Regionalization and Labour Market Rigidities in Developing Countries: A CGE Analysis of UEMOA[§]

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Summary

In this study, we analyse the impact of the creation of a customs union among UEMOA (Western African Economic and Monetary Union) countries, with a special emphasis on the labour market structure. The implementation of the customs union reform will translate in most of these countries, into a greater openness, even with third party countries. This greater openness raises concerns in these countries as regards its potential impact on welfare, production and employment. In this study, in contrast to many other papers, we relax the assumption of a perfect functioning of the labour market. We consider the presence of a dualism in the labour market and the existence of a minimum wage for the formal workers. We use a multi-country and multi-sectoral computable general equilibrium model (CGE) to assess the impact of the reform. We find that the presence of a minimum nominal wage for the formal workers may significantly reduce the gains stemming from the customs union reform. Our simulation results indicate that the costs induced by this rigidity may exceed 45%, in some cases, in terms of the reduction in the welfare gains obtained without rigidity.

1. Introduction

In this study we analyze the impact of the creation of regional trade agreement (RTA) in January 1994[4] among UEMOA[5] (Western African Economic and Monetary Union) countries, with a special emphasis on the labour market structure. The creation of this union occurs in an international environment characterized by a proliferation in the formation of regional blocs. Beyond the pessimism that this new trend in international trade may induce among some economists[6], as regards its impact on welfare, it is generally believed that such agreements can be beneficial, if they involve a reduction in the protection against non-member countries.[7] The implementation of the UEMOA agreement will translate into a tariff removal among its members and the application of common external tariffs to third party countries. The latter will result in a greater openness for most countries of the union. This greater openness raises many concerns in these countries, in relation to its potential impact on welfare, production and employment.

The economic impact of the agreement in each country will depend, among other factors, on its economic structure and, in particular, on the functioning of the labour market. Several studies, like Milner and Wright (1998), Devarajan, Ghanem and Thierfelder (1997) and Edwards and Edwards (1994), among others, have shown that functioning of the labour market may affect the gains resulting from a trade liberalization reform. In fact, the changes in relative prices, induced by the reduction in the protection afforded to some sectors, induce a factor reallocation in the economy. Efficiency gains from this reallocation depend, among other things, on wage flexibility in the labour market. Most of the previous studies, which analyzed the impact of RTAs in different regions of the world, gave little attention to the labour market structure, Decaluwé, Dissou and Patry (1998), Harrisson and al. (1997) and DeRosa (1995), among others. They made the assumption of a perfect labour market functioning. If this assumption is suitable for developed countries, it is less appropriate for developing countries. Many studies, like Agenor and Aizenman (1999), Fortin et al.

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[4] The full implementation of the treaty has been effective since January 2000.

[5] UEMOA was first composed by Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo, and was later joined by Guinée Bissau.

[6] Perroni and Whalley (2000) and Winters (1996) provide some interesting reviews on this theme.

[7] This idea is defended by the proponents of the "open regionalism" thesis. See Wei and Frankel (1998) for details on this notion.

(1997), Riveros (1994) and Rosenzweig (1988), among others, have reported the presence of numerous distortions and of a dualism on the labour market in developing countries. This dualism stems from the existence of two types of labour, namely the formal and informal workers. The former receives higher income and welfare benefits, as opposed to the latter. Moreover, the downward rigidity of formal workers' wage is the most encountered form of labour market distortion in developing countries. This exogenous[8] rigidity often originates from government laws or from the negotiation power of unions, which seek to insure a minimum income to their members.

The economic impacts of a minimum wage imposed for a particular category of labour, in a partial equilibrium framework, are well documented in the economic literature. With such a distortion, the level of employment being always determined by the firms, a quantity adjustment may occur following a change in relative prices. If the rationed formal workers are able to move to the non-regulated market, the reduction in their demand will entail greater competition between the newly unemployed formal workers and the informal workers. Consequently, a downward pressure will be exerted on the wage of informal labour. This phenomenon may negatively affect the size of the gains following a trade liberalization reform. The plausibility of this phenomenon is even higher when the workers protected by the minimum wage legislation are mainly employed in the most protected sectors before the reform. Moreover, this adjustment becomes more painful when protected sectors employ less informal workers. Taking into account the labour market structure is thus desirable in the evaluation of the real impacts of a customs union reform.

This aspect is very relevant in the case of UEMOA countries, where a recent study by Rama (1998) shows that the downward rigidity of the nominal wage in the "CFA countries[9]" has contributed to the overvaluation of their currency, recently devaluated by 100% in 1994. To our knowledge, Park (1995) presents the only regional integration model, involving developing countries, which departs from the assumption of perfect functioning of the labour market.

The objective of this study is to assess the impact of the reform on the UEMOA members, in the presence of distortions in the labour market. We use a multi-country and multi-sector computable general equilibrium (CGE) model to simulate the impact of the reform with and without these

[8] That is, not explained by the model, as opposed to an endogenous rigidity, as in efficiency wages models.

distortions. We consider the case of a downward rigidity of formal workers' nominal wage. We are thus able to evaluate the welfare cost of these distortions in each country.

The rest of the paper is organized as follows. In the next section, we present the model, then, in the third section, we discuss the data, the calibration procedures and the numerical resolution. The simulation results are discussed in the fourth section, followed by our conclusions in the last section.

2. The Model

We present in this section a thumbnail sketch of the model. Readers interested in fuller details may find the complete listing of equations, variables and parameters in Appendix 2. We develop a static, multi-sector and multi-country, general equilibrium model in the same tradition as De Melo and Tarr (1992). Our model features a disaggregation of the production and consumption sectors in each country as well as the flows of bilateral trade among them. A distinctive characteristic of this model from most of previous multi-country general equilibrium models is the functioning of the labour market. Two types of workers (formal and informal) are considered and the nominal wage of the former is downward rigid.

2.1 Production

Eighteen productive sectors are identified in each of the seven countries of the union[10]. In contrast to Decaluwé, Dissou and Patry (1998), we use the same sectoral disaggregation of the productive sectors in all countries. Firms have access to constant returns to scale technology. Like many general equilibrium models, the present one breaks down the production structure into a sequential decision process, which offers some interesting substitution possibilities among factors. This sequential structure is depicted by nested production functions. The composite output is a Cobb-Douglas function of value-added and the aggregate of material inputs. Value-added is obtained by combining capital and the aggregate input of labour with a constant elasticity of substitution function (CES). The aggregate input of labour is Cobb-Douglas function of the two types of labour categories[11].

