases of 3% and 28% respectively. The significant growth of the cotton activity under the lower bounded wage is due to the fact that the system restores his competitiveness in the main export commodity, not necessarily through the lowering of wages only, but through a reduced inflow of foreign currency.

Figure 8.3f. Activity levels: % changes with different family-labour wage regimes



Source: General equilibrium model results

Reduced foreign transfers to the government allows for a devaluation of the domestic currency in real terms, i.e. a general reduction of the level of domestic prices (including the remuneration of all the factors) with respect to the international prices. The significant inflow of foreign currency due to foreign transfers appears in this context as a deterrent to the development of the external competitiveness of the production sectors of the country. It appears here that foreign transfers generate a sort of “Dutch-Disease”⁴⁶ effect, sustaining an exchange rate which does not allow export sectors to afford reduced export prices.

The sign and magnitude of foreign transfers (aid) to the export potential of a less industrialized country is a debated issue. For example, Sundberg and Lofgren (2005), on the basis of a model for Ethiopia find a strong relationship between the increase of aid and the fall of exports. However IMF (2007) reports that, specifically for Burkina Faso, the “Dutch Disease” related to aid absorption is not an issue⁴⁷. Barder (2006), after reviewing some literature on this issue, argues that foreign transfers (aid), and even aid increases may not be detrimental to the welfare of a country in the long run provided that; 1) it is channelled towards increasing productivity; 2) its impact on exports is marginal; and 3) finance public or private consumption⁴⁸. By reversing these considerations, it can be inferred that aid reductions may be detrimental in the following cases: 1) they reduce the potential of the country to increase its productivity; 2) don’t have a beneficial effect on exports; and 3) reduce the potential for private consumption.

The cases above however don’t apply to the specific situation under investigation. The significant reduction of foreign transfers resulting from the adjustment of the system to joint price shocks under the lower bounded wage regime is not expected to have negative impacts on the productivity of the country as both investment and government consumption are fixed in real terms. In addition, the reduction of transfers has a positive impact on net exports, as the balance of trade improves. The only drawback of the reduction of foreign transfers is the larger reduction on the private consumption (-24%), compared with the one under the other two wage regimes (compare row b of panel C in table 12, with row b in panel A or B). Despite the fact that it does not look reasonable supporting the idea that medium long term aid is not detrimental only because it allows an economic system consuming more than it would be able to do without aid, a further investigation on private consumption, income expenditure and welfare is required to highlight the welfare impacts of the various price shocks under different wage regimes.

The aggregate changes of private consumption reflect diversified changes in welfare levels enjoyed by the different groups of households. The equivalent variation, i.e. the amount of money that households would be willing to give up to avoid the price shocks measured as percentage of the consumption expenditure at the benchmark, highlights that, overall, under the flexible wage regime, the negative impacts of shocks are more limited than under the fixed wage and the lower bounded regimes (Figure 8.4 panel B, compared with panel A and

⁴⁶ The Economist (1977). “The Dutch Disease”, November 26, 1977. pp. 82-83.

⁴⁷ IMF (2007). The IMF and Aid to Sub-Saharan Africa. Evaluation report, p.48. Independent Evaluation Office of the IMF. Washington D.C. USA

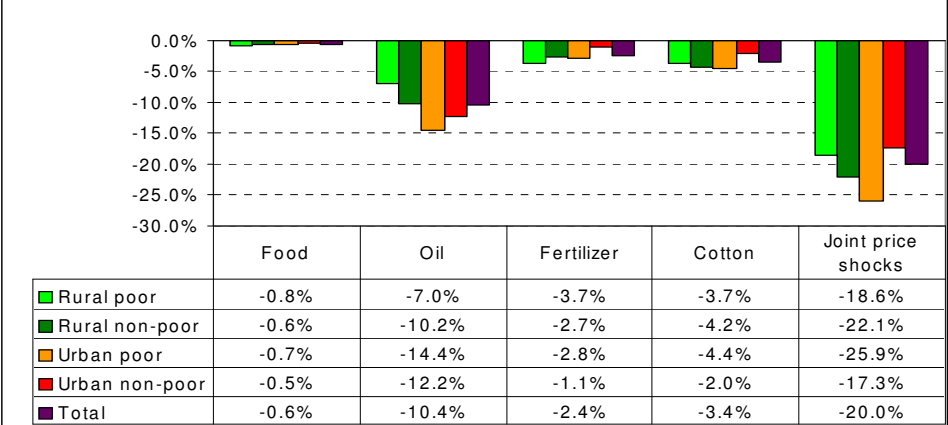
⁴⁸ Sundberg, M, and Lofgren, H. (2005). Absorptive capacity and achieving the MDGs: The case of Ethiopia. In Peter Isard, Leslie Lipschitz, Alexandros Mourmouras, and Peter Heller (eds). *Macroeconomic Management of Foreign Aid: Opportunities and Pitfalls*. International Monetary Fund, Washington, DC.

Barder, O. (2006) A Policymakers’ Guide to Dutch Disease. Working Paper Number 91 July 2006. Center for Global Development. London

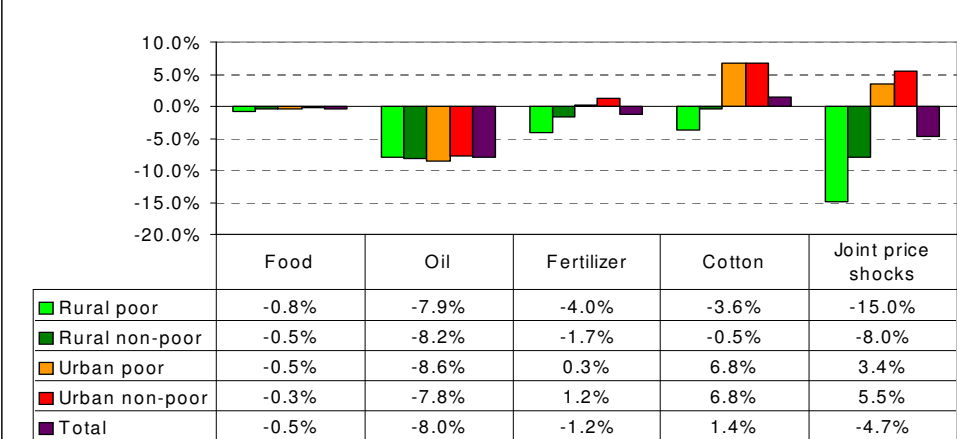
C). The Equivalent Variation is the result of a joint variation of price changes and nominal expenditure. Figure 8.4a reports the Laspeyres consumer price index and the nominal expenditure percentage changes by wage regimes. A detailed interpretation of the EV under the different wage regimes is provided here below.

Figure 8.4 Equivalent Variation with fixed, flexible, lower-bounded family labour wage

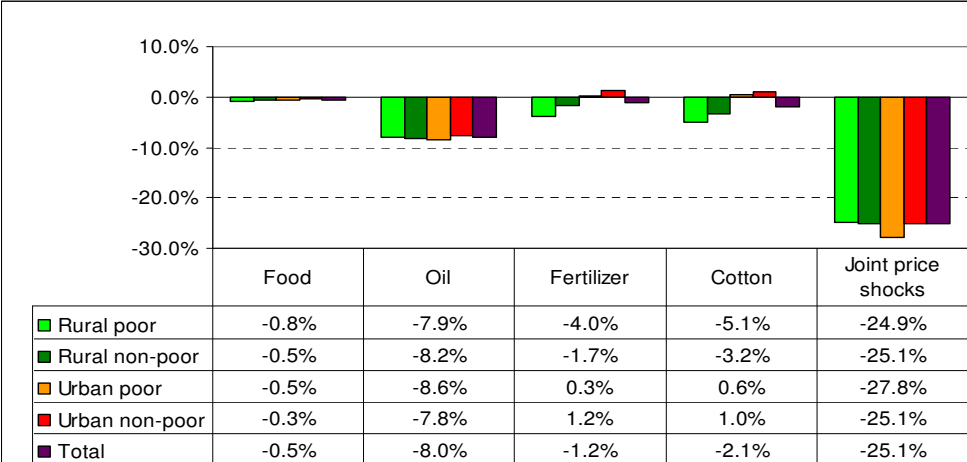
Panel A: fixed family-labour wage



Panel B: flexible family-labour wage



Panel C: Lower bounded family-labour wage

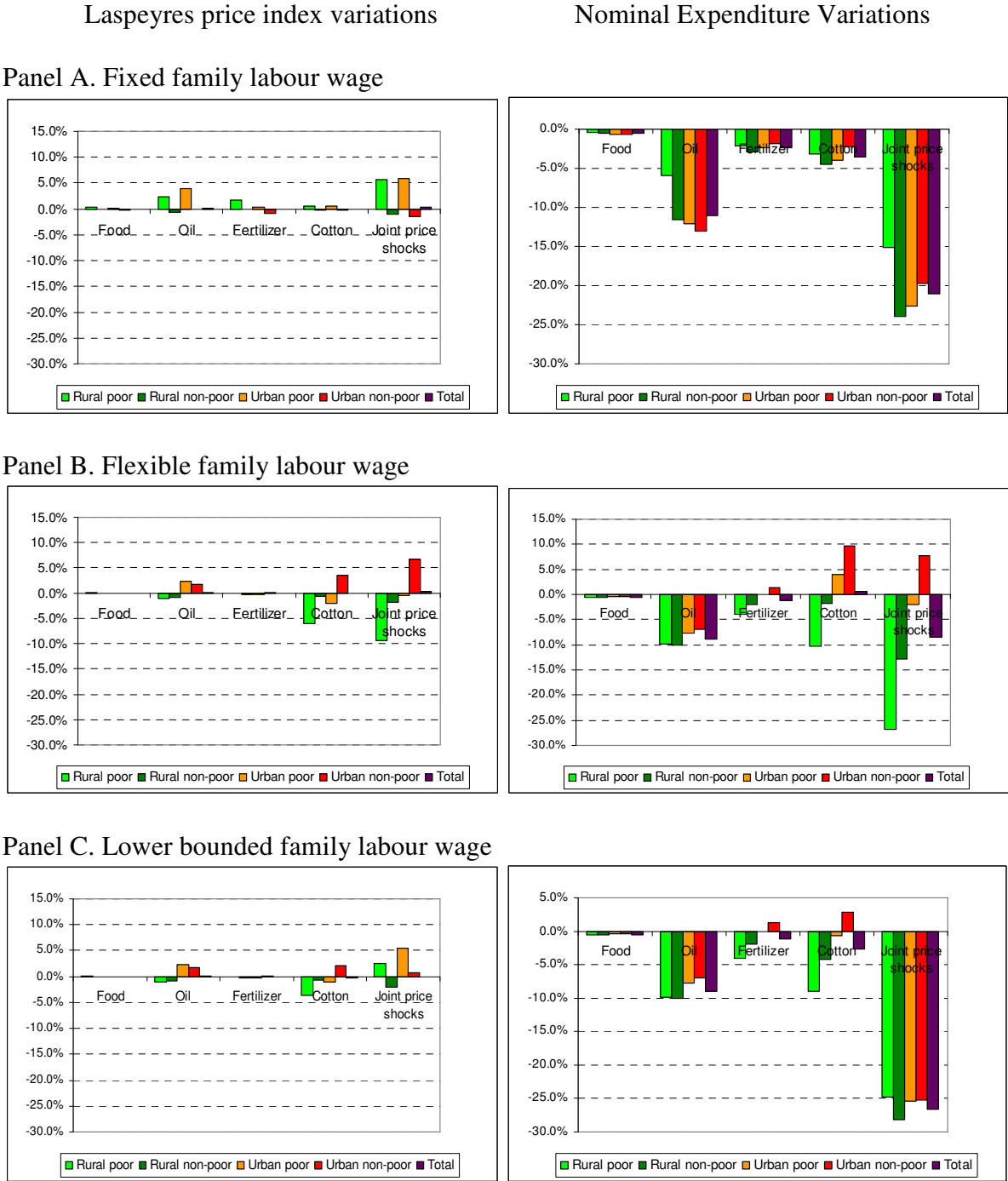


Under the **fixed wage regime**, the negative impacts on household welfare of the oil price shocks are more pronounced for of urban groups, due to the fact that these groups spend a larger part of their income on this commodity (see table 4), so their price index increases while their expenditure sharply decreases. On the other hand, the nominal expenditure of rural poor households only slightly reduces. This is due to the fact that the income from family-labour, which constitutes more than 50% of the income of rural poor, does not significantly change under this simulation (figure 8.5), thanks to the fixed wage (by hypothesis) and the limited reduction of the supply of family labour (figure 8.7). The welfare impacts of the cotton price shock is larger for rural non poor and urban poor groups due to the negative impacts on both primary production (cotton grains) and ginning, activities which involve both groups. The Joint prices shock under the fixed wage regime, affects more non poor and urban poor households, despite the fact that the income from family labour shows a 20% reduction, affecting the expenditure of rural poor households, which also face a 5% increase of their price index.

Under the **flexible wage regime** the *oil price shock* affects in a similar way the welfare of the different household groups (around -8%), despite the fact that the consumer price index of the urban groups increases more than the one of the rural ones. This is due to the fact that urban groups exhibit a more limited reduction of their nominal expenditure than the rural ones. The oil price shock affects the expenditure of rural poor through the reduction of the family labour income. The shock generates a 20% reduction in the family labour wage (figure 8.6), which, associated to a 10% increase in the labour supply (figure 8.7), leads to a -10% reduction of the family labour income (figure 8.5). The welfare impact of the *fertilizers' price shock* is essentially born by the rural households due to the reduction of the nominal expenditure, substantially due to a reduction of the family labour income. The *cotton price shock*, under this wage regime has quite important distributional impacts. While poor rural households are negatively hit (-3.6%), urban households (poor and non-poor) enjoy a welfare increase (almost + 7%). This is due to the fact that the decrease of the rural-poor consumer price index (-6%) is not enough to compensate the fall in the rural poor nominal expenditure (-10%), generated by a loss of the family wage income (-5%). The reduction in family wage income results from a -38% wage reduction, not offset by the increase of labour supply (+20%). In other words, the additional labour efforts provided are not enough to restore the level of expenditure achieved at the baseline, due to the sharp reduction of the family labour wage. The same considerations put forward for the cotton price shock apply to the *Joint price shock simulation*. The lower aggregate loss of welfare under the flexible wage regime (-4.7%) than under the fixed wage regime (-20%) is essentially due to the gains of the poor and non-poor urban household groups (+3.7% and 4.8% respectively) due to the additional labour efforts provided by rural households (+140%), which are left with less income from family labour (-50%) due to substantial reductions in family-labour wage (-80%), in spite of their increased supply of labour.

