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Devaluation and Cattle Markets Integration in Burkina Faso

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Abstract

This paper tests the positive impact of the CFA franc devaluation on cattle markets integration in Burkina Faso. We develop a model with two regimes consistent with the spatial and inter-temporal arbitrage conditions. Two markets are spatially integrated if the price spread is equal to transaction costs. Markets are autarkic if the price spread is less than transaction costs; in this case storage behaviour implies that prices follow a random walk. These two regimes are combined in a switching regression model with unknown sample separation. In this model, a selection equation with three exogenous variables influencing transaction costs sorts the observations between the two regimes. These variables are the distance between markets, the price of fuel and the real effective exchange rate as a proxy for labour cost. We cannot reject our hypothesis that the probability of market integration significantly increases after the devaluation.

Keywords.

Market integration, cattle, devaluation, Burkina Faso, switching regression model.

JEL classification

O12, Q13

Introduction

Cattle's breeding is a major activity in Burkina Faso. This activity benefits from an ancient and well-developed domestic and regional marketing network. A cattle is a durable good that may be inter-temporally held in order to smooth the inter-temporal profile of consumption. A cattle has the characteristic of being an internationally tradable good. Thus, the devaluation of the CFA franc that occurred in January 1994 induced an increase in real cattle prices and in the regional cattle trade towards Côte d'Ivoire and Ghana [*Ancey, 1998*]. A cattle is also a domestically tradable good. Therefore, in this paper, we focus on the impact of devaluation on the spatial integration of local cattle markets of Burkina Faso.

Spatial integration in developing countries is the subject of an abundant literature [*Baulch, 1997a; Fafchamps and Gavian, 1996; Ravallion, 1986; etc.*]. Earlier approaches to the problem used bivariate correlation coefficients between prices and were progressively improved with the development of time series analyses: Granger causality and cointegration tests (see for instance, Dercon [*1995*]). The validity of these approaches is however questionable. Indeed, they suppose the existence of a fixed hierarchy between markets and therefore rely on the hypothesis of exogenous prices on one market. Moreover, common trends in prices can bias results in favour of market integration. *A contrario,* flow reversals and trade discontinuities may erroneously lead to the rejection of the market integration hypothesis [*Baulch, 1997a*]. These problems led to the elaboration of a new model of spatial integration: the parity bounds model [*Sexton et al., 1991; Baulch, 1997b*].

The parity bounds model develops a microeconomic framework in which the trade opportunities depend on transaction costs. This model does not however take into account inter-temporal arbitrage, and this is a major weakness in the context of storable goods. Moreover, the hypothesis of spatial arbitrage is not imposed which is highly questionable in the long run under the standard rationality hypothesis. Consequently, in this paper, we develop an alternative model in which both spatial and inter-temporal arbitrage conditions are imposed. Our model is consistent with autarkic situations and trade reversals according to the level of transaction costs.

We explicitly model the transaction costs as a function of macroeconomic measures. The devaluation of the CFA franc is regarded as a major macroeconomic event affecting international trade but also, as argued here, arbitrage conditions on local markets of Burkina Faso. We show for cattle markets that the devaluation decreased real transaction costs, created new domestic trade opportunities and thus induced additional welfare gains. Despite the lack of statistical information, we capture the effect of the devaluation on market integration through a deterministic function relating transaction costs to the real exchange rate.

We first set our theoretical model with two prices regimes consistent with individual rationality: autarkic or integrated regimes. The latter regime is characterised by the existence of trade between markets. We then present the empirical evidence of the effects of devaluation on market integration using a deterministic switching model with unknown sample separation. We work on panel data of cattle markets and monthly prices on the period 1991-1997.

I. The theoretical model.

Basic hypotheses.

We postulate that cattle markets are arbitrated. This means that the sale or purchase of cattle is not systematically profitable. In our model, arbitrage is inter-temporal and spatial. These arbitrage conditions are derived from the rationality hypothesis.

The inter-temporal arbitrage condition is fulfilled whenever there is no pure or excess return from holding a particular asset from a period to another. The spatial arbitrage condition is fulfilled whenever there is no pure or excess return from trading a particular asset from a market to another. More precisely, two markets are spatially arbitrated when the absolute value of the price differential is less than or equal to transaction costs. The latter are defined as market use costs: transportation costs, trade margins, formal or informal taxes, bribes, risk premium, trade restrictions etc. Spatial arbitrage does not imply that trade takes place between markets. If transaction costs are too high, there are no opportunities to trade. Moreover arbitrage conditions do not mean that markets are competitive. Transaction costs can include traders' normal profits as well as mark-up margins.