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[9] CFA countries are those which use a common currency, F CFA, which is pegged to the French Franc.
[10] See Appendix 1 for the list of sectors.
[11] When they are simultaneously used in the sector.

Finally, the aggregate of material inputs is obtained with a Leontief technology. All firms evolve in a competitive environment and maximize profits to determine output supply and factor demands.

2.2 Demand

In each country, total domestic demand of each commodity is the sum of the demands for household and government's uses and, the demands for investment and intermediate consumption uses. In each country, the preferences of the representative household are represented by a Stone-Geary utility function (or Linear Expenditure System). The household receives income from primary factors' remuneration, transfers from the government and from the rest of the world. A fix portion of its income is used to pay income taxes to the government and its savings are a linear function of its disposable income.

Government's expenditures for each good are fixed in real terms. Its other expenses consist of transfers to households and net transfers to the rest of the world. Its income comes from taxes on international trade (mainly on imports) and taxes on the remuneration of primary factors. Taxes on imports consist of tariffs and other taxes such as value-added tax [12].

2.3 Trade

Referring to Armington (1969), domestic and foreign goods are distinguished by their origins. This specification has the advantage to accommodate both exports and imports of the same commodity (crosshauling). On the demand side, regional imports from other UEMOA countries are distinguished from imports from the rest of the world. Moreover imports from different countries of the Union are imperfect substitutes. A three-level nested CES function allows us to capture the differentiation between imports and domestic commodities. At the first level, domestic absorption (sum of the demands for final and intermediates uses) is a CES function of domestically produced goods and the aggregate of imports. The latter is obtained by combining, with a CES function at the second level, the aggregate of regional imports and the imports from the rest of the world. Finally, the aggregate of regional imports is another CES function of imports from different UEMOA

countries. This nested structure allows the representative agent's decision to take place in the form of a multi-step budgeting. A cost-minimization rule allows the determination of the optimal level of each component of the domestic absorption.

Like imports, exports are differentiated according to their destination. Three nested constant elasticity of transformation (CET) functions allow us to capture the imperfect substitution between the different components of the representative firm's supply in each sector. A revenue maximization principle allows firms to allocate the supply of the aggregate output among its various components. While a small country assumption is used to characterize each country's relationship with the rest of the world, implying fixed world import and export prices, the prices of bilaterally traded goods are fully endogenous. They are determined by the market clearing conditions. Finally, the total current account balance for each country is the sum of its balance with the rest of the world and its regional balance. The latter is the sum of balances with each Union's partner.

2.4 Labour market

Each labour category can move freely among sectors in a country, while it is immobile between countries. When the firm's technology allows the simultaneous use of the two types of labour, it can substitute one type of labour for the other according to Cobb-Douglas technology. Due to government legislation, the nominal wage of formal worker is downward rigid. We suppose that the employment level is always determined by firms, i.e. firms are always on their labour demand curve. When the formal workers' minimum wage is binding, following a change in the relative prices, firms are compelled to lay off some of these workers, since this is the only choice remaining to them. Note that these workers are still willing to work on the ongoing wage on the formal labour market. We assume that the rationed workers have no choice but to compete for employment in the informal labour market. This will translate into a downward pressure on the informal wage. In these conditions, the total labour supply being fixed, the supply of informal labour is endogenous. Its quantity is equal to the sum of the base-run quantity of informal workers and the excess supply of formal workers. In this paper, we depart from many other studies, which analyzed the impacts of

[12] UEMOA countries use the destination principle in the application of the value-added tax. Imports are subject to this tax like domestically produced goods, while exports are exempted.

wage rigidity in CGE models. Instead of simply fixing the level of the formal wage at its minimum value, we allow it to vary freely above its floor level. We are then able to model a truly downward rigidity of the formal workers' wage. Below, further indications, on the way we formalize this aspect in this model, are provided.

2.5 Equilibrium Conditions.

The general equilibrium of this model is represented by a static allocation of goods and factors supported by a vector of prices such that the following conditions are satisfied:

- Equilibrium in the domestic good's market in every country.
- Equilibrium between import demand and export supply in the bilateral trade of each good.
- Balance of payments equilibrium.
- Equilibrium in the labour market.

Referring to the latter equilibrium condition, some additional explanations are required in relation to the formal labour market. We specify the wage inequality condition on the formal labour market and impose an orthogonality condition between the excess supply of formal workers and the difference between the current and minimum formal wages. Referring to Drèze (1975), this orthogonality condition is a required equilibrium condition in the presence of price rigidity. Thus, if the minimum wage is binding, the rationing will be strictly positive, while it is equal to zero in the other case[13]. Finally, on the informal market, wage adjusts to achieve equilibrium between demand and supply of this factor.

2.6 Closure

The model's numéraire is the nominal exchange rate with the rest of the world or, in other words, the rest of the world's imports price index. We distinguish three closures rules in the model. The first closure rule is relative to the government's account. We fix the receipts from indirect taxation at their base-run values and use a new uniform domestic tax as a policy instrument. After a shock the new domestic tax, which replaces the old one, is set at a value such as to achieve the required

[13] Park (1995) has also used this formalisation in the specification of his analytical model.

constraint. The second closure pertains to the macroeconomic equilibrium condition between investment expenditures and savings. The model is savings-driven in the sense that investment expenditures are endogenous and determined by the amount of total available savings. The latter is equal to the sum of the savings of households, firms, government and foreign agents. Note that total foreign savings in each country is the sum of the rest of the word's savings and the regional savings. Finally, the last closure deals with the external account in each country. We assume that each country's total current account is equal to its total foreign savings, which we maintain fixed. This equilibrium condition is achieved by an adjustment of the real exchange rate.

3. Data, calibration and numerical resolution

We calibrate the model on the data of the year 1996, which is the most recent year for which detailed information on national accounts is available for all UEMOA countries. We built a social accounting matrix (SAM) for each UEMOA member, using input-output tables and trade data for each country. Information on government's financial operations and on the balance of payments allows us to complete the construction of the SAM. Tables 1 and 2 present each country's characteristics, according to their respective SAM.

Using these data and other behavior parameters found in the literature, we calibrated all other parameters, such as tax rates and distribution parameters in various functions in order to replicate the base data. The calibration process and the numerical resolution of the model follow classic procedures used in most static CGE models. Table 3 presents some of the critical parameters used in the model. We solve the model numerically with the software GAMS (General Algebraic Modelling Systems) and the solver Conopt.