Overall, the flexible-wage regime is likely to reflect a situation where, on the one hand, poor rural households, which essentially supply the bulk of family labour, have to supply additional work at lower wages in order to keep enjoying analogous levels of welfare as in the case of fixed-wage regime. On the other hand, under the flexible-wage regime all the other household groups are less negatively affected or even positively affected by external shocks, provided that poor rural households bear the costs of the adjustment of the economic system to these shocks. However, the increase of family labour supply, and the decrease of the family labour wage under the cotton price shocks and joint price shocks simulations are extreme variations unlikely to occur in practice.

Figure 8.4a Laspeyres price index variations and nominal expenditure variations by type of household under different family labour wage regimes.



Under the **lower-bounded wage regime**, for the *cotton price shock* simulation, the aggregate loss of welfare (-2.1%) is smaller than under the fixed wage regime (-3.4%). However, the rural poor are more affected (-5.1%) than under the fixed wage regime (-3.7%). The reduction of welfare of rural poor is due to a reduction in their nominal expenditure not completely offset by the reduction in their consumer price index. The reduction of the nominal expenditure is mostly determined by the 25% reduction of the family-labour wage (which for this simulation reaches its lower-bound) not completely offset by the slight increase of the

family labour supply. For the *Joint price shock*, the reduction of the aggregate private consumption highlighted in table 12, panel C, directly translates in a loss of welfare. The large devaluation led by the reduced inflow of foreign currency due to the reduction of transfers, favours exports, but, due to the degradation of terms of trade, it depresses imports, reducing the consumption possibilities of the country. However, the welfare loss hits almost equally all the household groups (-25%). A comparison with the fixed wage scenario, where the distributional impacts are relatively adverse to rural people and urban poor, suggests that, restoring the competitiveness of the system, affected by multiple international price shocks, through a consistent wage reduction (-25%) associated to a strong devaluation in real terms (-45%) and a sharp reduction of foreign transfers, leads to a stronger but more equitable loss of welfare. It has to be noted however, that, rural poor significantly suffer from this type of adjustment, as their loss of welfare shifts from -19% to -25%. This loss is partially due to the further reduction of the family labour income (figure 8.5) generated by a reduction of the wage, which reaches its lower bound. However, the reduction of the family wage contributes to contain the loss of employment, shifting the variation of the supply of family labour from -22% in the case of fixed wages to -10%.

Figure 8.5 Family-labour income with flexible, fixed and lower bounded family labour wage.

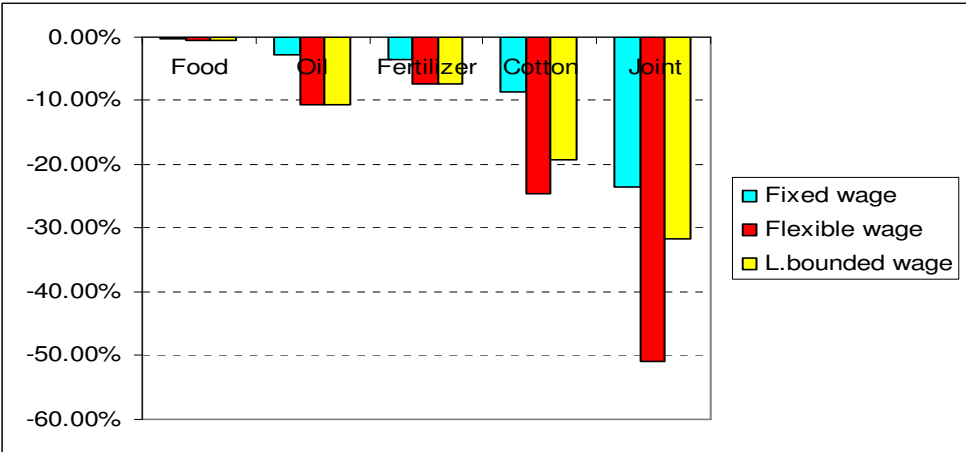


Figure 8.6 Family-labour wage under fixed, flexible and lower bounded wage scenarios

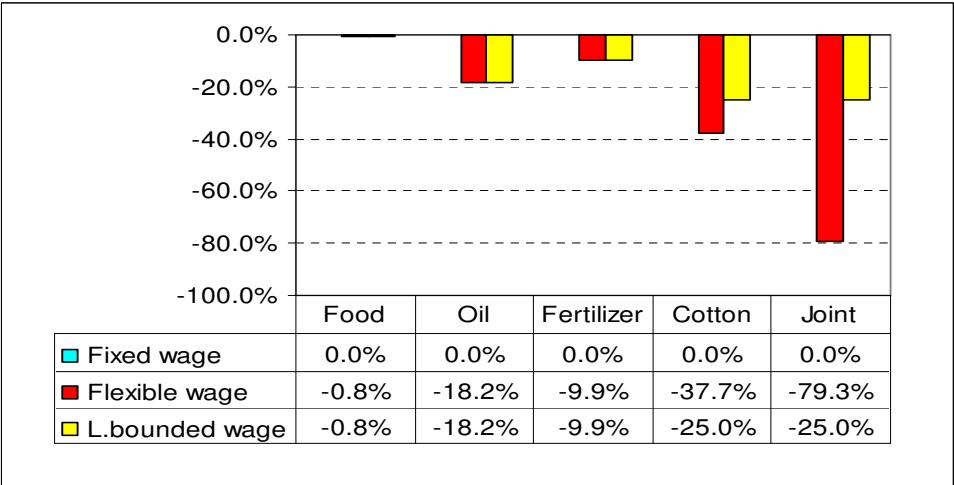
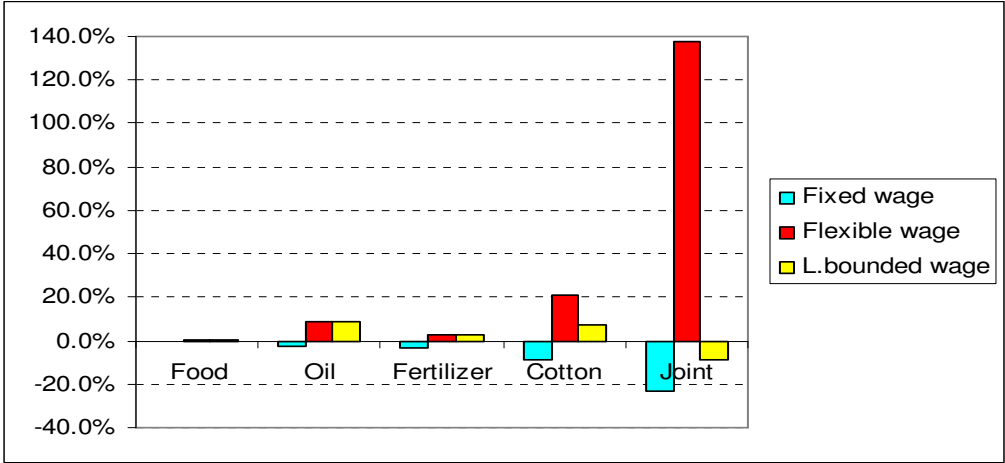


Figure 8.7 Family-labour supply with flexible, fixed, lower-bounded family labour wage



6.6 Implications of alternative macro and factor market closures

From the comparisons carried out in the previous section, it is apparent that analytical results on impacts of international price shocks crucially depend on modeling choices. Indeed, alternative macro and factor closures radically change the results of models. As a natural consequence, policy advice based on such results can be biased if the analyst is not aware of the implications of changing one or more assumptions on which the analysis rests.

In the specific case analyzed above, the actual availability of additional domestic factors, specifically family labour and the flexibility of wages may contribute to countervail negative external shocks but may have strong adverse distributional impacts.

In addition, considering the extent to which under some simulation scenarios, notably the “cotton” and the “joint price shocks” ones, family wages shrink if left free to vary, we should wonder whether these scenarios can be considered realistic in the light of the current level of actual agricultural wages and wages enjoyed by family labour, which are almost close to the subsistence level. Analogous considerations apply to the supply of family labour, which under the flexible-wage regime, for the “joint-price shock” scenario more than doubles. In these cases, imposing lower bound to wages (as considered in figure 8.1 panel B) better reflect the likelihood of possible adjustments of the economic system. Imposing realistic lower bounds to wages allow using the analytical findings obtained assuming a flexible-wage regime for actual policy advice.

Under the lower bound regime, it results that, in presence of adverse simultaneous international price shocks on exports and inputs, the current level of foreign transfers lowers the flexibility of the system for adjustments to international price shocks. Restoring the competitiveness of the system through a moderate wage reduction associated to a consistent devaluation in real terms and a cut of the foreign transfers, leads to improving selected macro-economic indicators such as the balance of trade and the dependency ratio, crucial for economic systems whose attained level of welfare is to a large extent supported by foreign aid and foreign loans. In addition, all this leads to a stronger but more equitable loss of welfare. However, this type of adjustment requires additional policy measures to improve the

productivity of factors and income distribution because the losses of welfare associated to the restoration of the competitiveness, affected by international price shocks, may not be affordable by the weaker layers of the society.

7 Technological Changes under “Good Agricultural Practices”

Among the possible policies to contrast international price shocks, policy measures aimed at increasing the productivity of factors and restoring occupational levels play an important role. Since 2005, the Food and Agriculture Organization of the United Nations (FAO UN), in collaboration with the “Institut de l’Environnement et de Recherches Agricoles (INERA)” (Institute for the Environment and the Agricultural Research) and the Ministry of Agriculture and Water Resources; support the “Union Nationale des Producteurs de Coton du Burkina Faso (UNPC-B)” (National Union of Cotton producers of Burkina Faso) in the promotion of the so-called “Good Agricultural Practices” (GAP) for the integrated Cotton-Cereals-Livestock production systems. This support comprises the identification and extension of appropriate production techniques, also by means of field experiments involving local farmers. In general terms, GAP aim at increasing yields by means of increased organic fertilisation, reduced use of chemicals (reduction of chemical fertilisers and elimination of pesticides) and increased use of agricultural labour⁴⁹. Figure 11 reports average yields per hectare for maize and cotton induced by GAP technologies with respect to “ordinary” agricultural practices, calculated on the basis of the experimental data reported in FAO (2008)⁵⁰. Figure 12 reports the different cost and value-added structure for maize and cotton under the two different agricultural practices as percent of the value of output.

It is apparent that, on the basis of the experimental results, GAPs lead to: a) a less input-intensive agriculture, making reduced use, in particular, of imported inputs; b) greater demand of factors per unit of output; and c) reduced land use, other things being equal, thanks to increased yields per hectare⁵¹.

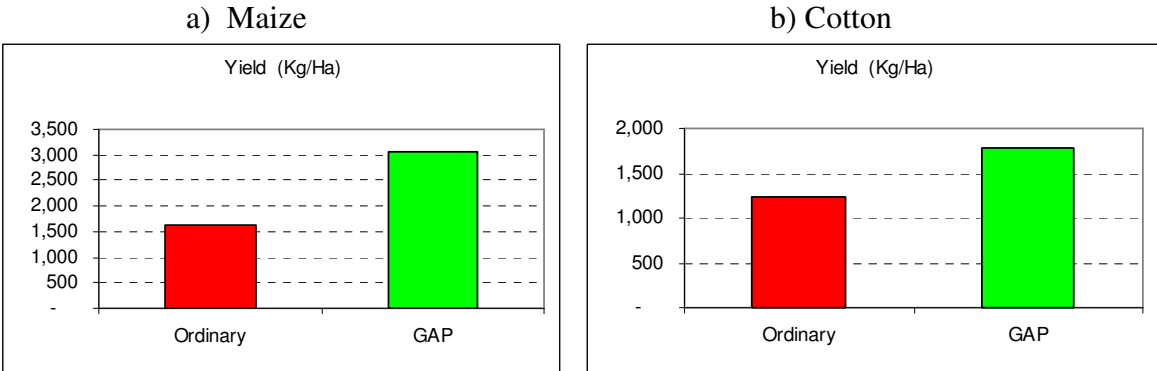
⁴⁹ For more details on conservation agriculture see e.g. Garcia-Torres, L., Benites, J., Martinez-Vilela, A. and Holgado-Cabrera, A.,(2003). (Eds.) Conservation Agriculture: Environment, Farmers Experiences, Innovations, Socio-Economy, Policy. Kluwer Academic Publishers, The Netherlands.

For a review of the experiences and the potential of organic agriculture for poverty reduction see: Setboonsarng S. 2006 Organic Agriculture, Poverty Reduction, and the Millennium Development Goals August 2006 Asian Development Bank Institute (ADBI).

⁵⁰ FAO UN (2008): Formation participative sur les bonnes pratiques agricoles dans les systèmes de production coton-céréales-élevage. Rapport final de la campagne 2007-2008 FAO-AGPP, Rome ; UNCPB –INERA, Burkina Faso; March 2008. Unpublished.

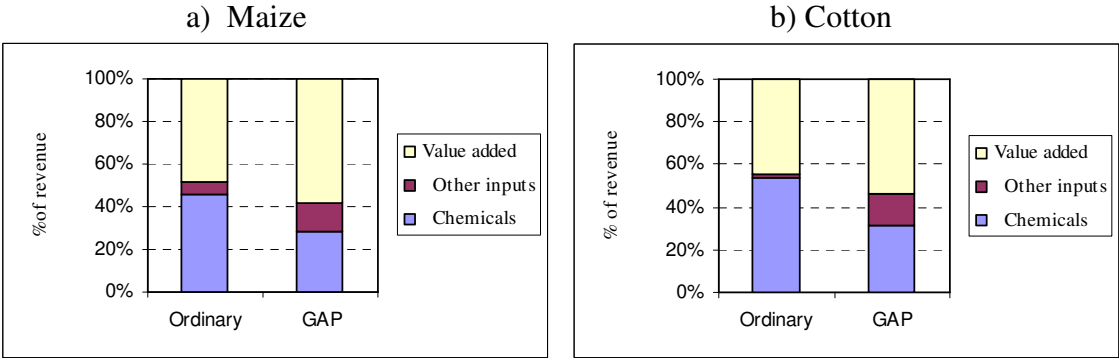
⁵¹ Detailed data on GAP based on FAO UN (2008), are reported in appendix.