The model.

According to the inter-temporal arbitrage condition, the return from holding cattle must equal the return from holding financial assets. The difference between contemporaneous and future prices equals *R*, defined as the opportunity cost of storage, *i.e.* physical storage cost, interest rate and risk premium [*Bernirshka and Binkley, 1995; Azam et Bonjean, 1995; Motel Combes, 1996*].

$$P_{i,t} = P_{i,t-1} + R \qquad \forall i \qquad (1)$$

When trade occurs between two markets *i* and *j*, prices move from a one to one basis according to the spatial arbitrage condition. In this case, the price differential is equal to transaction costs $K_{i,j}$ [*Ravallion, 1986; Baulch, 1997b*]. For instance if $P_{i,t}$ is greater than $P_{j,t}$, we have:

$$P_{i,t} = P_{j,t} + K_{ij,t} \qquad \forall i \neq j \qquad (2)$$

We distinguish two regimes of prices: the autarkic and the integrated regimes. In the former, no trade occurs and the evolution of price on each market is solely determined by equation (1). In the latter trade takes place, the two-arbitrage conditions (1) and (2) apply, and prices are determined according to:

$$P_{i,t} = P_{j,t-1} + K_{ij,t} + R \qquad \forall i \neq j \qquad (3)$$

The price rule depends on transaction costs and exogenous local market conditions. Formally, the autarkic regime holds if:

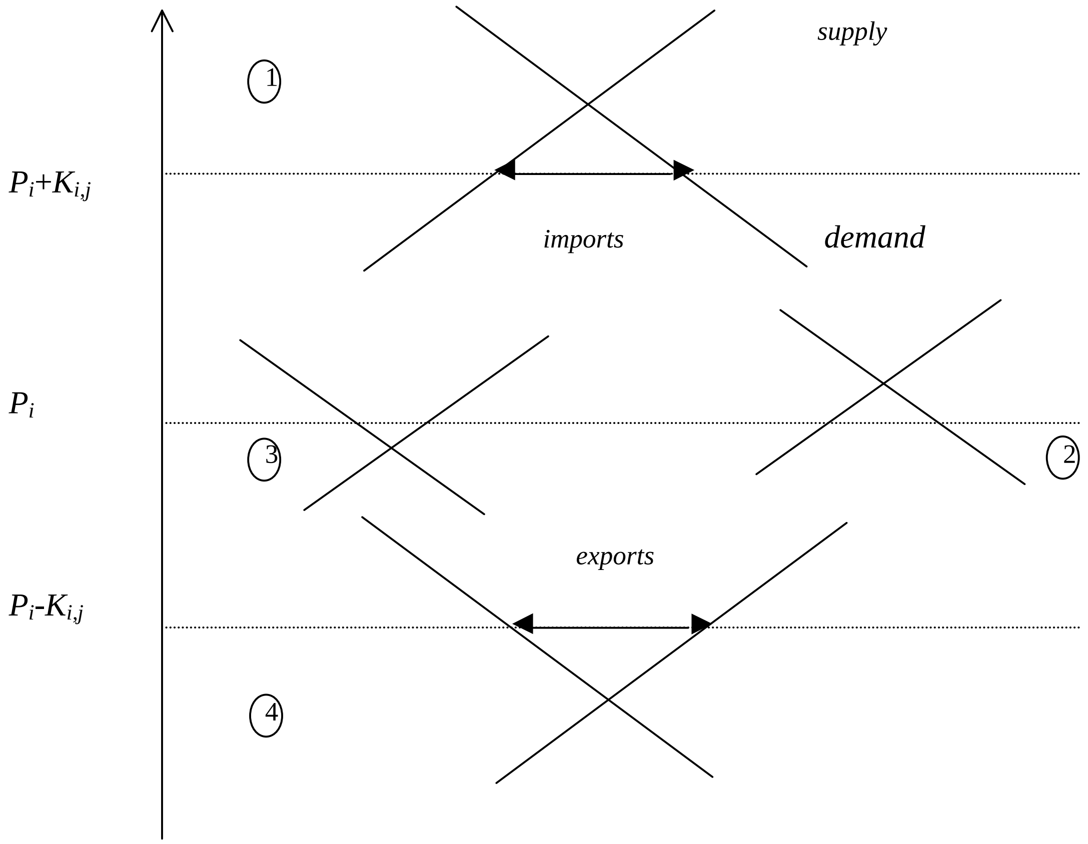
$$\left| P_{i,t} - P_{j,t} \right| < K_{ij,t} \qquad \forall i \neq j \qquad (4)$$