Table 1: GDP Structure (in %) of UEMOA countries, 1996

	Benin	**Burkina Faso**	**Ivory Coast**	**Mali**	**Niger**	**Senegal**	**Togo**
Private Consumption	82.92	85.14	68.23	83.11	80.03	84.50	82.48
Public Consumption	10.19	11.68	12.58	17.16	17.17	11.67	13.05
Investment	18.52	27.40	13.26	25.78	11.99	17.00	13.01
Exports	28.26	13.98	46.63	20.49	18.96	38.17	31.61
Imports	34.09	33.21	35.41	39.85	25.76	43.07	40.75

Table 2: Trade pattern (in %) of UEMOA countries, 1996

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Regional Exports	2.20	1.03	9.19	1.18	0.29	7.04	2.83
Exports to ROW	97.08	98.97	90.81	98.82	99.71	92.96	97.17
Regional Imports	7.07	18.09	1.34	24.45	13.07	2.22	6.79
Imports from ROW	92.93	81.91	98.66	75.55	86.93	97.78	93.21

Table 3: Substitution Elasticities for some functions

	CES	CES (Armington)			CET (supply)		
		1st level	2nd level	3rd level	1st level	2nd level	3rd level
Food crops	0.45	1.5	3	3	1.5	3	3
Industrial agriculture	0.45	1.5	3	3	1.5	3	3
Livestock	0.45	1.5	3	3	1.5	3	3
Fishing and forestry	0.45	1.5	3	3	1.5	3	3
Extractive industry	0.6	1.5	3	3	1.5	3	3
Food industry	1.5	2	4	4	2	4	4
Textile industry	1.5	2	4	4	2	4	4
Chemical industry	1.5	2	4	4	2	4	4
Metal industry	1.5	2	4	4	2	4	4
Other industry	1.5	2	4	4	2	4	4
Utilities	1.5	2	4	4	2	4	4
Construction	0.95	1.5	3	3	1.5	3	3
Transport, communication	2	1.5	3	3	1.5	3	3
Financial services	2	2	4	4	2	4	4
Real estate services	2	2	4	4	2	4	4
Hotels, bars, rest., commerce	2	2	4	4	2	4	4
Other services	2	2	4	4	2	4	4
Public administration	2	-	-	-	-	-	-

4. Simulations

We evaluate the impact of the customs union reform in two main simulations, where we consider different functioning of the labour market. In the first one, we assume that the labour market functions perfectly with no distortions. Wages adjust to achieve equilibrium between demand and supply for all labour categories. In the second simulation, we assume a downward rigidity of the formal worker's nominal wage. In both simulations, the reform consists of the complete elimination of all tariffs on regional imports and the application of common external tariffs for imports from non-members. These common external tariffs have been set by a UEMOA expert's commission.

Non-regional import goods are classified in four categories 0, I, II and III on which tariff rates of 0, 5, 10 and 20 %, are respectively applied. Given these rates and the product classification, we compute the average nominal tariff rate pertaining to each of the eighteen goods distinguished in the model. Table 4 presents these common external tariffs[14].

In order to take into consideration the exemptions on import duties granted to some agents in all UEMOA countries, we have appropriately scaled down these common external tariffs by using the average exemption rate on imports as provided in Duhamel and Gosset-Grainville (1996). As shown in Table 5, the application of common external tariffs translates into a reduction in trade barriers on non-regional imports, in all UEMOA countries. Moreover, as can be seen from Table 5, the customs union reform translates into a liberalization of total imports, and it allows each Union's member to get a better access to the regional export market.

For a better understanding of the difference between the results of the two main scenarios, we focus our discussions on the basic mechanisms at stake in the first one and explain, for the second simulation, the reasons of the observed changes. We pay particular attention to the adjustments in the labour market. For space restraints, we do not discuss the sectoral results; we mainly concentrate on aggregated results[15], which are presented in Tables 6 and 7.

Table 4: Common external tariffs in UEMOA countries in %

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Food crops	8.6	11.4	7.6	8.7	11.0	8.6	6.2
Ind. agriculture	5.0	5.2	7.8	5.1	5.1	5.4	5.6
Livestock	5.2	5.2	5.6	5.0	7.0	5.6	6.2
Fish.and for.	20.0	10.1	10.1	10.1	11.5	16.3	10.0
Extr. industry	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Food industry	13.8	12.6	12.1	14.7	15.5	13.6	16.4
Textile industry	18.7	19.2	16.0	19.0	18.6	17.3	18.9
Chem. industry	7.9	5.8	5.7	5.9	6.1	7.8	5.8
Metal industry	11.3	11.0	11.5	9.3	11.3	12.9	11.6
Other industry	13.4	13.6	12.0	12.9	13.7	12.0	11.9
Public utilities	8.6	8.1	9.4	8.7	9.2	10.0	10.0

[14] Differences in imports' composition explain the variation in the rate applied to the same commodity across countries.

[15] Interested readers may obtain sectoral results from the authors.

Table 5: Average total import tax rate, in %, before and after the reform.

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Before, on all imports	18.58	20.12	15.37	19.54	11.82	18.36	14.87
After, on all imports	17.30	8.99	9.03	17.73	7.11	7.26	8.60
Before, on regional imports	21.58	27.94	3.92	33.80	15.80	21.93	16.67
After, on regional imports	14.94	11.12	2.10	26.20	6.76	21.74	4.64
Before, on imports from ROW	18.35	18.39	15.52	14.93	11.22	18.28	14.74
After, on imports from ROW	17.48	8.52	9.12	14.98	7.16	6.93	8.89

4.1 Simulation 1: Customs union reform without downward rigidity of the nominal wage of formal workers

The reform's implementation translates into three direct impacts in each country: i) complete elimination of tariff barriers on regional imports; ii) reduction in nominal protection on non-regional imports; and iii) greater access to the regional market. Trade barriers being eliminated or reduced, total imports raise with some trade diversion effect though, in favor of regional imports, in all countries, except Mali and Senegal. Increased imports from the region or from the rest of the world put a downward pressure on domestic prices, which decrease in all countries, except Ivory Coast and Togo. In these two countries, the new uniform tax on domestic goods set to compensate for the drop in tariff revenue, neutralize the downward impact of increased imports on domestic prices.