Figure 11. Yields for Maize and Cotton With “ordinary” and GAP technologies.



Source: Author’s calculations on data reported in FAO UN (2008).

Figure 12. Input costs and value added for Maize and Cotton with “ordinary” and GAP technologies.



Source: Author’s calculations on data reported in FAO UN (2008).

Given the importance of cotton as export commodity and fertilisers as imported inputs in Burkina Faso as discussed in section 5, it is interesting to see to what extent the adoption of GAP technologies on a large scale could constitute a response to external shocks or, at least, could contribute to mitigate the negative impacts analysed in section 7.

The following simulations have been carried out using a CGE model in order to analyse the macro-economic and welfare impacts of a country-wide adoption of GAP practices for cotton, maize and other crops:

1. reduced use of chemicals (fertilisers and pesticides) (- 20% of chemicals per unit of aggregate intermediate input);
2. reduction (-20%) of the aggregate intermediate input per unit of output;
3. increased factor requirements (+20%) per unit of output;
4. joint effects of the three technological changes above; and
5. adoption of GAP practices in the context of international prices shifts.

Table 8 summarises the changes simulated with the CGE model, with respect to the base case assumed to reflect the “ordinary” technology⁵².

⁵² for cotton and other crop activities: simulation 1 reduces the technical coefficient of chemicals per unit of aggregate input (parameter “ica” in the model), simulation 2 reduces the technical coefficient of the aggregate input per unit of output (parameter “inta” in the model) and simulation 3 increases the value of the technical

Table 8: Simulations of technological changes for GAP

	Chemicals per unit of aggreg.input	Aggregated input per unit of output	Aggregated factor per unit of output
	(1)	(2)	(3)
Cotton	-20%	-18%	22%
Other crops	-24%	-19%	20%

As expected, reduced chemicals per unit of aggregated input and reduced aggregated input per unit of output (simulations 1 and 2) have positive impacts on GDP (see figure 13). On the other hand, increased factor use per unit of output imposes a burden on the socio-economic system (simulation 3). Overall, all GAP changes (simulation 4) have a slight positive impact on GDP (less than 1%), compared to the base case. GAP changes however become more relevant in the context of international price shocks, as they contribute to reduce the GDP losses from -7.8% (last shaded bar in picture 13) to -6.4%, (simulation 5). This is essentially due to the fact that GAPs reduce the demand of inputs affected by price shocks.

GAPs allow also reducing the domestic currency devaluation required to keep the external debt (in foreign currency) constant.⁵³

Figure 13. GDP at market prices (at constant prices, % changes)

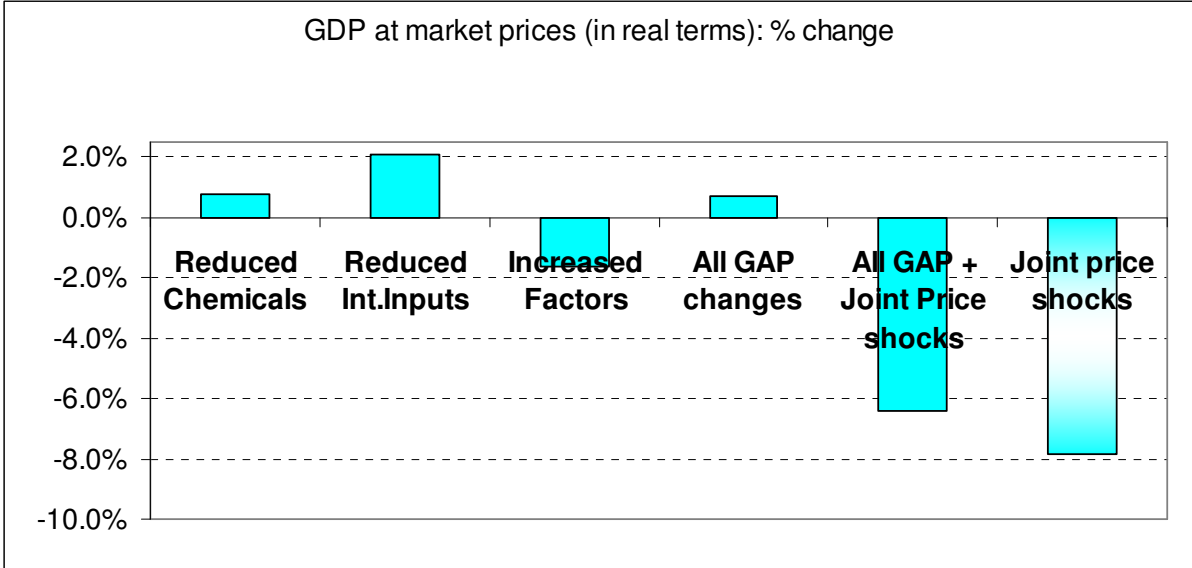


Table 9. Macro-economic impacts of Good Agricultural Practices

coefficient of the aggregate factor per unit of output (parameter “*iva*” in the model). If more detailed data on GAP technologies were available, it would be possible to simulate impacts of separate changes for energy consumption, agricultural labour and capital services.

⁵³ Recall that these results are obtained by keeping the external debt constant in foreign currency, allowing the real exchange rate to float to reach the equilibrium of the balance of payments. This implies that also the trade balance is kept constant in foreign currency.

		Base	Reduced Chemicals	Reduced Int.Inputs	Increased Factors	All GAP changes	Price shocks + GAP	Price shocks
		Million FCFA	% variation w.r.t.the base					
a=b+c+d	Total Absorbption	2,119,964	0.6%	1.8%	-1.4%	0.6%	-11.4%	-12.9%
b	Private consumption	1,441,816	0.9%	2.6%	-2.1%	0.9%	-16.7%	-19.0%
c	Investment	279,655	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
d	Government cons.	398,493	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
e	Exports	149,849	0.7%	7.6%	-14.3%	-8.0%	-15.8%	-11.4%
f	Imports	458,157	0.2%	2.5%	-4.7%	-2.6%	-32.5%	-32.7%
g=a+e-f	GDP at market prices	1,811,656	0.7%	2.1%	-1.6%	0.7%	-6.4%	-7.8%

Figure 14: Real exchange rate adjustments

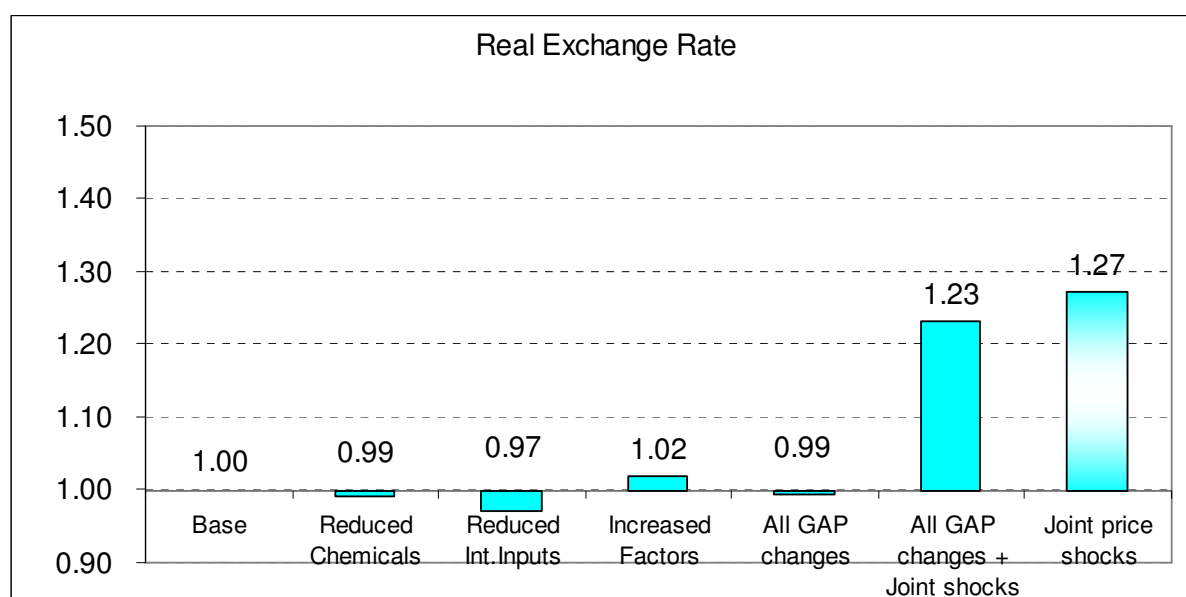
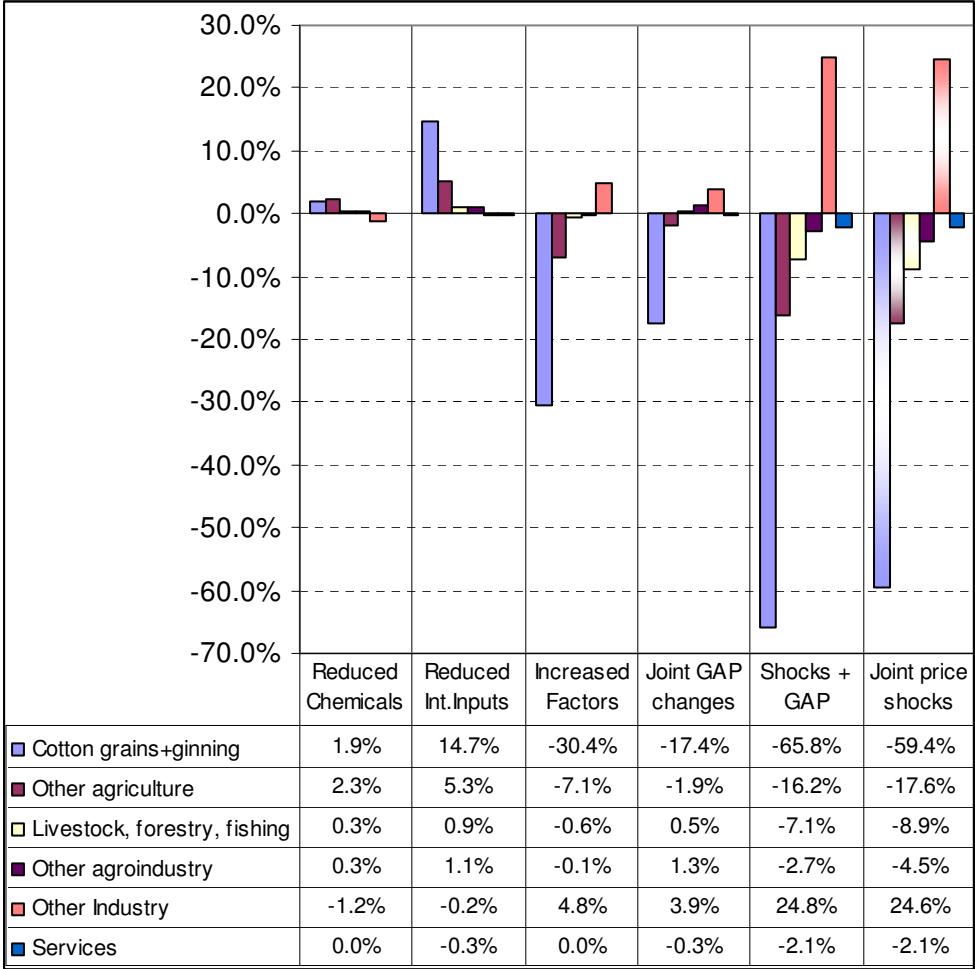
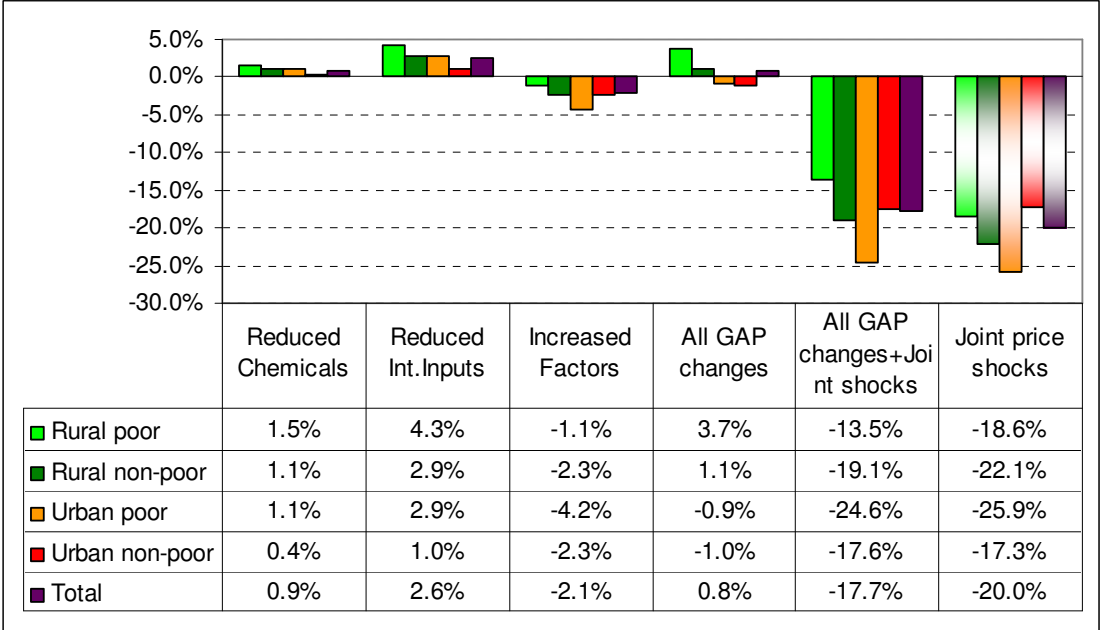