The integrated regime implies that:

$$\left| P_{i,t} - P_{j,t} \right| = K_{ij,t} \qquad \forall i \neq j \qquad (5)$$

The model can be graphically summarised in the following way:

Figure 1. The spatial arbitrage condition on local markets.



$P_i+K_{i,j}$: Import parity bound ; $P_i-K_{i,j}$: Export parity bound. Case 1: importing market, the price spread between markets equals transaction costs. Cases 2 and 3: potential importing and exporting markets, but no trade. Case 4: exporting market.

Impact of devaluation on domestic markets integration.

If local cattle markets are initially autarkic, the devaluation is expected to favour markets integration through its impact on transaction costs. The impact of devaluation on transaction costs mainly depends on the composition of transport services. The devaluation increases the price of traded goods entering the transaction costs. But since most cattle are herded throughout the country, labour is the main input in transport services. Hence by reducing the real wage, devaluation is supposed to promote inter market trade. That positive effect of the devaluation on local trade is welfare improving as it generates efficiency gains.

If local markets are initially integrated, the devaluation, like in the former case, can reduce the transaction costs. Thus, the devaluation is expected to reduce the price spreads between markets. This reduction is welfare improving as it may decrease the cattle price risk on local markets.

II. Empirical evidence.

The cattle sector in Burkina Faso.

The economic contribution of the livestock sector is important; its contribution to GDP and exports is respectively 12% and 30 % (after cotton and gold). Livestock is a traditional sector, production conditions are extensive and highly dependent on rains. We observe however a development of sedentariness among cattle breeders because of demographic pressure on arable lands. This evolution implies a closer integration of crop cultivation with cattle breeding [*Chambas et al., 1999*].