Since total foreign savings are exogenous in each country, total exports must increase by the same amount as total imports. This increase is achieved by a simultaneous rise in regional and non-regional exports, in different proportion depending on the trade structure of each country. The complete elimination of tariffs on regional imports in the Union promotes regional exports in every country. However, the rise in regional exports is insufficient to satisfy the required increase in total exports, hence, exports to the rest of the world have to rise. In most countries, this increase is brought by the depreciation of the real exchange rate. The largest depreciation is observed in Burkina Faso (5.94%), while Ivory Coast and Togo experience an appreciation, resulting from higher prices for domestically produced goods. Note that, notwithstanding the real exchange rate appreciation, exports to the rest of the world rise in both countries; this result is not counter-intuitive though. In fact, given the nested structure of firm supply by destination, total export supply may increase in spite of the drop in the price of exports relative to the domestic price, if the composite output supply increases.

Table 6: Aggregate impact of customs union reform in UEMOA countries without wage rigidity

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Prices (% change from benchmark)							
Real exchange rate[16]	0.62	5.94	-5.55	1.29	0.20	4.66	-0.24
Consumer price index	-0.64	-6.95	2.54	-2.38	-0.92	-5.79	-1.08
Domestic price index	-0.57	-5.92	5.17	-1.25	-0.19	-4.40	0.28
Nominal wage index	0.84	-6.54	16.74	0.33	1.13	-3.88	3.49
Real wage, formal labour	1.53	-0.36	17.29	-0.38	2.01	1.98	7.02
Real wage, informal labour	1.18	1.68	3.29	5.96	2.32	2.34	1.05
Nominal wage, formal labour	0.89	-7.29	20.28	-2.75	1.08	-3.93	5.86
Nominal wage, informal labour	0.54	-5.39	5.91	3.44	1.38	-3.59	-0.04
Trade (%change from benchmark)							
Total exports	1.50	7.21	40.83	1.59	8.86	7.44	15.64
Regional exports	13.13	21.76	12.25	15.46	13.37	21.42	7.51
Exports to ROW	1.24	7.06	43.71	1.43	8.85	6.38	15.87
Total imports	1.24	3.04	53.92	0.82	6.52	6.59	12.24
Regional imports	6.18	20.80	62.79	-0.12	22.67	-24.78	51.48
Imports from ROW	0.87	-0.89	53.80	1.13	4.09	7.31	9.38
Current Account Balance (% change from benchmark GDP)							
Regional balance	0.06	1.14	-0.21	-0.05	0.73	-0.75	1.28
ROW balance	-0.06	-1.14	0.21	0.05	-0.73	0.75	-1.28
Total balance	0	0	0	0	0	0	0
Households (% change from benchmark)							
Equivalent variation (% of GDP)	-0.09	0.19	6.95	1.01	0.53	0.57	2.15
Household disposable income	-0.15	-6.25	10.82	-0.16	-0.38	-5.53	1.41
Fiscal revenue (%change from benchmark)							
Total fiscal revenue	-0.17	-2.03	1.95	-1.12	-0.03	-1.67	0.1
Indirect tax revenue	-0.38	-7.17	8.85	-0.28	-0.59	-5.98	0.41
Import tax revenue	-6.14	-52.27	-27.89	-10.2	-36.15	-56.35	-33.54
Uniform tax rate on domestic goods (%)	1.35	4.37	5.67	1.94	1.82	4.45	3.89

Besides, the simultaneous change in the domestic and regional export prices affects firms' labour demand via the price of value-added. The nominal wage index increases in all countries, except for Burkina Faso and Senegal, where it falls by 6.54% and 3.88%, respectively. This change is the result of the simultaneous variation of the nominal wages of formal and informal workers. Following the reform, the nominal wage of formal workers falls in Burkina Faso, Mali and Senegal, and increases in all other countries. The nominal wage of informal workers decreases in Burkina Faso, Senegal and Togo and raises in the others. Though nominal wage falls in some countries, real wages (in terms of consumer price index) increase in all countries, except for formal workers in Burkina and Mali. This

latter result stems from the significant reduction in the consumer price index. This index falls in every country, except for Ivory Coast, where it increases by 2.54%. In this country, the increase in domestic prices outweighs the reduction in the price of import goods. In almost every country (except Benin), households benefit from the fall in consumer prices and enjoy a higher welfare, as reported in Table 6 by the equivalent variation expressed in percentage of base-run GDP.

4.2 Simulations 2: Customs union reform in the presence of a downward rigidity of the nominal wage of formal workers

In this simulation, we relax the assumption of perfect flexibility of the nominal wage of formal workers. We introduce a downward rigidity on the nominal wage for these workers and set a floor at the wage level observed in the benchmark data. The traditional adjustments following a trade liberalization and a greater access to regional markets are also observed in the present scenario. In comparison to the first scenario where wages are flexible, the rigidity will be restrictive in Burkina, Mali and Senegal only, where the formal nominal wage fell. Therefore the results will significantly differ from the ones obtained in the previous simulation in these three countries only. Table 7 reports the results of this simulation.

In these countries, firms must ration formal workers because the minimum nominal wage is binding. The surplus of formal workers varies from 2.50 % in Mali to 5.55 % in Burkina Faso. The spillover of rationed formal to the informal labour market increases labour supply and puts a downward pressure on their nominal wage. The latter decreases more or increases less, depending on the country, in comparison to the first simulation. An efficiency loss follows because firms are constrained to use a non-optimal quantity of formal workers. They would have employed more workers in perfect labour market environment.

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[16] An increase in the real exchange rate is equivalent to a depreciation.

Table 7: Aggregate impact of customs union reform in UEMOA countries with wage rigidity