Figure 14a. Activity levels under Good Agricultural Practices and



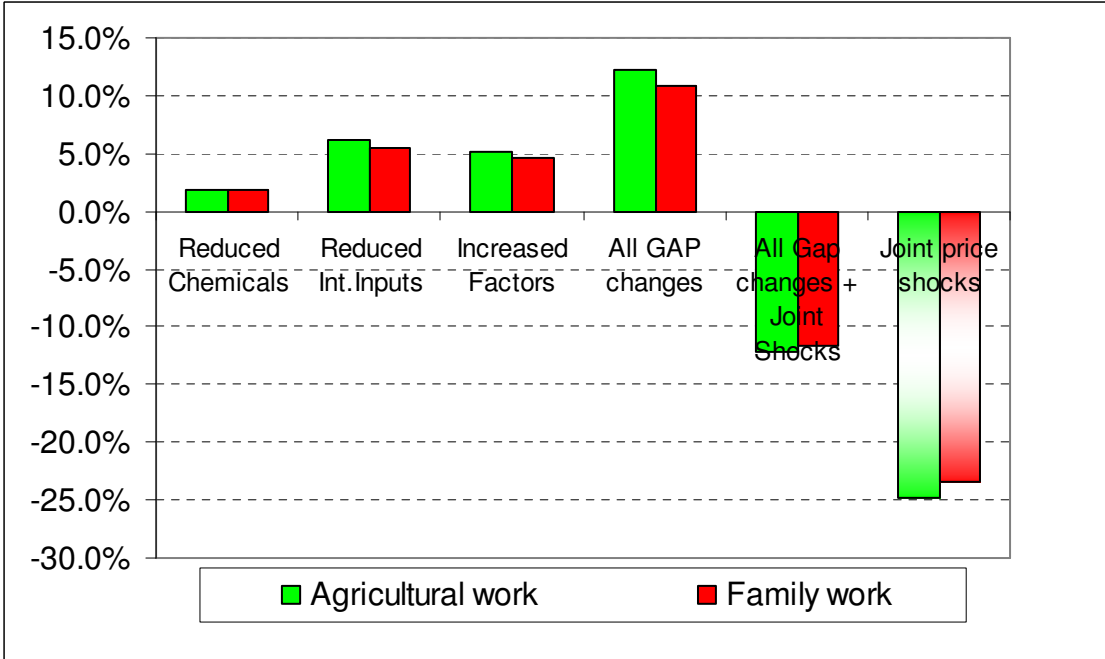
The reduction of intermediate inputs per unit of outputs (specifically, imported chemicals) has obvious positive welfare impacts on households (figure 14, simulations 1 and 2). However, their reduction has to be read jointly with the required increase of factors per unit of output (simulation 3), as reported in simulation 4 (Joint GAP changes). The large scale adoption of GAP practices implies a slightly positive welfare impact on all the households (+0.5%). Furthermore, it shows important distributional impacts to the advantage of the rural poor (+3.2%) which more than compensate the slight losses of the urban segments of the population. Therefore, the adoption of GAP practices is likely to imply important positive improvements of poverty and food security.

Figure 15. Burkina Faso. Households' welfare impacts (EV) of adoption of GAP practices and their mitigating impacts on price shocks. CGE simulations' results.



Source: CGE model results

Figure 16. Factor use (% changes) under GAP and international price shocks scenarios



Source: CGE model results

The positive impacts of the adoption of GAP technologies are particularly important when looking at factor use. Figure 16 reports employment changes for agricultural wage work and family work. Note that under the full adoption of GAP (fourth scenario from the left), employment increases more than 10%.

This appears particularly important if considered in the context of international price shocks. Negative employment impacts of these shocks are definitely mitigated. The adoption of GAP

shifts the job losses from almost -25% (figure 10, fifth scenario) to -13% (figure 14, fifth scenario).

8 Some policy implications

The analyses carried out above highlight that the country in general, and in particular the poorest layers of the population, are vulnerable to international price variations of selected commodities, both on the import and on the export side. This is essentially due to:

1. The dependency of the country on imports of energy products (oil in particular);
2. The need to rely on foreign markets for most of the industrial goods, including intermediate inputs, final consumption goods, investment goods and technology;
3. The dependency on the cotton sector as the main source of foreign currency;
4. The dependency of the country from foreign transfers to sustain the government budget.

It is important, in this context, to identify policies and strategies that while improving the overall macro-economic framework of the country, will also improve the welfare of the poorer layers of the population. Following Bhagwati (1988)⁵⁴, there are two alternative policy designs to achieve poverty reduction: a) the “indirect route”, i.e. the use of resources to promote growth, relying on the “trickle-down” effects, and b) the direct route i.e. “*the public provision of “minimum-needs-oriented” services relevant to achieve welfare improvements of selected layers.* Bagwati however, suggests shaping the first route in such a way that it results in a “*pull-up*” strategy, i.e. a growth strategy biased towards generating income in the hands of the poor, in order to bring them out of poverty. This approach, which paved the way to what nowadays is named “pro-poor” growth, is probably what is needed in Burkina Faso.

Both routes however require resources for funding investment and/or providing services. The way chosen to procure these resources however is not neutral, particularly in presence of shocks affecting both import and export prices. In this situation the country needs to restore its competitiveness through a mix of policies affecting the productivity and related remuneration of factors, as well as through a real devaluation, implying a general re-alignment of the domestic prices with respect to the international ones. Breaking the dependency of the country from foreign transfers through a significant cut of foreign aid may have beneficial macro-economic impacts, such as an improvement of the balance of trade and a reduction of the budget dependency ratio. In addition, the burden of the international price shocks would probably be better distributed on all the layers of the society than in the case of reductions in the remuneration of factors supplied by the weaker segments of the society. However, the cut of foreign aid is most likely negatively affecting the consumption possibilities of the country. While this may not be a severe issue for non-poor households, it certainly constitutes a problem for the poor ones. Redistribution policies, including general fiscal schemes, need to be carefully designed to further improve the income distribution and shift the burden of adjustments from poorer to non poor social groups.

In any case, to achieve an endogenously sustained development path it is of crucial importance breaking the energy dependency, re-designing technologies, adapting consumption towards less import-intensive patterns and diversifying export sources are

⁵⁴ Baghwati, J.N. (1988) Poverty and Public Policy. World Development. Vol 16, n. 5 pp. 539-555.

challenges that the country needs to address, in order to embrace more self-sustaining development strategies which would also be “pro-poor”.

In order to address the energy issue, the exploration of alternative energy sources is a possible way forward. This implies carrying out a thorough analysis of the various options available, considering their technical feasibility, economic viability, environmental sustainability and their geo-political strategic implications.

Among the options that may have direct and significant impacts on rural areas and/or agricultural activities, bio-energy technologies look particularly interesting for exploration. While some of them may conflict with food production, as for example those requiring high quality-irrigated land (e.g. sugarcane-based ethanol or cassava-based diesel) others, such as Jatorpha-based diesel, if properly managed, might not conflict with other crops.

In addition, decentralised solar energy production might be particularly important for the development of specific off-farm activities in rural areas. While probably requiring comparatively larger investment, this technology could be also important for direct income generation if it is associated with the extension of the electricity network, which is planned in the 2010-2015 Strategic Development Framework of the country⁵⁵. Once interconnected with the national electricity network, rural areas could also potentially become net sellers of energy.

The energy issue, but more generally, the import dependency, cannot be decoupled from technological research and technological choices, particularly relevant for predominant sectors such as agriculture. As shown above, the possibility to adopt on a large scale less import-intensive technologies, such as the “Good Agricultural Practices” (GAP) may lead to some improvement in the welfare of the poorest layers of the population. This implies developing and disseminating local knowledge on most adapted production and processing techniques and favoring their adoption by economic agents. Public policies aimed at supporting appropriate technological changes, while contributing to reduce pressure on the trade balance, may also be beneficial for employment generation and diversification of income sources. This may apply in particular to the adoption of carbon-fixing technologies, such as the technologies which increase the organic content of soil. These could receive adequate remuneration within the framework of current or future carbon-fixing international schemes.

As both the diversification of energy sources and the adoption of more appropriate technologies could contribute to reduce pressure on the balance of trade, appropriate policies to promote them could also lead to a reduction of pressure on export sectors, such as cotton and allowing for free resources, such as land and water, for other sectors.

9 Conclusions

This paper analysed the socio-economic impacts of selected international price shocks faced by Burkina Faso in recent years. It highlighted in particular that household welfare is

⁵⁵ (2009) Strategie de développement 2010-2015. Ministère de l’Economie et des Finances (Draft, unpublished)

significantly affected by oil and fertiliser price increases, as well as from the decline of cotton price. Among the possible ways to mitigate or countervail negative welfare impacts of international price shocks, the adoption of less-energy/import intensive technologies could play an important role.

Possible improvements of the analytical framework, in the context of enhanced, more detailed and updated information comprises, among other things: a more precise estimation of selected parameters such as the elasticities of transformation or substitution between exports and domestic products or the Armington elasticities. Also, an enhanced modelling of selected technological relationships, including the substitutability between capital and labour, as well as a closer investigation of factor uses and factor constraints.

However, in spite of some analytical limitations, essentially due to the weak information base, the findings of this work are quite interesting for their policy implications. It emerges in particular that the issue of energy is crucial if the country wants to achieve a sustainable reduction of poverty and food insecurity. In addition, reducing the energy dependency would also allow a reduction of the country's dependency on cotton, the main export crop, and from its international price variations.

This finding may also apply to other less industrialised net energy importing countries, with a similar socio-economic structure. A further general remark is that, to achieve sustained poverty reduction and food security in a given socio-economic system, it is of crucial importance to identify and fix the "bugs" that generate systematic and sustained drain of domestic resources, pretty much as in the energy sector in Burkina Faso, hampering local surplus accumulation and related endogenous growth potential.

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11 Appendix A: Detailed data and tables

Table A1 Consumer Prices (composite domestic-import prices) under different international price shock scenarios

	Base	Food	Oil	Fertilizer	Cotton	Joint
Cotton grains	1.000	-0.3%	3.3%	1.5%	1.0%	5.8%
Cash crops	1.033	2.0%	4.2%	6.1%	0.8%	16.0%
Vegetables	1.000	-0.3%	1.5%	6.5%	-1.8%	5.8%
Food crops	1.002	0.1%	0.4%	10.7%	0.7%	14.6%
Other Agriculture	1.002	0.3%	0.4%	7.9%	0.6%	11.3%
Livestock-bovine	1.001	0.0%	-5.0%	-1.2%	-2.2%	-12.4%
Other livestock	1.002	-0.3%	-6.9%	-1.4%	-2.0%	-14.8%
Hunting	1.000	-0.4%	-6.7%	-1.5%	-0.8%	-12.5%
Forestry	1.000	-0.4%	-6.6%	-1.5%	-0.7%	-12.2%
Fisheries	1.000	-0.4%	-6.6%	-1.5%	-0.7%	-12.2%
Mining	1.017	-0.9%	-6.9%	-2.2%	-3.5%	-27.7%
Cotton ginning	1.000	2.0%	-25.4%	-4.3%	137.6%	90.7%
Slaughtering	1.003	-1.1%	-21.2%	-5.3%	-7.4%	-39.9%
Agro-industry	1.057	2.4%	-7.7%	-1.3%	1.2%	-9.8%
Fertilizers and Pesticides	1.000	-0.8%	0.2%	126.5%	9.1%	166.7%
Other industry	1.110	-0.9%	2.0%	0.2%	7.3%	10.8%
Oil and oil products	1.000	-1.1%	116.1%	-0.9%	6.6%	154.5%
Power, water and gas	1.056	-1.0%	23.5%	-2.1%	-0.7%	27.2%
Trade	1.000	-0.8%	3.9%	-2.2%	-4.3%	-6.9%
Transport	1.028	-1.0%	8.5%	-1.1%	1.9%	12.1%
Financial services	1.189	-1.0%	-15.2%	-3.3%	-5.7%	-31.3%
Services to enterprises	1.023	-0.9%	-16.0%	-3.4%	-4.7%	-30.2%
Services to households	1.000	-0.9%	-9.0%	-3.0%	-5.5%	-21.7%

Source: CGE model output

Table A2. Yields, cost structure and value added for maize and cotton under ordinary and GAP technologies.

	Maize			Cotton		
	Current	GAP	Var %	Current	GAP	Var %
Yield (Kg/Ha)	1,617	3,047	88.5%	1,229	1,777	44.7%
Revenue	100.0	100.0	0.0%	100.0	100.0	0.0%
Interm.Cons.	51.5	41.7	-18.9%	55.8	45.9	-17.7%
<i>Chemicals</i>	45.9	28.4	-38.0%	53.8	31.7	-41.1%
<i>Other inputs</i>	5.6	13.3	138.0%	2.0	14.2	606.9%
Value added	48.5	58.3	20.1%	44.2	54.1	22.4%

Source: Author's calculations on data reported in FAO UN (2008).

Table A3 Consumer Prices (composite domestic-import prices) under different technologies and international price shock scenarios.