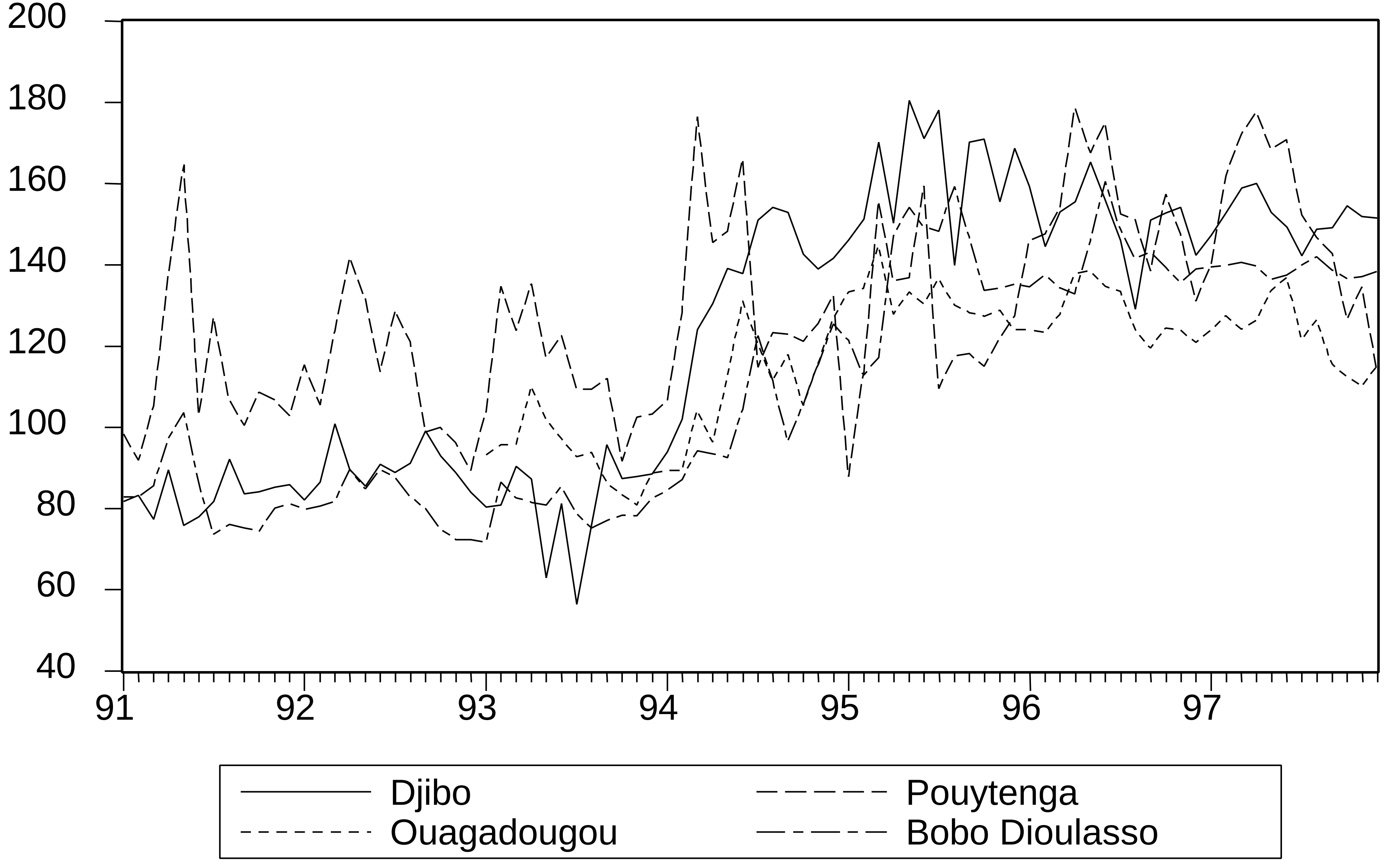
The marketing system is highly decentralised and operates fairly independently from public interventions. Transactions mostly occur in formal markets with local traders. There is no collusion because of the large number of intermediaries, and price information is transmitted within and among markets [*World Bank, 1982*]. According to Herman and Makinen [*1981*] marketing margins seem to be reasonable. Grazing and passage fees have to be paid to local authorities in addition to other unofficial charges. The traditional flows of exchange run from the north-east towards the consumption markets of Bobo-Dioulasso, Ouagadougou and coastal cities. Transport infrastructures are generally poor; within the country, most cattle are herded between producing regions and the major consumption and export markets.

There are five main cattle markets: Pouytenga, Djibo, Bobo-Dioulasso, Gorom[1] and Ouagadougou (*cf*. map). Pouytenga and Bobo-Dioulasso are important export markets, Djibo belongs to the main producing region, Bobo-Dioulasso and Ouagadougou are the major consumption markets. We consider one category of animals, the «fattened bulls» («taureaux en bon état d'engraissement»), for which long price series are available.

Source : Encarta

After the devaluation, the Ivoirian demand (nearly 60 % of exports) for Burkinabe cattle increased because of a substitution effect, at the expense of European imports [Chambas *et al.,* 1999]. The exports toward other African markets, outside the Franc Zone, have also been boosted by the CFA franc devaluation (Ghana: 34 % of exports). Figure 2 illustrates the effect of devaluation on the local real price levels. This figure also shows transitory reversals in the price spreads between markets implying trade reversals between local markets.

Figure 2 : The evolution of the real prices of cattle on four markets (real thousand CFA francs per head, base 100 in 1995)



The data.

Cattle prices are collected on a monthly basis (Ministère de l'agriculture et des ressources animales, various issues). The data cover four markets and seven years from 1991 to 1997. The data are organised in a panel structure with twelve bilateral markets combinations on 84 months (1008 potential observations).

Prices are expressed per unit of livestock presented on local markets and are deflated by the national consumer price index (IMF). Data measuring flows between local markets and data on transaction costs are not available and not easily calculable. The latter are thus hypothesised to be an increasing function of the distance between markets and of the oil price expressed in local currency (*FUEL*); this variable is a rough estimate for fuel prices in Burkina Faso[2]. The transaction costs are also an increasing function of the real effective exchange rate (*REER*)[3] that can be interpreted as a proxy for the real wage. It is calculated as the ratio between the national consumer price index and a weighted price index of the main trade partners expressed in the same currency. An increase in the real effective exchange rate means an appreciation of the local currency.