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Prices (% change from benchmark)							
Real exchange rate	0.62	5.25	-5.55	1.04	0.20	4.31	-0.24
Consumer price index	-0.64	-6.40	2.54	-2.19	-0.92	-5.52	-1.08
Domestic price index	-0.57	-5.22	5.17	-1.00	-0.19	-4.03	0.28
Nominal wage index	0.83	-3.67	16.73	1.04	1.13	-1.85	3.49
Real wage, formal labour	1.53	6.84	17.29	2.24	2.01	5.84	7.01
Real wage, informal labour	1.18	-2.93	3.29	4.38	2.32	-8.03	1.04
Nominal wage, formal labour	0.88	0	20	0	1	0	5.86
Nominal wage, informal labour	0.54	-9.15	5.91	2.09	1.38	-13.11	-0.04
Trade (% change from benchmark)							
Total exports	1.50	6.59	40.83	1.51	8.86	6.38	15.63
Regional exports	13.15	21.17	12.39	15.27	13.46	20.69	7.43
Exports to ROW	1.24	6.44	43.70	1.35	8.85	5.30	15.87
Total imports	1.25	2.77	53.92	0.78	6.52	5.66	12.23
Regional imports	5.97	21.05	61.87	-0.06	22.64	-25.18	51.42
Imports from ROW	0.89	-1.26	53.81	1.05	4.10	6.36	9.38
Current Account Balance (% change from benchmark GDP)							
Regional balance	0.06	1.16	-0.22	-0.04	0.73	-0.74	1.28
ROW balance	-0.06	-1.16	0.22	0.04	-0.73	0.74	-1.28
Total balance	0	0	0	0	0	0	0
Households (% change from benchmark)							
Equivalent variation (% of GDP)	-0.09	0.13	6.95	1.01	0.53	0.30	2.15
Excess supply of formal workers	0	5.55	0	2.50	0	4.37	0
Household disposable income	-0.16	-5.92	10.82	-0.16	-0.38	-5.86	1.4
Fiscal revenue (% change from benchmark)							
Total fiscal revenue	-0.17	-1.88	1.95	-0.75	-0.03	-1.76	0.1
Indirect tax revenue	-0.38	-6.89	8.85	-0.27	-0.59	-6.31	0.41
Import tax revenue	-6.14	-52.35	-27.88	-10.2	-36.15	-56.75	-33.55
Uniform tax rate on domestic goods (%)	1.35	4.37	5.67	1.94	1.82	4.50	3.89

Consequently, all three countries experience smaller welfare gains compared to the situation where wages are perfectly flexible. The cost in terms of welfare of the rigidity is high and even reaches 47% in Senegal where the equivalent variation falls from 0.57 to 0.30.

4.3 Sensitivity Analysis

In order to verify the result sensibility to the parameters used, we run four other scenarios in which we use lower and higher values for some key behavioral parameters. We respectively reduced substitution elasticities at different level for the nested Armington function by 25% and raised by 50%. Results from these simulations (see Tables 8 and 9) confirm the qualitative results obtained in the previous simulations with, however, a magnitude that varies depending on the elasticities' value. More precisely, the higher the Armington elasticities are, the greater the excess of rationed workers on the formal market. Furthermore, the welfare loss due to the rigidity on the labour market increases with higher elasticity values in most countries. In Senegal, for instance, the loss reaches 60% in the case of highest elasticities of substitution.

Table 8: Sensitivity analysis of customs union reform in UEMOA countries without wage rigidity (% change from benchmark)

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Real exchange rate (low[17])	0.63	5.6	-5.93	1.12	-0.24	4.03	-0.69
Real exchange rate (high[18])	0.58	6.39	-4.87	1.46	0.8	5.52	0.38
Domestic price index (low)	-0.59	-5.58	5.56	-1.08	0.24	-3.68	0.73
Domestic price index (high)	-0.52	-6.36	4.48	-1.42	-0.79	-5.37	-0.35
Nom. wage, formal (low)	0.91	-6.97	19.4	-2.3	1.44	-3.43	5.93
Nom. wage, formal (high)	0.86	-7.64	22.03	-3.26	0.54	-4.57	5.96
Nom. wage, informal (low)	0.43	-5.48	6.16	3.18	1.59	-3.44	0.25
Nom. wage, informal (high)	0.73	-5.02	5.54	3.94	1.17	-3.79	-0.35
Total exports (low)	1.44	6.75	35.69	1.42	8.04	6.56	13.17
Total exports (high)	1.59	7.87	50.75	1.82	10.03	8.69	19.95
Total imports (low)	1.19	2.84	47.13	0.73	5.92	5.82	10.31
Total imports (high)	1.32	3.31	67.02	0.94	7.38	7.7	15.61
Total fiscal revenue (low)	-0.2	-1.97	1.95	-1.02	0.18	-1.51	0.17
Total fiscal revenue(high)	-0.13	-2.09	1.93	-1.23	-0.31	-1.88	0.04
Equivalent variation % (low)	-0.08	0.11	6.3	0.95	0.53	0.56	1.99
Equivalent variation %(high)	-0.1	0.34	8.17	1.13	0.53	0.59	2.48

[17] Low: Base Armington elasticities are reduced by 25%.
[18] High: Base Armington elasticities are increased by 50%.

Table 9: Sensitivity analysis of customs union reform in UEMOA countries with wage rigidity (% change from benchmark)

	Benin	Burkina Faso	Ivory Coast	Mali	Niger	Senegal	Togo
Real exchange rate (low)	0.63	4.9	-5.93	0.9	-0.24	3.71	-0.69
Real exchange rate (high)	0.58	5.72	-4.87	1.19	0.8	5.14	0.38
Domestic price index (low)	-0.59	-4.88	5.56	-0.86	0.24	-3.34	0.73
Domestic price index (high)	-0.52	-5.68	4.48	-1.16	-0.79	-4.97	-0.35
Nom. wage, formal (low)	0.91	0	19.39	0	1.44	0	5.93
Nom. wage, formal (high)	0.86	0	22.03	0	0.54	0	5.96
Nom. wage, informal (low)	0.43	-9.04	6.16	2.07	1.59	-11.81	0.25
Nom. wage, informal (high)	0.73	-9.02	5.54	2.27	1.17	-14.8	-0.36
Total exports (low)	1.44	6.1	35.68	1.34	8.04	5.7	13.17
Total exports (high)	1.59	7.29	50.75	1.74	10.03	7.33	19.95
Total imports (low)	1.19	2.57	47.13	0.69	5.92	5.05	10.31
Total imports (high)	1.32	3.07	67.03	0.9	7.38	6.5	15.61
Total fiscal revenue (low)	-0.2	-1.82	1.95	-0.7	0.18	-1.59	0.17
Total fiscal revenue (high)	-0.13	-1.95	1.93	-0.79	-0.31	-2	0.04
Equivalent variation (low)	-0.08	0.06	6.29	0.95	0.53	0.34	1.99
Equivalent variation (high)	-0.1	0.28	8.17	1.12	0.53	0.24	2.47
Formal surplus (low)	0	5.25	0	2.05	0	3.76	0
Formal surplus (high)	0	5.91	0	3.03	0	5.22	0

5. Conclusion

The presence of a dualism in the labour market and the existence of an exogenous downward rigidity of the wage of some labour categories are some characteristics, peculiar to many developing countries, reported by many studies on the functioning of the labour market. These characteristics have frequently been identified as obstacles to economic growth in these countries. In this paper, we studied the impacts of the customs union implementation among UEMOA countries taking into account the above-mentioned characteristics. Using a static, multi-sectoral and multi-country CGE model, we found that the presence of a minimum nominal wage for the formal workers may significantly reduce the gains stemming from the customs union reform. Without a downward rigidity of formal workers' wage, our simulation results show the reform is welfare improving in all member-countries, except Benin, which experiences a small loss. The introduction of a downward rigidity in the formal workers' nominal wage reduces the welfare gains experienced in the absence of that distortion. Our results indicate that the reduction in the welfare gains may exceed 45% in some cases, as in Senegal.