	Base	Food	Oil	Fertilizer	Cotton	Joint
Cotton grains	1.000	-0.3%	3.3%	1.5%	1.0%	5.8%
Cash crops	1.033	2.0%	4.2%	6.1%	0.8%	16.0%
Vegetables	1.000	-0.3%	1.5%	6.5%	-1.8%	5.8%
Food crops	1.002	0.1%	0.4%	10.7%	0.7%	14.6%
Other Agriculture	1.002	0.3%	0.4%	7.9%	0.6%	11.3%
Livestock-bovine	1.001	0.0%	-5.0%	-1.2%	-2.2%	-12.4%
Other livestock	1.002	-0.3%	-6.9%	-1.4%	-2.0%	-14.8%
Hunting	1.000	-0.4%	-6.7%	-1.5%	-0.8%	-12.5%
Forestry	1.000	-0.4%	-6.6%	-1.5%	-0.7%	-12.2%
Fisheries	1.000	-0.4%	-6.6%	-1.5%	-0.7%	-12.2%
Mining	1.017	-0.9%	-6.9%	-2.2%	-3.5%	-27.7%
Cotton ginning	1.000	2.0%	-25.4%	-4.3%	137.6%	90.7%
Slaughtering	1.003	-1.1%	-21.2%	-5.3%	-7.4%	-39.9%
Agro-industry	1.057	2.4%	-7.7%	-1.3%	1.2%	-9.8%
Fertilizers and Pesticides	1.000	-0.8%	0.2%	126.5%	9.1%	166.7%
Other industry	1.110	-0.9%	2.0%	0.2%	7.3%	10.8%
Oil and oil products	1.000	-1.1%	116.1%	-0.9%	6.6%	154.5%
Power, water and gas	1.056	-1.0%	23.5%	-2.1%	-0.7%	27.2%
Trade	1.000	-0.8%	3.9%	-2.2%	-4.3%	-6.9%
Transport	1.028	-1.0%	8.5%	-1.1%	1.9%	12.1%
Financial services	1.189	-1.0%	-15.2%	-3.3%	-5.7%	-31.3%
Services to enterprises	1.023	-0.9%	-16.0%	-3.4%	-4.7%	-30.2%
Services to households	1.000	-0.9%	-9.0%	-3.0%	-5.5%	-21.7%

	Base	Reduced Chemicals	Reduced Int.Inputs	Increased Factors	Joint GAP changes	Shocks + GAP
Cotton grains	1.000	-0.2%	-7.9%	12.6%	5.0%	10.6%
Cash crops	1.033	-1.4%	-9.0%	12.2%	2.9%	14.9%
Vegetables	1.000	-1.4%	-13.1%	6.5%	-6.6%	-1.7%
Food crops	1.002	-2.6%	-5.6%	14.5%	7.7%	17.1%
Other Agriculture	1.002	-1.9%	-4.8%	15.2%	9.5%	17.2%
Livestock-bovine	1.001	0.3%	1.2%	-1.1%	0.2%	-10.5%
Other livestock	1.002	0.3%	1.2%	-1.0%	0.4%	-12.6%
Hunting	1.000	0.3%	1.6%	-0.7%	1.0%	-10.3%
Forestry	1.000	0.3%	1.6%	-0.7%	1.0%	-10.1%
Fisheries	1.000	0.3%	1.6%	-0.7%	1.0%	-10.1%
Mining	1.017	0.6%	0.0%	-6.1%	-5.5%	-29.2%
Cotton ginning	1.000	0.9%	-15.0%	38.1%	17.3%	136.8%
Slaughtering	1.003	1.2%	5.7%	-5.1%	0.8%	-36.8%
Agro-industry	1.057	0.3%	0.4%	-1.6%	-1.0%	-9.1%
Fertilizers and Pesticides	1.000	-9.7%	-9.4%	-2.8%	-12.1%	151.0%
Other industry	1.110	0.1%	-2.2%	-0.6%	-2.3%	7.7%
Oil and oil products	1.000	0.3%	2.6%	0.1%	2.7%	149.0%
Power, water and gas	1.056	0.5%	2.6%	-4.2%	-1.7%	25.0%
Trade	1.000	1.1%	-6.0%	-8.0%	-12.9%	-13.0%
Transport	1.028	0.3%	0.5%	-3.0%	-2.3%	9.7%
Financial services	1.189	0.7%	3.6%	-6.7%	-3.1%	-31.0%
Services to enterprises	1.023	0.7%	3.2%	-6.1%	-2.7%	-29.8%
Services to households	1.000	0.6%	3.7%	-7.1%	-3.7%	-22.4%

Source: CGE model output

Table A4 activity levels under different price shock and technology scenarios

	Base	Food	Oil	Fertilizer	Cotton	Joint
Cotton grains	58,637	-2.5%	53.7%	6.4%	-66.1%	-57.2%
Cash crops	37,730	1.9%	-12.5%	-8.8%	3.7%	-18.0%
Vegetables	27,900	-0.2%	-7.9%	-4.0%	-1.5%	-15.5%
Food crops	147,770	0.1%	-8.7%	-5.9%	-2.2%	-18.7%
Other Agriculture	42,897	0.5%	-7.9%	-4.7%	-0.8%	-14.6%
Livestock-bovine	111,708	-0.3%	-4.1%	-0.9%	-0.1%	-8.0%
Other livestock	109,470	-0.2%	-4.6%	-1.0%	-0.7%	-9.1%
Hunting	8,025	-0.4%	-8.4%	-1.8%	-2.8%	-16.9%
Forestry	49,636	-0.3%	-5.2%	-0.6%	0.9%	-4.3%
Fisheries	8,896	-0.3%	-7.5%	-1.7%	-2.6%	-15.4%
Mining	13,640	-0.1%	13.2%	4.4%	23.0%	99.0%
Cotton ginning	76,146	-2.7%	57.3%	6.9%	-70.6%	-61.1%
Slaughtering	119,992	-0.1%	-3.3%	-0.7%	-0.8%	-10.5%
Agro-industry	257,294	0.9%	-2.9%	-1.0%	0.5%	-4.5%
Other industry	232,837	-0.1%	2.8%	1.5%	7.5%	20.2%
Power, water and gas	51,129	-0.1%	-7.8%	-0.8%	-2.6%	-13.7%
Trade	255,150	0.0%	2.6%	0.1%	-0.6%	2.9%
Transport	93,443	0.0%	-2.8%	0.6%	1.8%	-0.6%
Financial erVICES	34,637	-0.2%	-2.7%	-0.6%	-1.0%	-8.1%
Services to enterprises	672,900	-0.1%	-2.1%	-0.3%	-0.2%	-3.9%
Services to households	413,041	0.0%	-0.3%	0.0%	0.0%	-0.5%

Aggregated activity levels

	Food	Oil	Fertilizer	Cotton	Joint	Base	% base
Cotton grains+ginning	-2.6%	55.7%	6.7%	-68.7%	-59.4%	134,783	4.8%
Other agriculture	0.4%	-9.0%	-5.9%	-1.0%	-17.6%	256,296	9.1%
Livestock, forestry, fishing	-0.2%	-4.3%	-0.9%	-0.5%	-8.9%	407,728	14.4%
Other agroindustry	0.9%	-2.9%	-1.0%	0.5%	-4.5%	257,294	9.1%
Other Industry	-0.1%	3.3%	1.7%	8.3%	24.6%	246,477	8.7%
Services	0.0%	-1.1%	-0.1%	-0.2%	-2.1%	1,520,299	53.9%
total						2,822,877	100.0%

	Base	Reduced Chemicals	Reduced Int.Inputs	Increased Factors	Joint GAP changes	Shocks + GAP
Cotton grains	58,637	1.8%	14.1%	-29.3%	-16.8%	-63.4%
Cash crops	37,730	4.2%	9.8%	-13.3%	-4.0%	-16.9%
Vegetables	27,900	1.4%	7.0%	-3.5%	2.9%	-12.5%
Food crops	147,770	2.1%	4.3%	-6.3%	-1.9%	-17.2%
Other Agriculture	42,897	2.0%	3.6%	-6.7%	-3.0%	-14.4%
Livestock-bovine	111,708	0.3%	0.8%	-0.6%	0.4%	-6.5%
Other livestock	109,470	0.4%	1.0%	-0.9%	0.3%	-7.7%
Hunting	8,025	0.7%	1.8%	-1.9%	0.3%	-15.1%
Forestry	49,636	0.0%	1.0%	0.1%	1.2%	-3.4%
Fisheries	8,896	0.7%	1.7%	-1.6%	0.4%	-13.5%
Mining	13,640	-2.4%	-2.3%	12.3%	8.2%	97.4%
Cotton ginning	76,146	1.9%	15.1%	-31.3%	-17.9%	-67.7%
Slaughtering	119,992	0.2%	0.7%	-0.4%	0.5%	-7.7%
Agro-industry	257,294	0.3%	1.1%	-0.1%	1.3%	-2.7%
Other industry	232,837	-1.1%	-0.1%	4.4%	3.7%	20.5%
Power, water and gas	51,129	0.4%	0.8%	-0.8%	0.2%	-12.9%
Trade	255,150	0.0%	-2.3%	-0.7%	-2.8%	0.5%
Transport	93,443	-0.2%	-1.4%	1.1%	-0.2%	-1.3%
Financial Services	34,637	0.2%	0.4%	0.3%	1.0%	-6.2%
Services to enterprises	672,900	0.1%	0.2%	0.1%	0.4%	-3.2%
Services to households	413,041	0.0%	0.0%	0.0%	0.1%	-0.4%

Aggregated activity levels

	Reduced Chemicals	Reduced Int.Inputs	Increased Factors	Joint GAP changes	Shocks + GAP	Joint price shocks	Base	% base
Cotton grains+ginning	1.9%	14.7%	-30.4%	-17.4%	-65.8%	-59.4%	134,783	4.8%
Other agriculture	2.3%	5.3%	-7.1%	-1.9%	-16.2%	-17.6%	256,296	9.1%
Livestock, forestry, fishing	0.3%	0.9%	-0.6%	0.5%	-7.1%	-8.9%	407,728	14.4%
Other agroindustry	0.3%	1.1%	-0.1%	1.3%	-2.7%	-4.5%	257,294	9.1%
Other Industry	-1.2%	-0.2%	4.8%	3.9%	24.8%	24.6%	246,477	8.7%
Services	0.0%	-0.3%	0.0%	-0.3%	-2.1%	-2.1%	1,520,299	53.9%
total							2,822,877	100.0%

12 Appendix B: features of the CGE model adopted

12.1 The LES demand system

As final demand functions, the model uses a Linear Expenditure System (LES), based on the Stone-Geary utility function.

Demand functions for each commodity c are as follows:

$$p_i c_i = p_i \gamma_i + \beta_i \left[Y - \sum_j p_j \gamma_j \right]$$

where parameters γ_i may be thought of as representing the purchase of "subsistence quantities" of every good c , and the term in square brackets as "supernumerary" expenditures (remaining resources after having purchased subsistence quantities) to be divided among goods on the basis of a fixed proportion (parameters β_i). Note that the β_i are the marginal expenditure shares, which tell how much the expenditure share of a commodity changes, as expenditure changes (the first derivative of the expenditure on c w.r.t. Y)

Note that the major attractiveness of this system is that it is the only theoretical consistent demand function for which demand for every good is a linear function of all prices and expenditures. Unfortunately, Engel curves are linear, which is somehow not realistic.

In the model, the user provides the following data:

1. expenditure by commodity per type of household (from the SAM), to calculate expenditure shares
2. Expenditure elasticities
3. The FRISCH parameter, the so called "flexibility of money" i.e. the elasticity of the marginal utility of income wrt the income (how the marginal utility of income changes for an 1% increase of income) (See FRISCH, *Econometrica* 1959)

The model works out the betas and gammas, to be then used in the demand functions, using the links among LES parameters of the demand functions, and expenditure elasticities, expenditure shares and FRISCH parameter (for formulae about these links see e.g. Sadoulet, De Janvry 1995 p. 42).

Calculation of Betas

In the model the parameters beta are calculated as follows:

$$betam(C,H) = BUDSHR(C,H)*LESELASI(C,H);$$

Note that for LES holds: $\eta_i = \frac{\beta_i}{w_i}$, i.e. the expenditure elasticity of commodity C equals the ratio of the beta parameter of the demand function and the expenditure share for commodity C, as derived here below:

$$c_i = \gamma_i + \frac{\beta_i}{p_i} \left[Y - \sum_j p_j \gamma_j \right]$$

$$\eta_i = \frac{\partial c_i}{\partial Y} \frac{Y}{c_i}$$

$$\frac{\partial c_i}{\partial Y} = \frac{\beta_i}{p_i}$$

$$\eta_i = \frac{\beta_i}{p_i} \frac{Y}{c_i}$$

Nothing that $\frac{Y}{p_i c_i} = \frac{1}{w_i}$ i.e. the inverse of the expenditure share for Ci, we get:

$$\eta_i = \frac{\beta_i}{w_i}$$

This implies therefore: $\beta_i = \eta_i w_i$, which is the formula applied in the model:

Calculation of the subsistence consumptions gammas

In the model the subsistence consumption for each (marketed)commodity γ_i and for each household type H, is calculated as:

$$\begin{aligned} \text{gammam0}(C,H) &= \text{\$BUDSHR}(C,H) \\ &= ((\text{SUM}(CP, \text{SAM}(CP,H)) + \text{SUM}(AP, \text{SAM}(AP,H))) / \text{PQ0}(C)) \\ &\quad * (\text{BUDSHR}(C,H) + \text{betam}(C,H)/\text{FRISCH}(H)); \end{aligned}$$

- the dollar condition $\text{\$BUDSHR}(C,H)$ to be interpreted “...for all the commodities whose budget share is different from zero (the “NE 0” i.e. “not equal to 0” is omitted because it is the default)
- The sum of the two summations in the RHS: $(\text{SUM}(CP, \text{SAM}(CP,H)) + \text{SUM}(AP, \text{SAM}(AP,H)))$ represents the total expenditure Y .
- $\text{PQ0}(C)$ is the price of commodity i , p_i (at the benchmark)
- $\text{BUDSHR}(C,H)$ is the budget share for commodity C in household H, i.e. $\frac{p_i c_i}{Y}$
- $\text{betam}(C,H)$ is the other LES parameter defined above;
- $\text{FRISCH}(H)$ is the FRISCH parameter for the household type H
- For the home consumption the same apply.

The γ parameter is directly derived by the demand function of the LES for each commodity C, i.e. and from the definition of the FRISCH parameter. On the basis of the fact that the LES is based on a pointwise separable utility function (i.e. the marginal utility of one good does not depend on the level of consumption of other goods), the FRISCH parameter in the LES is⁵⁶:

$$\omega = -\frac{Y}{Y - \sum_j p_j \gamma_j} \Rightarrow \sum_j p_j \gamma_j = \frac{Y}{\omega} + Y$$

Substituting to the summation in the demand function:

$$p_i c_i = p_i \gamma_i + \beta_i \left[Y - \frac{Y}{\omega} + Y \right]$$

and working out the parameter γ_i gives:

$$\gamma_i = \frac{p_i c_i}{p_i} + \frac{\beta_i Y}{p_i \omega}$$

$$\gamma_i = c_i + \frac{\beta_i Y}{p_i \omega}$$

Alternatively, multiplying both numerator and denominator of the first term in the RHS by Y gives:

$$\gamma_i = \frac{p_i c_i Y}{p_i Y} + \frac{\beta_i Y}{p_i \omega} \Rightarrow \gamma_i = \frac{Y}{p_i} \left[\frac{p_i c_i}{Y} + \frac{\beta_i Y}{p_i \omega} \right] \text{ and noting that } \frac{p_i c_i}{Y} \text{ is the budget share for}$$

commodity C, w_i , we get:

$$\gamma_i = \frac{Y}{p_i} \left[w_i + \frac{\beta_i Y}{p_i \omega} \right] \text{ which is the formula used in the model.}$$

⁵⁶ See e.g. Sadoulet, De Janvry 1995 p. 42.