The econometric tools.

We use an exogenous deterministic switching regression model with unknown sample separation [*Maddala, 1983*]. Two price regimes are considered: the autarkic and the integrated regimes. The selection between the two regimes is based on transaction costs. There are two main differences between our approach and previous analyses [*Baulch, 1997b; Sexton et al., 1991; Fafchamps and Gavian, 1996*]:

- Only two regimes are considered instead of three: prices move inside the parity bound or at the parity bound. Prices cannot be durably outside the parity bounds as the spatial arbitrage condition always holds (as in Spiller and Huang [*1986*]).
- The selection between the two regimes is explicitly determined as a function of transaction costs.

The two regimes can be written as follows:

Autarkic regime: $$P_{i,t} = \alpha + \beta \cdot P_{i,t-1} + \gamma \cdot \Omega_t + \mu_{i,t} \qquad (6)$$

Integrated regime: $$P_{i,t} = \rho + \theta \cdot P_{j,t-1} + \eta \cdot \Phi_{ij,t} + \zeta_{i,t} \qquad (7)$$

Where $P_{i,t}$ is the real price of cattle on market i (i = 1 to 4) at time t; $P_{j,t}$ is the real price of cattle on the market j ($i \neq j$) at time t; Ω_t and $\Phi_{ij,t}$ are other exogenous variables which differ according to our specification; $\mu_{i,t}$ and $\zeta_{i,t}$ are disturbance terms distributed according to the bivariate normal density with zero means, standard errors σ_A and σ_I and not identifiable covariance [*Maddala, 1983; Quandt, 1988*].

The selection rule between the two regimes is given by the following conditions:

Autarkic regime if: $$\kappa' \cdot Z_{ij,t} + \omega_{ij,t} > 0 \qquad (8)$$

Integrated regime if: $$\kappa' \cdot Z_{ij,t} + \omega_{ij,t} \leq 0 \qquad (9)$$

The exogenous transaction costs $\kappa'.Z_{ij,t}$ are a function of the distance (D_{ij}) between markets i and j, intra-annual effects ($Month_t$), fuel price ($FUEL_t$) and real effective exchange rate ($REER_t$). We hypothesise that transaction costs are an increasing function of distance, that the marginal effect of distance on transaction costs is an increasing function of fuel price and of the real effective exchange rate. Finally, we consider that transaction costs may depend on

$REER_t$ independently of distance (for example traders' fees). The residuals $\omega_{ij,t}$ capture chocks that affect the markets.

Following Maddala [*1983*], we suppose that the residuals $\omega_{ij,t}$ are normally distributed with a nil mean and a standard error equal to one. The constant coefficient in the selection equation is set to one, so that the other coefficients are calculated only up to a positive scale factor [*Maddala and Nelson, 1975*].

The integrated regime holds if $I_t = 1$ (equation 9) and does not otherwise (equation 8). The two regimes can then be combined in the following equation:

$$P_{i,t} = (\alpha + \beta \cdot P_{i,t-1} + \gamma \cdot \Omega_t + \mu_{i,t}) \cdot (1 - I_t) + (\rho + \theta \cdot P_{j,t-1} + \eta \cdot \Phi_{ij,t} + \zeta_{i,t}) \cdot I_t \qquad (10)$$

And we use the probit function to approximate the probability of the integrated regime I_t:

$$\widehat{I}_t = \int_{-\infty}^{-\kappa' \cdot Z_{ij,t}} \left(\frac{\exp\left(-\omega_{ij,t}^2 / 2\right)}{\sqrt{2\pi}} \right) \cdot d\omega \qquad (11)$$

Equations (10) and (11) are estimated by a maximum likelihood procedure[4]. An increase in fuel price, distance or *REER* implies higher transaction costs and a lower probability of market integration.

The results.