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Appendix 1: List of sectors

1. Food crops
2. Industrial agriculture
3. Livestock
4. Fishing and forestry
5. Extractive industry
6. Food industry
7. Textile industry
8. Chemical industry
9. Metal industry
10. Other industry
11. Public utilities
12. Construction
13. Transport and communication
14. Financial services
15. Real estate services
16. Hotels, bars, rest. and commerce
17. Other services
18. Public administration

Appendix 2 : Variables, parameters and equations

Superscripts f, and h refer countries

Subscripts i or j refer to goods or commodities

Subscript LC refers to labour categories

Variables

C_i^f	Household consumption (volume) of good *i*
$C_{\min_i}^f$	Minimal household consumption
CM^f	Total household's consumption expenditures
CG^f	Total value of government consumption
DG^f	Total value of government expenditures
$DINT_i^f$	Intermediate demand for good *i*
$DINV_i^f$	Investment demand for good *i*
$DIRTAX^f$	Total direct taxes
$DSTK_i^f$	Stocks variation (exogenous)
$ESAV^f$	Firms' savings
EXP_i^{fh}	Exports of good *i* from country *f* to country *h*
$Exrdm_i^f$	Exports of good *i* from country *f* to the rest of the world
$EXREG_i^f$	Exports of good *i* from country *f* to the region
EXT_i^f	Total country f 's exports of good i
$FSAV^f$	Foreign savings
G_i^f	Government consumption of good *i*
$GSAV^f$	Government savings
$HSAV^f$	Households savings
$INDTAX^f$	Total indirect taxes
Int_i^f	Intermediate composite volume for sector *i*
K_i^f	Demand for capital of sector *i* (exogenous)
$LD_{LC_i}^f$	Demand for labour for each category, by sector *i*
LCS_{LC}^f	Labour supply by category
$LCS0_{infor}^f$	Informal labour supply in the benchmark data
LDT_i^f	Aggregate labour

MP_i^{fh}	Imports of good *i* by country *f* from country *h*
$Mrdm_i^f$	Imports of good *i* by country *f* from the rest of the world
$Mreg_i^f$	Imports of good *i* by country *f* from the region
MT_i^f	Total imports of good *i by country f*
P_i^f	Price of composite output *i*
Pc_i^f	Consumer price of good i
Pd_i^f	Domestic price of good i
$Pexp_i^{fh}$	Producer's export price of good *i* from country *f* to country *h* (net of tax)
$Pexrdm_i^f$	Producer's export price of good *i* from country *f* to the rest of the world (net of tax)
$Pexreg_i^f$	Producer's export price of good *i* from country *f* to the region (net of tax)
$Pext_i^f$	Producer's total export price of good *i* in country *f* (net of tax)
$Pint_i^f$	Composite price of intermediate consumption
Pmp_i^{fh}	Import price of good i in country f from country h (including taxes)
$Pmrdm_i^f$	Import price of good i in country f from the rest of the world (including taxes)
$Pmreg_i^f$	Import price of good i in country f from the regional (including taxes)
Pmt_i^f	Total import price of good i in country f (including taxes)
$PSAV^{fh}$	Current account balance of country *f* with country *h*
Pva_i^f	Value-added price
$Pwexp_i^{fh}$	FOB price of exports of good i from *f* to *h*
$Pwmp_i^{fh}$	World price of imports by country *f* from country *h*
$Pwmrdm_i^f$	World price of imports by *f* from the rest of the world
$RDMSAV^f$	Current account balance with the rest of the world
$REGSAV^f$	Regional current account balance
RKE^f	Firms' capital income
RKM^f	Households' capital income
RRK_i^f	Sectoral capital remuneration
$TOTSAV^f$	Total savings
VA_i^f	Value added (volume)
$WC_{LC_I}^f$	Nominal wage rate by labour category
WT_i^f	Index of nominal wage in sector *i*
XDD_i^f	Demand for domestic good *i*
XS_i^f	Firm's composite output in sector i
XSD_i^f	Supply of domestic good *in sector i*

XT_i^f	Domestic absorption of commodity i
YDM^f	Households' disposable income
YG^f	Government income
YL^f	Households' labour income
YM^f	Households' total factor income
ER^f	Nominal exchange rate
U^f	Excess supply of formal workers
$TRGE^f$	Government transfers to firms (exogenous)
$TRGM^f$	Government transfers to households (exogenous)
$TRGROW^f$	Government transfers to the rest of the world (exogenous)
$TROWM^f$	Rest of the world transfers to households (exogenous)

Parameters

AD_i^f	Shift parameter in the composite output function
a_{ij}^f	Input-output coefficient
α_i^f	Share parameter in the composite output function
$AM1_i^f$	Shift parameter in the Armington function (first level)
$AM2_i^f$	Shift parameter in the Armington function (second level)
$AM3_i^f$	Shift parameter in the Armington function (third level)
AP_i^f	Shift parameter in the added value function
AW_i^f	Shift parameter in the labour aggregation function
$AX1_i^f$	Shift parameter in the CET function (first level)
$AX2_i^f$	Shift parameter in the CET function (second level)
$AX3_i^f$	Shift parameter in the CET function (third level)
$\beta_{E_i}^f$	Share of good i in total investment expenditures
$\beta_{LES_i}^f$	Marginal budget share in the LES function
$\delta_{1_i}^f$	Share parameter in the Armington function (first level)
$\delta_{2_i}^f$	Share parameter in the Armington function (second level)
$\delta_{3_i}^f$	Share parameter in the Armington function (third level)
$\gamma_{1_i}^f$	Share parameter in the CET function (first level)
$\gamma_{2_i}^f$	Share parameter in the CET function (second level)
$\gamma_{3_i}^f$	Share parameter in the CET function (third level)