Own and Cross-price elasticities of LES in the CGE model

In the model, own and cross-price elasticities are calculated on the basis of expenditure elasticities and the parameters beta and gamma of the LES demand functions worked out above.

Own-price elasticities.

The model calculates in a similar way own-price elasticities for both marketed commodities of non-marketed commodities, say, home consumption, for different types of households H. For example, the own price elasticities for the marketed commodities are calculated as follows:

$$LESELASP(H, 'MRK', C, 'MRK', C) = -LESELASI(C, H) * (PQO(C) * \text{gammam}(C, H) / (SUM(CP, SAM(CP, H)) + SUM(AP, SAM(AP, H)))) - 1/FRISCH(H);$$

Note that:

$(SUM(CP, SAM(CP, H)) + SUM(AP, SAM(AP, H)))$ corresponds to the total expenditure Y .

The model makes use of the own-price elasticity formula⁵⁷:

$$\eta_{(i,i)} = -\eta_i \left[\frac{\gamma_i p_i}{y} - \frac{1}{\omega} \right]$$

In general, the LES elasticities are derived as follows. We suppose a two-good case and then generalise the result to n-good case.

$$c_1 = \gamma_1 + \frac{\beta_1}{p_1} [Y - p_1 \gamma_1 - p_2 \gamma_2]$$

$$\eta_{(1,1)} = \frac{\partial c_1}{\partial p_1} \frac{p_1}{c_1}$$

$$\frac{\partial c_1}{\partial p_1} = \frac{\beta_1}{p_1^2} [p_2 \gamma_2 - Y]$$

$$\eta_{(1,1)} = \frac{\beta_1}{p_1^2} [p_2 \gamma_2 - Y] \frac{p_1}{c_1}$$

After rearranging we get:

⁵⁷ This formula is provided in K. Dervis, J. De Melo, Robinson (1982): General Equilibrium models for development policy. World Bank Research Publication. Cambridge University Press.

$$\eta_{(1,1)} = \frac{\beta_1 [p_2 \gamma_2 - Y]}{p_1 c_1} \text{ Adding and subtracting 1 :}$$

$$\eta_{(1,1)} = \frac{\beta_1 [p_2 \gamma_2 - Y]}{p_1 c_1} + 1 - 1$$

$$\eta_{(1,1)} = \frac{\beta_1 [p_2 \gamma_2 - Y] + p_1 c_1}{p_1 c_1} - 1 \text{ Recalling that, from the demand function :}$$

$p_1 c_1 = p_1 \gamma_1 + \beta_1 (Y - p_1 \gamma_1 - p_2 \gamma_2)$ and substituting in the numerator :

$$\eta_{(1,1)} = \frac{\beta_1 (p_2 \gamma_2 - Y) + p_1 \gamma_1 + \beta_1 (Y - p_1 \gamma_1 - p_2 \gamma_2)}{p_1 c_1} - 1. \text{ From which :}$$

$$\eta_{(1,1)} = \frac{\beta_1 p_2 \gamma_2 - \beta_1 Y + p_1 \gamma_1 + \beta_1 Y - \beta_1 p_1 \gamma_1 - \beta_1 p_2 \gamma_2}{p_1 c_1} - 1.$$

$$\eta_{(1,1)} = \frac{+ p_1 \gamma_1 - \beta_1 p_1 \gamma_1}{p_1 c_1} - 1$$

$$\eta_{(1,1)} = \frac{(1 - \beta_1) p_1 \gamma_1}{p_1 c_1} - 1.$$

Cleaning p and generalising to the n-commodity case⁵⁸:

$$\eta_{(i,i)} = \frac{\gamma_i (1 - \beta_i)}{c_i} - 1.$$

The model applies a different rearrangement of this formula, derived as follows:

$$\eta_{(i,i)} = \frac{\gamma_i (1 - \beta_i)}{c_i} - 1$$

$$\eta_{(i,i)} = \frac{\gamma_i - c_i - \gamma_i \beta_i}{c_i}$$

Recall from the demand function that:

$$\gamma_i - c_i = -\frac{\beta_i}{p_i} \left[Y - \sum_j p_j \gamma_j \right]$$

Substituting into the numerator, leads to:

⁵⁸ This is the same formula reported in Sadoulet and de Janvry (1995)

$$\eta_{(i,i)} = \frac{-\frac{\beta_i}{p_i} \left[Y - \sum_j p_j \gamma_j \right] - \gamma_i \beta_i}{c_i} \quad \text{rearranging, we get :}$$

$$\eta_{(i,i)} = \frac{-\beta_i \left[Y - \sum_j p_j \gamma_j \right]}{p_i c_i} - \frac{\gamma_i \beta_i}{c_i} \quad \text{multiplying and dividing both RHS terms by } Y :$$

$$\eta_{(i,i)} = \frac{-\beta_i \left[Y - \sum_j p_j \gamma_j \right] Y}{p_i c_i Y} - \frac{\gamma_i \beta_i Y}{c_i Y} \quad \text{and recalling that :}$$

$$\frac{-\left[Y - \sum_j p_j \gamma_j \right]}{Y} = \frac{1}{\omega} \quad \text{i.e. the inverse of the LES Frisch parameter, and substituting :}$$

$$\eta_{(i,i)} = \frac{\beta_i Y}{p_i c_i \omega} - \frac{\gamma_i \beta_i Y}{c_i Y}$$

Recall also that the partial derivative of the LES demand functions, w.r.t. the total expenditure is ⁵⁹:

$$\frac{\partial c_i}{\partial y} = \frac{\beta_i}{p_i} \quad \text{and substituting in the above leads to:}$$

$$\frac{\partial c_i}{\partial Y} = \frac{\beta_i}{p_i} \quad \text{and noting that } \frac{\partial c_i}{\partial Y} \frac{Y}{c_i} = \eta_i, \text{ i.e. the expenditure elasticity of } C_i,$$

$$\eta_{(i,i)} = \frac{\partial c_i}{\partial Y} \frac{Y}{c_i} \frac{1}{\omega} - \frac{\partial c_i}{\partial Y} \frac{Y}{c_i} \frac{\gamma_i p_i}{Y}$$

this implies:

$$\eta_{(i,i)} = \eta_i \frac{1}{\omega} - \eta_i \frac{\gamma_i p_i}{Y}$$

$$\eta_{(i,i)} = -\eta_i \left[\frac{\gamma_i p_i}{Y} - \frac{1}{\omega} \right]$$

After rearranging:

$$\eta_{(i,i)} = -\eta_i \left[\frac{\gamma_i p_i}{Y} - \frac{1}{\omega} \right]$$

which is the formula for the own price elasticity provided in Dervis et al (1982) and used in the model.

⁵⁹ In the LES, the betas are the marginal budget shares, i.e. the change in the budget allocated to each commodity C_i for a change in the total expenditure. This is easily verifiable by differentiating the demand function for C_i in value form w.r.t. the total expenditure y

Cross price elasticities in LES

The model calculates cross-price elasticities in a similar way for both marketed commodities of non-marketed commodities, say, home consumption, for different types of households H. For example, the cross price elasticities for the marketed commodities with the other marketed commodities are calculated as follows⁶⁰:

$$\begin{aligned} &LESELASP(H, 'MRK', C, 'MRK', CP) \\ &\$((ORD(C) NE ORD(CP)) AND LESELASI(C, H) AND LESELASI(CP, H)) \\ &= -LESELASI(C, H) \\ &* PQO(CP) * gammam(CP, H) / (SUM(CPP, SAM(CPP, H)) + SUM(APP, SAM(APP, H))); \end{aligned}$$

In mathematical notation (after dropping the household index H, the formula is the following

$$\eta_{(i,j)} = \frac{-\eta_i p_j \gamma_j}{Y}$$

The formula is derived as follows:

$$c_1 = \gamma_1 + \frac{\beta_1}{p_1} [Y - p_1 \gamma_1 - p_2 \gamma_2]$$

$$\eta_{(1,2)} = \frac{\partial c_1}{\partial p_2} \frac{p_2}{c_1}$$

$$\frac{\partial c_1}{\partial p_2} = -\frac{\beta_1}{p_1} \gamma_2$$

$$\eta_{(1,2)} = -\frac{\beta_1 p_2 \gamma_2}{p_1 c_1}$$

Generalising to the n-case⁶¹:

$$\eta_{(i,j)} = \frac{-\beta_i p_j \gamma_j}{c_i p_i}$$

Noting that: $\beta_i = p_i \frac{\partial c_i}{\partial Y}$ as it can be easily verified differentiating the demand function w.r.t.

Y, and substituting into the numerator:

$$\eta_{(i,j)} = \frac{\partial c_i}{\partial Y} \frac{p_j \gamma_j p_i}{c_i p_i}$$

Cleaning up Pi and multiplying both numerator and denominator by Y, we

get:

$$\eta_{(i,j)} = \frac{\partial c_i}{\partial Y} \frac{Y}{c_i} \frac{p_j \gamma_j}{Y}$$

Recalling the definition of the expenditure elasticity for commodity Ci:

⁶⁰ The

⁶¹ The same formula is provided e.g. in Sadoulet, De Janvry (1995)

$$\eta_i = \frac{\partial c_i}{\partial Y} \frac{Y}{c_i}$$

and substituting it in to the formula above, leads to:

$$\eta_{(i,j)} = \frac{-\eta_i P_j \gamma_j}{Y} \text{ which is the formula used in the model}^{62}.$$

12.2 Armington functions for imported goods

For all the commodities C which are both imported ($Q_m > 0$) and produced domestically ($Q_d > 0$) the model utilises a Constant Elasticity of Substitution (CES) function in order to aggregate domestic production and imports to create a “minimum cost” composite commodity Q_q ⁶³. Therefore, the problem for the economy is to choose the appropriate mix of Q_m and Q_d which minimizes the cost of a given quantity Q_q , knowing that Q_q is linked to Q_m and Q_d by the CES “production” function⁶⁴.

$$\overline{Min}_{Q_m, Q_d} P_q Q_q = P_m Q_m + P_d Q_d$$

$$\text{s.t. } Q_q = \alpha \left[\delta Q_m^{-\rho} + (1 - \delta) Q_d^{-\rho} \right]^{\frac{1}{\rho}}$$

Using the method of Lagrange multipliers, the minimization problem amounts to:

$$\overline{Min}_{Q_m, Q_d, \lambda} L = P_m Q_m + P_d Q_d - \lambda \left\{ \alpha \left[\delta Q_m^{-\rho} + (1 - \delta) Q_d^{-\rho} \right]^{\frac{1}{\rho}} - Q_q \right\}$$

The first order partial derivatives of the lagrangean are:

$$\frac{\partial L}{\partial Q_m} = P_m - \frac{\partial \lambda \{ \dots \}}{\partial \{ \dots \}} \frac{\partial \{ \dots \}}{\partial Q_m} = P_m - \lambda \alpha \left(-\frac{1}{\rho} \right) \left[\dots \right]^{\frac{\rho-1}{\rho}} (-\rho) \delta Q_m^{-(\rho+1)}$$

$$\frac{\partial L}{\partial Q_d} = P_d - \frac{\partial \lambda \{ \dots \}}{\partial \{ \dots \}} \frac{\partial \{ \dots \}}{\partial Q_d} = P_d - \lambda \alpha \left(-\frac{1}{\rho} \right) \left[\dots \right]^{\frac{\rho-1}{\rho}} (-\rho) (1 - \delta) Q_d^{-(\rho+1)}$$

⁶² As also provided in Dervis et Al. (1982).

⁶³ The CES function was originally introduced by K.J. Arrow, H.B. Chenery, B.S. Minhas and R.M. Solow (1961): Capital-Labour Substitution and Economic Efficiency, Review of Economics and Statistics, August 1961 pp 225-50.

⁶⁴ The objective function of the minimization problem enters in the CGE model as the equation of the “absorption” for each commodity C which is both produced domestically and imported. This equation provides the total value of the composite commodity C absorbed by the economic system. Note that, dividing both sides of the equation by Q_q , the equation provides the price of the composite commodity C as the weighted sum of prices P_d and P_m , where the weights are the shares of Q_m and Q_d with respect to Q_q .

$$\frac{\partial L}{\partial \lambda} = \alpha[\dots]^{\frac{1}{\rho}} - Qq$$

The first order conditions amount to:

$$Pm - \lambda \alpha \left(-\frac{1}{\rho} \right) [\dots]^{\frac{\rho-1}{\rho}} (-\rho) \delta Qm^{*-(\rho+1)} = 0 \Rightarrow Pm = \lambda \alpha \left(-\frac{1}{\rho} \right) [\dots]^{\frac{\rho-1}{\rho}} (-\rho) \delta Qm^{*-(\rho+1)}$$

$$Pd - \lambda \alpha \left(-\frac{1}{\rho} \right) [\dots]^{\frac{\rho-1}{\rho}} (-\rho)(1-\delta) Qd^{*-(\rho+1)} = 0 \Rightarrow Pd = \lambda \alpha \left(-\frac{1}{\rho} \right) [\dots]^{\frac{\rho-1}{\rho}} (-\rho)(1-\delta) Qd^{*-(\rho+1)}$$

$$\alpha \left[\delta Qm^{*-\rho} + (1-\delta) Qd^{*-\rho} \right]^{\frac{1}{\rho}} - Qq = 0 \Rightarrow \alpha \left[\delta Qm^{*-\rho} + (1-\delta) Qd^{*-\rho} \right]^{\frac{1}{\rho}} = Qq$$

This implies that, taking the ratio of the first two first order conditions:

$$\frac{Pm}{Pd} = \frac{\lambda \alpha \left(-\frac{1}{\rho} \right) [\dots]^{\frac{\rho-1}{\rho}} (-\rho) \delta Qm^{*-(\rho+1)}}{\lambda \alpha \left(-\frac{1}{\rho} \right) [\dots]^{\frac{\rho-1}{\rho}} (-\rho)(1-\delta) Qd^{*-(\rho+1)}} \Rightarrow \frac{Pm}{Pd} = \frac{\delta}{(1-\delta)} \left[\frac{Qm^*}{Qd^*} \right]^{-(\rho+1)}$$

Here, the import-domestic price ratio is expressed as a function of the import-domestic demand ratio. We can then work out the import-domestic demand ratio as a function of the domestic-import price ratio:

$$\frac{(1-\delta) Pm}{\delta Pd} = \left[\frac{Qm^*}{Qd^*} \right]^{-(\rho+1)} \Rightarrow \frac{Qm^*}{Qd^*} = \left[\frac{(1-\delta) Pm}{\delta Pd} \right]^{\frac{-1}{(\rho+1)}} \Rightarrow \frac{Qm^*}{Qd^*} = \left[\frac{\delta Pd}{(1-\delta) Pm} \right]^{\frac{1}{(\rho+1)}}$$

The import-domestic demand ratio expressed as a function of the domestic-import price ratio enter, together with the CES Composite supply function (the Armington function) and the price function of the composite commodity, as expressed by the objective function of the minimisation problem, into the set of equations of the model⁶⁵.