The results are compiled in Tables 1 and 2. We test the robustness of our main results using various specifications. Using lagged instead of contemporaneous prices eliminates a possible source of simultaneity bias. Infra-annual trends (*Month* and *Month*^{2}) control for seasonal deterministic effects[5]. We unsuccessfully introduced annual dummy variables in order to catch climatic shocks. Models 2 and 3 introduce quarterly and yearly lags justified by seasonal effects, adjustment delays and divergence between analytical and calendar time. Fixed effects are introduced in the integrated regime (models 1, 2 and 3) in order to control for the possible heterogeneity of markets combinations in our panel data[6]. Transaction costs are included in the integrated regime of Model 4 and are not significant. The later results from the reduction in the transaction costs variability within the sub-samples. We thus focus on models 1, 2 and 3 where the constant in the integrated regime is greater than in the autarkic one, the difference reflecting the level of transaction costs.

We introduce the $REER_t$ additionally in the selection equation of model 3 on the basis that real wages can affect transaction costs independently of distance. Whatever the distance between markets, there is a cost of trading, for example gathering cattle before transportation. The infra-annual trend catches seasonal fluctuations in transaction costs that are independent of distance and labour, but linked to the practicability of transport infrastructures that may differ according to the seasons.

We calculate (table 2) the total impact of distance on the probability of market integration as the sum of the *Distance* coefficient and the average values of $FUEL_t$ and the $REER_t$ weighted by their respective coefficients. We also calculate the total impact of the real effective exchange rate.

We do not reject the random walk hypothesis in the autarkic regime of Model 1 (β=1). In the integrated regime, the lagged price coefficient is, however, low with respect to our theoretical restriction. This result can be explained by the existence of delays in prices adjustments.

Table 1. Exogenous switching regression with unknown sample separation (robust t-statistics).

Number of observations	**Model 1** 852	**Model 2** 720	**Model 3** 720	**Model 4** 720
Selection equation				
Distance	0.03	0.05	0.04	0.03
	(1.65)	(2.14)	(2.90)	(2.31)
Distance.FUEL$_t$	$-0.20\ 10^{-5}$	$-0.28\ 10^{-5}$	$-0.20\ 10^{-5}$	$-0.14\ 10^{-5}$
	(1.73)	(1.67)	(2.53)	(1.86)
Distance.REER$_t$	$-0.34\ 10^{-3}$	$-0.56\ 10^{-3}$	$-0.36\ 10^{-3}$	$-0.22\ 10^{-3}$
	(1.75)	(3.16)	(3.12)	(2.59)
Month $_t$	-0.18	0.06	1.25	-0.99
	(1.96)	(0.44)	(3.64)	(3.33)
$(Month)^2_t$	$-0.13\ 10^{-2}$	-0.02	-0.11	-0.10
	(0.15)	(1.56)	(3.88)	(4.04)
REER$_t$			-0.07	-0.07
			(4.65)	(4.37)
Autarkic equation				
Constant	10.97	10.09	11.25	10.00
	(7.14)	(5.80)	(6.39)	(5.72)
$P_{i,t-1}$	0.95	0.78	0.74	0.75
	(78.51)	(20.41)	(18.72)	(18.95)
$P_{i,t-3}$		0.14	0.15	0.17
		(4.36)	(4.90)	(5.14)
$P_{i,t-12}$		0.04	0.06	0.05
		(1.50)	(2.47)	(1.74)
Month $_t$	-1.32	-1.06	-1.80	-1.13
	(3.22)	(2.11)	(3.70)	(2.30)
$(Month)^2_t$	0.07	0.05	0.11	0.05
	(2.44)	(1.24)	(2.82)	(1.38)
σ_A	8.41	7.99	7.53	8.11
	(24.05)	(18.60)	(22.28)	(21.32)
Integrated equation				
Constant	53.97	34.00	26.09	-122.80
	(3.02)	(1.43)	(1.16)	(0.54)
$P_{j,t-1}$	0.36	-0.10	-0.12	-0.40
	(2.77)	(0.71)	(1.10)	(2.70)
$P_{j,t-3}$		0.37	0.30	0.05
		(2.51)	(2.92)	(0.46)
$P_{j,t-12}$		0.22	0.24	0.06
		(2.68)	(4.50)	(0.51)
Month$_t$	7.96	11.91	16.93	35.27
	(1.82)	(1.91)	(2.97)	(3.80)
$(Month)^2_t$	-0.76	-1.17	-1.55	-3.81
	(1.76)	(1.72)	(2.88)	(3.84)
Distance				0.09
				(0.11)
Distance.FUEL$_t$				$-0.25\ 10^{-4}$
				(1.27)
Distance.REER.$_t$				$0.27\ 10^{-2}$
				(0.20)
REER.$_t$				4.11
				(1.02)
σ_I	18.13	16.14	15.44	15.55
	(10.06)	(8.37)	(11.58)	(10.71)
Log of likelihood function	-3185	-2655	-2628	-2640

Table 2. Impact of distance and devaluation.