λ^f	Share of total capital income to households
mps^f	Marginal propensity to save
$\mu^f_{LC_i}$	Share of each labour category in sectoral total labour income
$\rho^f_{M1_i}$	Elasticity parameter in the CES function (first level)
$\rho^f_{M2_i}$	Elasticity parameter in the CES function (second level)
$\rho^f_{M3_i}$	Elasticity parameter in the CES function (third level)
$\rho^f_{P_i}$	Elasticity parameter in the added value function
$\rho^f_{X1_i}$	Elasticity parameter in the CET function (first level)
$\rho^f_{X2_i}$	Elasticity parameter in the CET function (second level)
$\rho^f_{X3_i}$	Elasticity parameter in the CET function (third level)
$\sigma^f_{M1_i}$	Substitution elasticity for the CES function (first level)
$\sigma^f_{M2_i}$	Substitution elasticity for the CES function (second level)
$\sigma^f_{M3_i}$	Substitution elasticity for the CES function (third level)
$\sigma^f_{P3_i}$	Substitution elasticity for the added value function
$\sigma^f_{X1_i}$	Substitution elasticity for the CET function (first level)
$\sigma^f_{X2_i}$	Substitution elasticity for the CET function (second level)
$\sigma^f_{X3_i}$	Substitution elasticity for the CET function (third level)
SO^f	Intercept in the households saving function
τmp_i^{fh}	Duty rate on imports of country f from country h
$\tau mrdm_i^f$	Duty rate1 on imports from the rest of the world
$texp_i^{fh}$	Tax rate on exports of country f to country h
$texrdm_i^f$	Tax rate on exports to the rest of the world
θ_i^f	Share parameter in the added value function
$tmrdm_i^f$	Average rate (all taxes) on imports from the rest of the world
TP_i^f	Production tax rate
$txmp_i^{fh}$	Other taxes' rate on imports of country f from country h
$txmrdm_i^f$	Other taxes' rate on imports country f from the rest of the world
ty_E^f	Firms' income tax rate
ty_M^f	Households' income tax rate

List of equations

Firms

(1) $Pva_i^f VA_i^f = \alpha_i^f P_i^f XS_i^f$

(2) $Pint_i^f Int_i^f = (1-\alpha_i^f) P_i^f XS_i^f$

(3) $P_i^f = \frac{1}{AD_i^f}\left[\frac{Pva_i^f}{\alpha_i^f}\right]^{\alpha_i^f}\left[\frac{Pint_i^f}{1-\alpha_i^f}\right]^{1-\alpha_i^f}$

(4) $Pint_i^f = \sum_j a_{ji}^f Pc_j^f$

(5) $VA_i^f = AP_i^f\left[\theta_i^f\left(K_i^f\right)^{-\rho_{P_i}^f} + \left(1-\theta_i^f\right)\left(LDT_i^f\right)^{-\rho_{P_i}^f}\right]^{-1/\rho_{P_i}^f}$

(6) $WT_i^f = Pva_i^f\left(1-\theta_i^f\right)\left(AP_i^f\right)^{-\rho_{P_i}^f}\left[\frac{VA_i^f}{LDT_i^f}\right]^{1/\sigma_{P_i}^f}$

(7) $LD_{LC_i}^f = \frac{\mu_{LC_i}^f WT_i^f LDT_i^f}{WC_{LC_i}^f}$

(8) $WT_i^f = \frac{1}{AW_i^f}\prod_{LC}\left[\frac{WC_{LC_i}^f}{\mu_{LC_i}^f}\right]^{\mu_{LC_i}^f}$

(9) $RRK_i^f = Pva_i^f VA_i^f - WT_i^f LDT_i^f$

(10) $RKE^f = \left(1-\lambda^f\right)\sum_i RRK_i^f$

(11) $ESAV^f = \left(1-ty_E^f\right)RKE^f + TRGE^f$

Households

(12) $YM^f = YL^f + RKM^f$

(13) $YL^f = \sum_i WT_i^f LDT_i^f$

(14) $RKM^f = \lambda^f \sum_i RRK_i^f$

(15) $$YDM^f = \left(1 - ty_M^f\right) YM^f + TRGM^f + ER^f TROWM^f$$

(16) $$CM^f = YDM^f - HSAV^f$$

(17) $$Pc_i^f C_i^f = Pc_i^f C_{\min_i}^f + \beta_{LES_i}^f \left[CM^f - \sum_i Pc_i^f C_{\min_i}^f \right]$$

(18) $$HSAV^f = SO^f + mps^f YDM^f$$

Other demand components

(19) $$DINV_i^f Pc_i^f = \beta_{E_i}^f TOTSAV^f$$

(20) $$DINT_i^f = \sum_j a_{ij}^f Int_j^f$$

(21) $$XT_i^f = C_i^f + G_i^f + DINV_i^f + DINT_i^f + DSTK_i^f$$

(22) $$TOTSAV^f = ESAV^f + HSAV^f + GSAV^f + ER^f FSAV^f - \sum_i Pc_i^f DSTK_i^f$$

Government

(23) $$YG^f = DIRTAX^f + INDTAX^f + \sum_{inomarch} RRK_i^f$$

(24) $$DIRTAX^f = ty_M^f YM^f + ty_E^f RKE^f$$

(25)
$$\begin{aligned} INDTAX^f = & \sum_i TP_i^f P_i^f XS_i^f \\ & + ER^f \sum_i Pwmrdm_i^f Mrdm_i^f \left(txmrdm_i^f + \tau mrdm_i^f \left(1 + txmrdm_i^f\right)\right) \\ & + \sum_i \sum_h Pwmp_i^{fh} MP_i^{fh} \left(txmp_i^{fh} + \tau mp_i^{fh} \left(1 + txmp_i^{fh}\right)\right) \\ & + \sum_i Pexrdm_i^f Exrdm_i^f texrdm_i^f + \sum_i \sum_h Pexp_i^{fh} EXP_i^{fh} texp_i^{fh} \end{aligned}$$

(26) $$DG^f = CG^f + TRGM^f + TRGE^f + ER^f TRGROW^f$$

(27) $$CG^f = \sum_i Pc_i^f G_i^f$$

(28) $$GSAV^f = YG^f - DG^f$$

Relations with the rest of the world

Imports

(29) $$XT_i^f = AM1_i^f \left[\delta_{1_i}^f \left(MT_i^f \right)^{-\rho_{M1_i}^f} + \left(1-\delta_{1_i}^f\right)\left(XDD_i^f \right)^{-\rho_{M1_i}^f} \right]^{-1/\rho_{M1_i}^f}$$