Note that, as the production function constraining the cost minimisation problem is a CES, the elasticity of the import-domestic demand ratio with respect to the domestic-import price ratio is constant (i.e. does not depend upon the level of the demand or price ratios). It is expressed by:

⁶⁵ Note that, if the prices Pm and Pd are assumed exogenous as well as the quantity of composite commodity to be obtained Qq, these three equations determine the three endogenous variables Qm Qd and Pq, i.e. the optimal quantities of “inputs” Qm and Qd to obtain a given quantity of “output” Qq at the minimum cost Pq.

$$\varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} = \frac{\partial \frac{Qm^* Pd}{Qd^* Pm}}{\partial \frac{Pd}{Pm} \frac{Qm^*}{Qd^*}} = \frac{1}{(\rho+1)} \left[\frac{\delta}{(1-\delta)} \right]^{(\rho+1)} \left[\frac{Pd}{Pm} \right]^{(\rho+1)-1} \frac{Pd}{Pm} \left[\frac{\delta}{(1-\delta)} \right]^{-(\rho+1)} \left[\frac{Pd}{Pm} \right]^{-(\rho+1)}$$

$$\frac{\partial \frac{Qm^* Pd}{Qd^* Pm}}{\partial \frac{Pd}{Pm} \frac{Qm^*}{Qd^*}} = \frac{1}{(\rho+1)} \left[\frac{\delta}{(1-\delta)} \right]^{(\rho+1)} \left[\frac{Pd}{Pm} \right]^{(\rho+1)-1} \frac{Pd}{Pm} \left[\frac{\delta}{(1-\delta)} \right]^{-(\rho+1)} \left[\frac{Pd}{Pm} \right]^{-(\rho+1)}$$

Executing the multiplications on the RHS above, leads to:

$$\varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} = \frac{1}{(\rho+1)} \left[\frac{\delta}{(1-\delta)} \right]^{(\rho+1)} \left[\frac{Pd}{Pm} \right]^{1-\rho-1+\rho+1} \Rightarrow$$

$$\varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} = \frac{1}{(\rho+1)} \quad (\rho+1) \neq 0 \Rightarrow \rho \neq -1$$

A positive elasticity of substitution ensures that the share of imported goods in the mix of the composite commodity increases if the price of the domestic good increases relative with respect to the price of the imported good, and vice-versa. This implies:

$$\varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} > 0 \Rightarrow \frac{1}{(\rho+1)} > 0 \Rightarrow \rho > -1$$

However, note that in the CES function ρ appears at the denominator of the exponent. This implies that:

$$\rho \neq 0 \Rightarrow \frac{1}{(\rho+1)} \neq 1 \Rightarrow \varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} \neq 1$$

i.e. the elasticity of substitution, when using a CES, cannot take the value 1, as in the case of the Cobb Douglass. It can approximate to 1 for $\rho \rightarrow 0$.

On the other hand, the elasticity of substitution cannot take the value 0 for any value of ρ . It can only approximate to 0 for $\rho \rightarrow \infty$. To summarize, when using the CES function, the links between the value of ρ and the elasticity of substitution are as follows:

$$-1 < \rho < 0 \Rightarrow 1 < \varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} < \infty$$

$$\rho > 0 \Rightarrow 0 < \varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} < 1$$

$$\rho < -1 \Rightarrow \varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} < 0$$

$$\rho \neq 0, \rho \neq -1$$

Calibration of the Armington functions in the model

In the model, the rho (exponent) for each commodity, which is both imported and produced domestically, is worked out from the elasticity of substitution SIGMAQ, provided in the database of specific country data:

$$\varepsilon_{\frac{Qm^* Pd}{Qd^* Pm}} = \frac{1}{(\rho + 1)} \Rightarrow \rho = \frac{1 - \varepsilon}{\varepsilon}$$

The delta (share parameter) is worked out from the tangency condition with prices and

quantities at the benchmark: $\frac{Qm_0^*}{Qd_0^*} = \left[\frac{\delta Pd_0}{(1 - \delta) Pm_0} \right]^{\frac{1}{(\rho+1)}}$

After some algebraic calculations, this leads to⁶⁶:

$$\delta = \frac{\frac{Pm_0}{Pd_0} \left[\frac{Qm_0}{Qd_0} \right]^{(\rho+1)}}{1 + \frac{Pm_0}{Pd_0} \left[\frac{Qm_0}{Qd_0} \right]^{(\rho+1)}}$$

Once delta is worked out, it is replaced in the Armington production function in order to work out alpha (scale parameter).

$$Qq = \alpha \left[\delta Qm^{-\rho_c} + (1 - \delta) Qd^{-\rho_c} \right]^{\frac{1}{\rho_c}} \Rightarrow$$

$$\alpha = Qq \left[\delta Qm^{-\rho_c} + (1 - \delta) Qd^{-\rho_c} \right]^{\frac{1}{\rho_c}}$$

12.3 CET functions for Export versus Domestic Supply.

The problem of trading-off the output to be sold on the domestic market QD versus the output to be exported QE is addressed by the producer by trying to maximise his/her aggregated sales revenue on domestic and export markets. The producer faces a technical constraint expressed by means of a Constant Elasticity of Transformation (CET) function, where QD can be transformed into QE and vice-versa but QD is not a perfect transformation of QE, in a

⁶⁶ Note that in the model the numerator is called; PREDELTA. Therefore:

$$PREDELTA = \frac{Pm_0}{Pd_0} \left[\frac{Qm_0}{Qd_0} \right]^{(\rho+1)} \quad \text{therefore: } \delta = \frac{PREDELTA}{1 + PREDELTA}$$

one-to-one way. This means that a reduction of one unit of QD allows one to obtain less than or more than one unit of QE according to the relative quantity QE/QD. Broadly speaking, if QE/QD is relatively high, a reduction of a unit of QD will allow only small increases of QE. Vice-versa, if QE/QD is small, a reduction in QD will allow large increases of QE.

The maximisation problem can be set as follows:

$$\begin{aligned} \underset{Qe, Qd}{\text{Max}} \overline{PXQX} &= PeQe + PdQd \\ \text{s.t. } QX &= \alpha \left[\delta Qe^{-\rho} + (1-\delta)Qd^{-\rho} \right]^{-\frac{1}{\rho}} \end{aligned}$$

Using the method of Lagrange multipliers, the maximisation problem amounts to:

$$\underset{Qe, Qd, \lambda}{\text{Max}} L = PeQe + PdQd - \lambda \left\{ \alpha \left[\delta Qe^{-\rho} + (1-\delta)Qd^{-\rho} \right]^{\frac{1}{\rho}} - QX \right\}$$

The revenue maximisation problem, which can be solved in a similar way as the Armington cost minimisation problem described in the section above, gives rise to two supply functions, one for Qe and one for Qd which are direct functions of own-prices (Pe and Pd respectively) and inverse functions of the cross-prices (Pd and Pe respectively). In an alternative, the quantity ratio⁶⁷ can be derived from the ratio of the two first-order conditions:

$$\frac{Qe^*}{Qd^*} = \left[\frac{\delta}{(1-\delta)} \frac{Pd^*}{Pe^*} \right]^{\frac{1}{(\rho+1)}}$$

The elasticity of transformation can be worked out, as above as⁶⁸:

$$\mathcal{E}_{\frac{Qe}{Qd}, \frac{Pd}{Pe}} = \frac{\partial \frac{Qe}{Qd} \frac{Pd}{Pe}}{\partial \frac{Pd}{Pe} \frac{Qe}{Qd}} = \frac{1}{(\rho+1)} \left[\frac{\delta}{(1-\delta)} \right]^{\frac{1}{(\rho+1)}} \left[\frac{Pd}{Pe} \right]^{\frac{1}{(\rho+1)}-1} \frac{Pd}{Pe} \left[\frac{\delta}{(1-\delta)} \right]^{\frac{-1}{(\rho+1)}} \left[\frac{Pd}{Pe} \right]^{\frac{-1}{(\rho+1)}}$$

After some manipulations we get:

$$\begin{aligned} \mathcal{E}_{\frac{Qe}{Qd}, \frac{Pd}{Pe}} &= \frac{1}{(\rho+1)} \left[\frac{\delta}{(1-\delta)} \right]^{\frac{1-1}{(\rho+1)}} \left[\frac{Pd}{Pe} \right]^{\frac{1-\rho-1+\rho+1}{(\rho+1)}} \Rightarrow \\ \mathcal{E}_{\frac{Qe}{Qd}, \frac{Pd}{Pe}} &= \frac{1}{(\rho+1)} \end{aligned}$$

⁶⁷ This ratio enters in the set of equations of the model. In this model however, the CET is written with the positive power ρ , which implies that the quantity ratio is reported with the exponent $(-\rho+1)$ or analogously,

with exponent $(\rho-1)$ but the inversed basis, as follows: $\frac{Qe^*}{Qd^*} = \left[\frac{(1-\delta) Pe}{\delta Pd} \right]^{\frac{1}{(\rho-1)}}$

⁶⁸ From now on we drop the star signalling optimality, for simplicity of notation.

Note that the denominator has to be different from zero, therefore:

$$(\rho + 1) \neq 0 \Rightarrow \rho \neq -1$$

We assume the elasticity of transformation to be negative⁶⁹:

$$\frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe} < 0 \Rightarrow \frac{1}{(\rho + 1)} < 0 \Rightarrow \rho < -1$$

Note also that ρ can also be expressed as function of the elasticity of transformation:

$$\frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe} = \frac{1}{(\rho + 1)} \Rightarrow (\rho + 1) = \frac{1}{\frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe}}, \text{ so that}^{70}:$$

$$\rho = \frac{1}{\frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe}} - 1 .$$

This implies that, when using a CET, the elasticity of substitution cannot be zero:

$$\frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe} \neq 0$$

Calibration of the CET parameters ρ , δ and α

The calibration of the CET parameters is analogous to the calibration of the CES. ρ is calculated from the elasticity parameter as above.

δ is worked out starting from the quantity ratio, where prices and quantities are set at the benchmark level:

$$\delta = \frac{\frac{Pe_0}{Pd_0} \left[\frac{Qe_0}{Qd_0} \right]^{(\rho+1)}}{1 + \frac{Pe_0}{Pd_0} \left[\frac{Qe_0}{Qd_0} \right]^{(\rho+1)}} \text{ or, analogously, after some manipulations:}$$

$$\delta = \frac{1}{1 + \frac{Pd_0}{Pe_0} \left[\frac{Qd_0}{Qe_0} \right]^{(\rho+1)}}$$

⁶⁹ Note that in the model, given the change in the sign of ρ in the CET, the elasticity results:

$$\frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe} = \frac{1}{(1 - \rho)} . \text{ Therefore: } \frac{\mathcal{E}_{Qd', Pe}^{Qe, Pd}}{Qd', Pe} < 0 \Rightarrow \frac{1}{(1 - \rho)} < 0 \Rightarrow \rho > 1 .$$

⁷⁰ Note that, for some reasons, in the model, the elasticity value (parameter *SIGMAT*) is inserted in the country database as a positive value. Therefore, ρ has to be calculated as: $\rho = \frac{1}{SIGMAT} + 1$. This ensures a positive

ρ (and always greater than 1) and, given the positive sign of the exponent ρ in the CET, leads to a negative elasticity of transformation, as desired.

Note that $0 < \delta < 1$ as the denominator is always greater than 1 because it is 1 plus a positive quantity. Indeed, the price ratio is positive, the quantity ratio is positive as well and it keeps the positive sign even if powered with whatever exponent (for whatever value of rho).

Note also that the restriction of the elasticity of transformation to be negative implies that $\rho < -1$, thus $(\rho + 1) < 0$. This leads, other things equal, to $\delta \rightarrow 0$ if $\frac{Qd}{Qe} \rightarrow 0$, as this

implies that $\left[\frac{Qd}{Qe} \right]^{(\rho+1)} \rightarrow \infty$ as well as all the denominator. On the other hand $\delta \rightarrow 1$ if

$\frac{Qd}{Qe} \rightarrow \infty$. In other words, a large share of exports implies a small delta, vice-versa, a small share of exports implies a large delta.

Closure of the “Rest of the World” account.

So far, in discussing the different macro-closures, we made reference to a “closed economy” simplified CGE.

The exchange rate (variable *EXR*) in the CGE model adopted plays the role of converting prices on internationally traded commodities, as well as incoming and outgoing flows of transfers (e.g. remittances for factor services) expressed in foreign currency, into domestic currency.

The variable *EXR* is a “real exchange rate”, as the numeraire of the model is the domestic price level (consumer price index- variables *CPI* – or producer price index), so that *EXR*, i.e. the “price” of the foreign currency is expressed relative to the domestic price level.

In general terms, the “real exchange rate” for period (or scenario) 1, *RER*₁ is the quantity of domestic currency expressed in real terms, i.e. at constant prices (net of the domestic price changes) required for buying one unit of foreign currency at constant (expressed in real terms as well).⁷¹

$$RER_1 = \frac{DC_1 / PD_{1,0}}{FC_1 / PF_{1,0}}, \text{ where: } DC_1 \text{ is the quantity of domestic currency required in period}$$

(scenario) 1 to buy one unit of foreign currency (*FC*₁) in period (scenario) 1, *PD*_{1,0} and *PF*_{1,0} are respectively the domestic and foreign price indexes for period (scenario) m1 with respect to period (scenario) 0.

EXR plays the role of equilibrating the current external account (equation *CURACCBAL* in the model), if the deficit in foreign currency (variable *FSAV*) is exogenously fixed.

⁷¹ Note that to calculate “real” exchange rates, a “benchmark” (period or scenario) is needed, which allows to express the two currencies in terms of their constant purchasing power within their respective domestic economic systems.