	Model 1	Model 2	Model 3	Model 4
***Probability of the integrated regime*:**				
Overall	0.13	0.14	0.12	0.07
Before devaluation	0.08	0.06	0.03 10^{-1}	0.02 10^{-1}
After devaluation	0.16	0.20	0.21	0.12
***Total impact of distance on the integrated regime probability*:**				
Overall	-0.05 10^{-1}	-0.09 10^{-1}	-0.03 10^{-1}	-0.01 10^{-1}
Before devaluation	-0.07 10^{-1}	-0.01	-0.04 10^{-1}	-0.02 10^{-1}
After devaluation	-0.04 10^{-1}	-0.06 10^{-1}	-0.01 10^{-1}	-0.07 10^{-2}
Total impact of REER on the integrated regime probability:	-0.10	-0.16	-0.10	-0.08

As expected, fuel price and real effective exchange rate affect negatively the probability of market integration (table 1). When examining overall probabilities (table 2), we can notice a strong increase in the probability of market integration after the devaluation. Although the devaluation increased the fuel price expressed in local currency, this potential negative impact on the transaction costs was overcompensated by the depreciation of the real effective exchange rate. This result comforts our hypothesis relating to the composition of transaction costs being mainly constituted of labour costs.

As expected, the total impact of distance on the probability that markets are integrated is negative (table 2). This result confirms our theoretical model in so far as distance positively affects transaction costs, other things held equal. We also observe that the impact of distance on the probability of market integration decreases after devaluation (see above). We interpret this result as a fall in the influence of distance on transaction costs after devaluation.

Despite the devaluation, the probability of market integration remains low, around 20 %. This result is consistent with previous analyses in other Sahelian countries using alternative methods [*Caupin and Laporte, 1998; Araujo Bonjean and Azam, 1996; Fafchamps and Gavian, 1996; Daubrée, 1994; Ravallion, 1986*] and does not contradict the usual observation of segmented markets in developing countries[7].

III. Conclusion.

Despite the lack and the poor quality of data, cattle price series exhibit a positive impact of devaluation on market integration and consequently on trade flows in Burkina Faso. This positive effect on welfare has been ignored in previous studies and leads support to devaluation decision.

The usual justification for the devaluation of the CFA franc is the positive impact on the Ivoirian economy [*Chambas et al., 1999*] which was expected to benefit the Burkinabe economy. Indeed, the Burkinabe real effective exchange rate had never shown patent overvaluation before 1994. According to our theoretical model and the econometric results, another positive impact of devaluation has been identified: devaluation favours local market integration through a fall in labour costs.

This result is due to the predominance of traditional systems of marketing within the country. An interesting extension of this work would be to test the devaluation impact on West-African markets integration. Our results may not be obviously generalised when markets are more distant. Indeed, means of transport can be less labour intensive and thus the effect of devaluation on market integration less perceptible.

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Notes

[1] We do not have reliable data on the Gorom market so this market is not included in our sample.

[2] *Source*: Average crude price of petroleum (IMF). We consider that the international fuel price reflects the evolution of effective fuel price in Burkina Faso because of the importance of informal trade with Nigeria.

[3] Our own calculation.

[4] Estimations are run on TSP using the Berndt, Hall, Hall and Hausman algorithm. We use a robust standard errors matrix to control for possible heteroskedasticity [*White, 1982*].

[5] Prices are at their maximum level at the end of the dry season and at their minimum level at the end of the rainy season. Our quadratic trend captures this non-linear evolution.

[6] Single markets fixed effects are not significant in the autarkic regime.

[7] We also tested our model on small livestock (sheep). The main differences are the following: fuel prices do not affect significantly transaction costs; this can be explained by a different composition of transaction costs. Market integration is more likely: 32 % before and 45 % after devaluation. Lower levels of transaction costs can explain this result on small cattle.