(30) $$\frac{MT_i^f}{XDD_i^f} = \left[\frac{\delta_{1_i}^f Pd_i^f}{\left(1-\delta_{1_i}^f\right) Pm_i^f} \right]^{\sigma_{M1_i}^f}$$

(31) $$Pc_i^f XT_i^f = Pd_i^f XDD_i^f + Pmt_i^f MT_i^f$$

(32) $$Pmt_i^f = \frac{1}{AM2_i^f} \left[\left(\delta_{2_i}^f\right)^{\sigma_{M2_i}^f} \left(Pmreg_i^f \right)^{1-\sigma_{M2_i}^f} + \left(1-\delta_{2_i}^f\right)^{\sigma_{M2_i}^f} \left(Pmrdm_i^f \right)^{1-\sigma_{M2_i}^f} \right]^{1/\left(1-\sigma_{M2_i}^f\right)}$$

(33) $$Mreg_i^f = AM2_i^{f\left(\sigma_{M2_i}^f - 1\right)} \left[MT_i^f \frac{\delta_{2_i}^f Pmt_i^f}{Pmreg_i^f} \right]^{\sigma_{M2_i}^f}$$

(34) $$Mrdm_i^f = AM2_i^{f\left(\sigma_{M2_i}^f - 1\right)} \left[MT_i^f \frac{\left(1-\delta_{2_i}^f\right) Pmt_i^f}{Pmrdm_i^f} \right]^{\sigma_{M2_i}^f}$$

(35) $$Pmreg_i^f = \frac{1}{AM3_i^f} \left[\sum_h \left(\delta_{3_i}^{fh}\right)^{\sigma_{M/i}^f} \left(Pmp_i^{fh} \right)^{1-\sigma_{M3_i}^f} \right]^{1/\left(1-\sigma_{M3_i}^f\right)}$$

(36) $$MP_i^{fh} = AM3_i^{f\left(\sigma_{M3_i}^f - 1\right)} \left[Mreg_i^f \frac{\delta_{3_i}^{fh} Pmreg_i^f}{Pmp_i^{fh}} \right]^{\sigma_{M3_i}^f}$$

Exports

(37) $$XS_i^f = AX1_i^f \left[\gamma_{1_i}^f \left(EXT_i^f \right)^{\rho_{X1_i}^f} + \left(1-\gamma_{1_i}^f\right)\left(XSD_i^f \right)^{\rho_{X1_i}^f} \right]^{1/\rho_{X1_i}^f}$$

(38) $$\frac{EXT_i^f}{XSD_i^f} = \left[\frac{\left(1-\gamma_{1_i}^f\right) Pext_i^f}{\gamma_{1_i}^f Pd_i^f} \right]^{\sigma_{X1_i}^f}$$

(39) $$P_i^f XS_i^f = \frac{1}{1+tp_i^f} \left(Pd_i^f XsD_i^f + Pext_i^f EXT_i^f \right)$$

(40) $$Pext_i^f = \frac{1}{AX2_i^f}\left[\left(\gamma_{2_i}^f\right)^{-\sigma_{X2_i}^f}\left(Pexreg_i^f\right)^{1+\sigma_{X2_i}^f} + \left(1-\gamma_{2_i}^f\right)^{-\sigma_{X2_i}^f}\left(Pexrdm_i^f\right)^{1+\sigma_{X2_i}^f}\right]^{1/\left(1+\sigma_{X2_i}^f\right)}$$

(41) $$Exreg_i^f = AX2_i^{f\left(-\sigma_{X2_i}^f-1\right)}\left[\frac{EXT_i^f\, Pexreg_i^f}{\gamma_{2_i}^f\, Pext_i^f}\right]^{\sigma_{X2_i}^f}$$

(42) $$Exrdm_i^f = AX2_i^{f\left(-\sigma_{X2_i}^f-1\right)}\left[\frac{EXT_i^f\, Pexrdm_i^f}{\left(1-\gamma_{2_i}^f\right)Pext_i^f}\right]^{\sigma_{X2_i}^f}$$

(43) $$Pexreg_i^f = \frac{1}{AX3_i^f}\left[\sum_h\left(\gamma_{3_i}^{fh}\right)^{-\sigma_{X3_i}^f}\left(Pexp_i^{fh}\right)^{1+\sigma_{X3_i}^f}\right]^{1/\left(1+\sigma_{X3_i}^f\right)}$$

(44) $$EXP_i^{fh} = AX3_i^{f\left(-\sigma_{X3_i}^f-1\right)}\left[\frac{Exreg_i^f\, Pexp_i^{fh}}{\gamma_{3_i}^{fh}\, Pexreg_i^f}\right]^{\sigma_{X3_i}^f}$$

Current account balance

(45) $$PSAV^{fh} = \sum_i Pwmp_i^{fh} MP_i^{fh} - \sum_i Pwep_i^{fh} EXP_i^{fh}$$

(46) $$REGSAV^f = \sum_h PSAV^{fh}$$

(47) $$RDMAV^f = \sum_i Pwmrdm_i^f MRDM_i^f - \sum_i Pwewrdm_i^f Exrdm_i^f - TROWM^f + TRGROW^f$$

(48) $$FSAV^f = REGSAV^f + RDMAV^f$$

Prices

(49) $$Pmp_i^{fh} = Pwmp_i^{fh} ER^f\left(1+\tau mp_i^{fh}\right)\left(1+txmp_i^{fh}\right)$$

(50) $$Pmrdm_i^f = Pwmrdm_i^f ER^f\left(1+\tau mrdm_i^f\right)\left(1+txmrdm_i^f\right)$$

(51) $$Pwexp_i^{fh} ER^f = Pexp_i^{fh}\left(1+texp_i^{fh}\right)$$

(52) $$Pwexrdm_i^f ER^f = Pexrdm_i^f\left(1+texrdm_i^f\right)$$

(53) $$Pwexp_i^{fh} = Pwmp_i^{hf}$$

Equilibrium conditions

(54) $$\sum_i LCD^f_{infor_i} = LCS^f_{infor}$$

(55) $$LCS^f_{infor} = LCS0^f_{infor} + U^f$$

(56) $$\sum_i LCD^f_{for_i} + U^f = LCS^f_{for}$$

(57) $$WC^f_{for} \geq WC^f_{for_{min}}$$

(58) $$\left(WC^f_{for} - WC^f_{for_{min}}\right) U^f = 0$$

(59) $$XSD^f_i = XDD^f_i$$

(60) $$MP^{fh}_i = EXP^{hf}_i$$