In its simplest version (assuming one import commodity and one export commodity and no transfers), the model for the current external balance is as follows:

$$QM \cdot PWM - QE \cdot PWE = FSAV \quad (1)$$

$$QM = f\left(\frac{PM}{PD}\right) \quad (2)$$

$$PM = PWM \cdot EXR \quad (3)$$

$$QE = g\left(\frac{PE}{PD}\right) \quad (4)$$

$$PE = PWE \cdot EXR \quad (5)$$

where:

QM and QE are respectively the quantity of imports and exports, PWM and PWE are respectively the international price of imports, PM and PE are respectively the prices of imports and exports in domestic currency, PD is the domestic price level, $FSAV$ and EXR are defined as above, f and g are functional forms for the demand of imports (2) and the supply of exports (4) respectively, (1) is the current account balance.

Assuming that the domestic price level is given (determined in other parts of the model), the international prices are exogenous and the deficit of the current account $FSAV$ is exogenously fixed as well, the model becomes:

$$QM \cdot \overline{PWM} - QE \cdot \overline{PWE} = \overline{FSAV} \quad (1a)$$

$$QM = f\left(\frac{PM}{PD}\right) \quad (2a)$$

$$PM = \overline{PWM} \cdot EXR \quad (3a)$$

$$QE = g\left(\frac{PE}{PD}\right) \quad (4a)$$

$$PE = \overline{PWE} \cdot EXR \quad (5a)$$

i.e. a model of five equations with five variables: QM , QE , PM , PE and EXR .

Any shift in the international prices of imports and/or exports has to be adjusted, in order to satisfy the (1a), by changes of QM and QE . These physical quantities are functions of PM and PE respectively, which in turn are functions of the exchange rate EXR and of \overline{PWM} and \overline{PWE} respectively. The exchange rate therefore has to adjust in order to alter the prices of imports and exports with respect to the domestic prices, in such a way that QM and QE vary up to a point where the (1a) is satisfied.

The (1a) can be interpreted also as the equilibrium condition of the Foreign Currency (FC) market, for any given level of the exchange rate EXR , where:

$$FC_d = QM \cdot \overline{PWM} \quad (6)$$

$$FC_s = QE \cdot \overline{PWE} + \overline{FSAV} \quad (7)$$

represent respectively the quantity of FC demanded for importing goods and the quantity of FC supplied by exporting goods plus the currency made available by the foreign investors.

Substituting (2a) in (6) and (4a) in (7) yields:

$$FC_d = f\left(\frac{PM}{PD}\right) \cdot \overline{PWW} \quad (6a)$$

$$FC_s = g\left(\frac{PE}{PD}\right) \cdot \overline{PWE} + \overline{FSAV} \quad (7a)$$

Furthermore, substituting (3a) and (5a) in (6a) and (7a) respectively, yields:

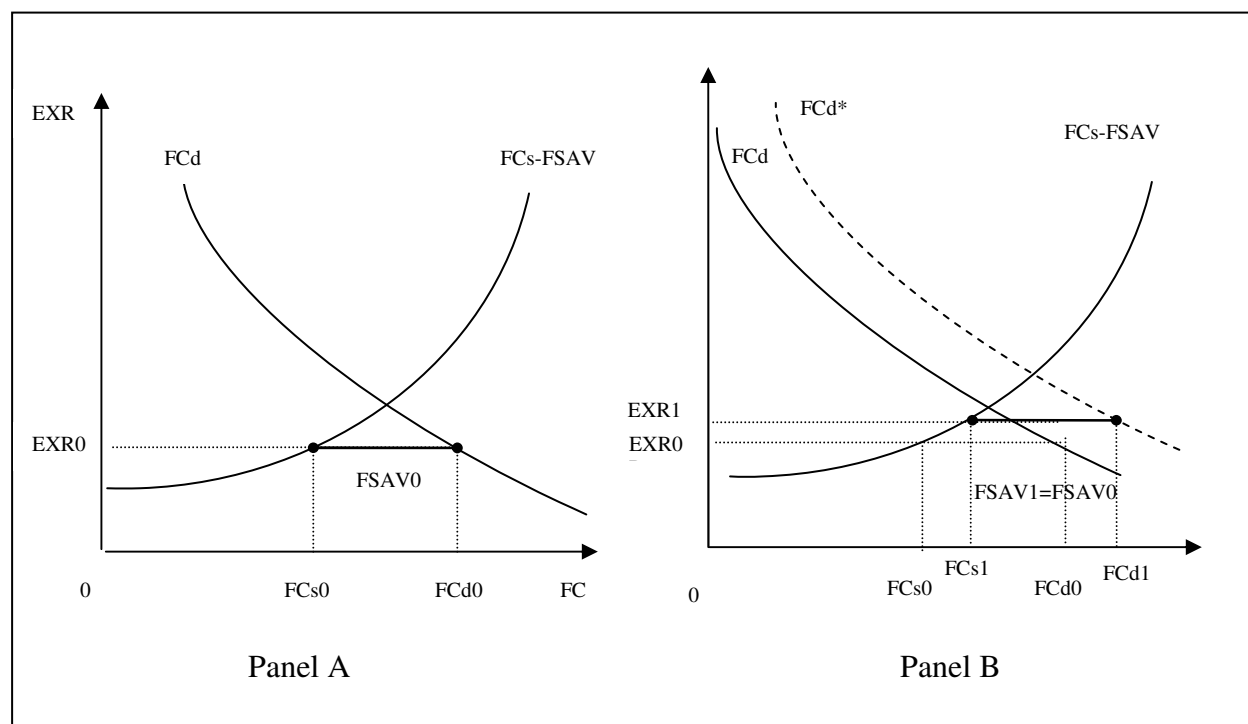
$$FC_d = f\left(\frac{\overline{PWW} \cdot EXR}{PD}\right) \cdot \overline{PWW} \quad (6b)$$

$$FC_s = g\left(\frac{\overline{PWE} \cdot EXR}{PD}\right) \cdot \overline{PWE} + \overline{FSAV} \quad (7b)$$

To ensure the convergence of the foreign currency market, the first derivatives of the FC demand and supply should have opposite signs. It is expected that, when EXR increases, other things equal, imports decrease and exports increase, i.e. that FC_d and FC_s be downward and upward sloping functions w.r.t. EXR , respectively.

The foreign currency market can therefore be represented as in figure A1, panel A. At $EXR = EXR_0$ the excess demand of foreign currency is compensated by the level of $FSAV = FSAV_0$.

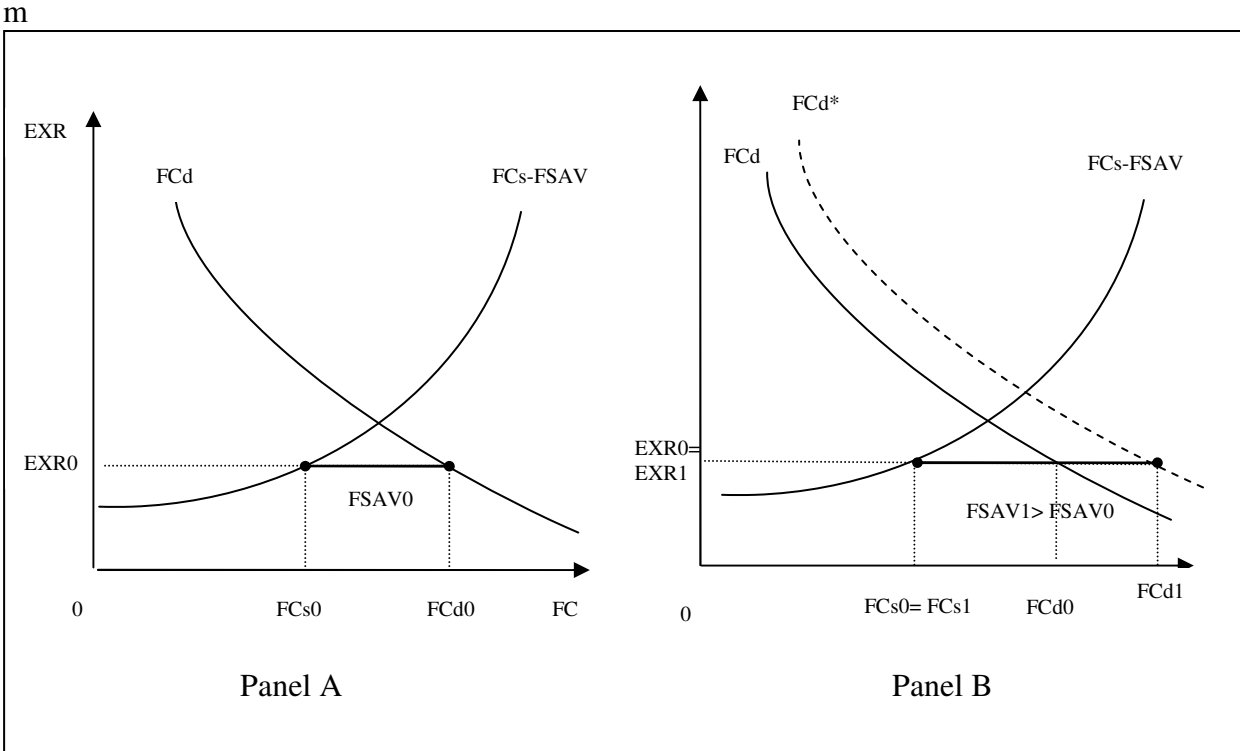
Figure A1 The Foreign currency market: adjustment of the EXR



A shift in an international price, say of imports, other things equal will shift the FC demand curve upward (see panel B of figure A1). If the deficit of the balance of trade has to be kept at the level $FSAV = FSAV_0$, the exchange rate has to increase up to the level EXR_1 .

If, in alternative the RER is fixed, on the foreign currency market shifts in the deficit/surplus are generated. If, e.g.

Figure A2 Foreign currency market: adjustment of the deficit/surplus



Adjustments of the real exchange rate under fixed nominal exchange rate

In a concrete situation where the nominal exchange rate is fixed, as in the case of the Franc CFA with respect to the Euro, the real exchange rate has to adjust via adjustments in the ratios of price changes. This is apparent if the real exchange rate formula is rewritten as:

$$RER_1 = \frac{DC_1}{FC_1} \frac{PF_{1,0}}{PD_{1,0}} \tag{8}$$

The same formula can be written for period (scenario) 0:

$$RER_0 = \frac{DC_0}{FC_0} \frac{PF_{0,-1}}{PD_{0,-1}} \tag{9}$$

The first factor in the right hand side of the (8), $\frac{DC_1}{FC_1}$, is the nominal exchange rate in period (scenario) 1. As this is by definition equal to that of period (scenario) 0, i.e.

$$\frac{DC_1}{FC_1} = \frac{DC_0}{FC_0} \quad (10)$$

In the case of an upward shift of the demand of foreign currency due to e.g. a rise in the international price of imports, the RER has to increase by means of an upward shift of the second factor, i.e. it has to be:

$$\frac{PF_{1,0}}{PD_{1,0}} > \frac{PF_{0,-1}}{PD_{0,-1}} \quad (11)$$

Assuming that the change of foreign prices (i.e. the foreign inflation) $PF_{1,0}$ is exogenous (as it is in almost all practical situations) and fixed, the increase in the RER occurs by means of a decrease of the domestic inflation, i.e. it has to be :

$PD_{1,0} < PD_{0,-1}$. In summary, to keep the domestic currency pegged to the foreign currency, yet obtaining an increase of the RER, the domestic inflation has to decrease. Following Sadoulet & De Janvry 1995⁷², this may happen because an increased demand of foreign currency generates an increased deficit in the current account balance. The central bank, to maintain the nominal exchange rate, has to sell foreign against domestic currency, thus absorbing liquidity in the system. This reduced money supply entails a reduction of the general level of domestic prices, thus reducing $PD_{1,0}$ with respect to $PD_{0,-1}$.

Slope of the demand and supply of the foreign currency

Note that QM and QE are respectively functions of $\frac{PM}{PD}$ and $\frac{PE}{PD}$ (equations 2a and 4a), and

$\frac{PM}{PD}$ and $\frac{PE}{PD}$ are both functions of EXR : (equations 3a and 5a, respectively).

Therefore, the first derivative of FC_d and FC_s with respect to EXR can be expressed, by means of the chain rule for the derivatives of functions of functions, as:

$$\frac{\partial FC_d}{\partial EXR} = \frac{\partial QM}{\partial \left(\frac{PM}{PD} \right)} \cdot \frac{\partial PM}{\partial EXR} \cdot \overline{PWW} \quad (12)$$

$$\frac{\partial FC_s}{\partial EXR} = \frac{\partial QE}{\partial \left(\frac{PE}{PD} \right)} \cdot \frac{\partial PE}{\partial EXR} \cdot \overline{PWE} \quad (13)$$

As $\frac{\partial PM}{\partial EXR}$ and $\frac{\partial PE}{\partial EXR}$ on the basis of (3a) and (5a) are \overline{PWW} and \overline{PWE} respectively, (12) and (13) can be written as:

⁷² Sadoulet E, De Janvry A. 1995: Quantitative development policy analysis Johns Hopkins Ed. p.215.

$$\frac{\partial FC_d}{\partial EXR} = \frac{\partial QM}{\partial \left(\frac{PM}{PD} \right)} \cdot \overline{PWM}^2 \quad (12a)$$

$$\frac{\partial FC_s}{\partial EXR} = \frac{\partial QE}{\partial \left(\frac{PE}{PD} \right)} \cdot \overline{PWE}^2 \quad (13a)$$

This implies that:

$$\frac{\partial FC_d}{\partial EXR} < 0 \quad (14)$$

$$\frac{\partial FC_s}{\partial EXR} > 0 \quad (15)$$

On the basis of (12a) and (13a), therefore, it has to be that:

$$\frac{\partial QM}{\partial \left(\frac{PM}{PD} \right)} < 0 \quad (16)$$

$$\frac{\partial QE}{\partial \left(\frac{PE}{PD} \right)} > 0 \quad (17)$$

i.e. that the imports decrease as the relative price of imports with respect to the domestic price level increase and that exports increase as the relative price of exports with respect to the domestic price level increase.

In the CGE model The (16) and (17) are assured by the proper signs of the elasticities of substitution between imports and domestic commodities in the CES functions and of the elasticities of transformation of exports into domestic commodities in the CET functions.