Vertical price transmission between wheat and flour in Ukraine: A Markov-switching vector error correction approach

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Abstract

The analysis of price transmission in transition countries is complicated by their often unstable policy environments. We utilise a Markov-switching vector error correction model (MSVECM) to allow for multiple regime shifts in the price relationship between wheat and wheat flour in Ukraine from June 2000 to November 2004. The analysis reveals four regimes. The observed temporal pattern of these regimes corresponds well to political and economic events in Ukraine. In particular, we find a strong link between a 'high uncertainty' regime and discretionary policy interventions in 2003, confirming that *ad hoc* policy responses to fluctuations in Ukrainian grain harvests have tended to increase rather than reduce instability. The Markov-switching VECM is shown to be a useful addition to the set of tools that can be used to analyse price transmission.

Keywords: Markov-switching vector error correction model; vertical price transmission; regime shifts; grain policies; Ukraine

JEL classification: C22, Q11, Q18

Disclaimer: The opinions expressed in this paper are those of the authors alone and not necessarily those of the University of Göttingen or the World Bank.

1 Introduction

"Oh! I will go into business again, I will buy wheat in Odessa; out there, wheat fetches a quarter of the price it sells for here. There is a law against the importation of grain, but the good folk who made the law forgot to prohibit the introduction of wheat products and food stuffs made from corn. Hey! Hey!? That struck me this morning. There is a fine trade to be done in starch." – Honoré de Balzac, Old Goriot.

Prices play a key role in market economies. They coordinate the decisions of producers and consumers in a manner that, under perfect competition, leads to a *Pareto* optimal allocation of scarce resources. While the conditions that define perfect competition are never met to the letter, the efficiency of the price mechanism as a means of allocation under a broad range of realistic conditions is widely acknowledged.

The price mechanism was not allowed to play this role in the centrally planned economies of Central and Eastern Europe (CEE). At the onset of transition considerable hopes were therefore pinned on market liberalisation and the harnessing of the price mechanism as a way of increasing economic efficiency and welfare in the region. Consequently, economists have invested considerable effort in monitoring market liberalisation and the functioning of emerging markets in CEE countries. An important strand of the resulting literature deals with questions of price transmission and the integration of agro-food markets in the region (e.g. Bakucs and Fertö, 2005; Berkowitz and DeJong, 2000; Bojnec and Peter, 2002; Kuhn, 2000; Loy and Wehrheim, 1999; Yahshilikov and Brosig, 2005). We add to this literature by studying the vertical transmission from milling wheat to flour prices in Ukraine.

The literature on price transmission and market integration in the transition economies of CEE is part of a much larger and rapidly growing body of literature on price transmission in general that highlights both the development of new empirical methods and their application in a variety of product and country/region settings. Economists have developed a variety of empirical methods for studying price transmission and market integration (for recent reviews see Fackler and Goodwin, 2001, and Meyer and von Cramon-Taubadel, 2004). In the course of this development, the analysis of simple correlations between price series has been supplanted by increasingly sophisticated econometric techniques. The introduction of cointegration methods in the mid- to late-1980s provided a considerable impetus to the price transmission literature by enabling practitioners to distinguish non-spurious from spurious relationships between (commonly non-stationary) prices, and by providing deeper insights into the equilibrating dynamics – generally attributed to arbitrage – that underlie the former.

In the late 1990s, however, important research demonstrated that there are pitfalls associated with the application of cointegration methods to the analysis of price transmission and market integration (Barrett, 2001; Baulch, 1997; McNew and Fackler, 1997). For example, failure to account for non-stationary transfer costs (e.g. transport costs in a spatial context, or marketing margins in a vertical context) in an analysis of cointegration between prices can generate misleading results. Similarly, reversals of trade flows due to supply or demand shocks can lead to price series that are not cointegrated even though the markets in questions are integrated.

These insights have spurred economists to further refine the empirical methods that they use to analyse price transmission. Two broad lines of work can be identified. First, Goodwin and Piggott (2001), Meyer (2004) and Sephton (2003), among others, adapt threshold cointegration techniques to the study of price transmission. Second, elaborating on the parity bounds model developed by Baulch (1997), Barrett and Li (2002) employ a mixture distribution model that incorporates not only price but also transfer cost and trade flow data to study price transmission.

While each of these approaches has broadened the set of empirical tools at our disposal and deepened our understanding of price transmission, each also has its shortcomings. Threshold cointegration allows for non-linearity and discontinuity in the equilibrating dynamics that link prices, but maintains the hypothesis that there is a unique equilibrium relationship between the prices being studied. In some cases (e.g. when trade flows reverse) it may, however, be reasonable to expect that there is more than one equilibrium relationship (e.g. one each for the import and export regimes). The parity bounds approach does not maintain the hypothesis of a unique equilibrium relationship between prices, but it does not take the time series nature of price (and other) data into account. Instead, it attributes each observation in a series individually to one of six possible regimes using maximum likelihood methods[1]. Failure to account for the time series nature of data (e.g. when prices in one period affect trade flows in subsequent periods) may lead to a loss of efficiency, and greatly reduces the insights into the dynamics of price response that can be derived. Furthermore, while the "hazards of omitting trade volumes and transactions costs" (Barrett, 2001, p. 24) in price transmission analysis are manifest, in many important and interesting contexts this data is simply not available.

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[1] These six regimes are defined by the possible states of two variables: two possible states of trade between two locations (takes place or not) multiplied by three possible states of the difference in price between these locations (greater than, equal to or less than transfer costs between the locations).

In the case of wheat/flour price transmission in Ukraine there is reason to expect more than one equilibrium relationship because Ukraine has shifted from a net export to a net import position and back for milling wheat several times over the 2000-2004 period that we study. Furthermore, as outlined below, and partly in reaction to these import/export shifts, policy makers in Ukraine have frequently intervened on domestic wheat and flour markets, sometimes radically affecting the policy environment within which wheat and flour prices interact. As a result, the threshold cointegration approach would not appear to be appropriate for our purposes. At the same time, the parity bounds approach is not feasible because there is no data available on the weekly flows of wheat to millers that would correspond to the weekly price data at our disposal. Moreover, to our knowledge the parity bounds approach has only been applied in a spatial context to date, while the wheat and flour markets that interest us are vertically linked.

For these reasons we propose to employ a Markov-switching vector error correction model (VECM). This approach allows for multiple equilibrium relationships between the prices being studied; it provides insights into the dynamics of price response in the vertical wheat/flour chain, and it does not require trade data or other data beyond prices.

The rest of the paper is structured as follows. In section 2 an overview of policy developments on Ukrainian wheat and flour markets is provided. Section 3 introduces the Markov-switching VECM approach and describes the data employed. Empirical results are presented in section 4. In section 5 these results are discussed in relation to developments on Ukrainian wheat and flour markets, and section 6 concludes.

2 Policy intervention on wheat and wheat flour markets in Ukraine

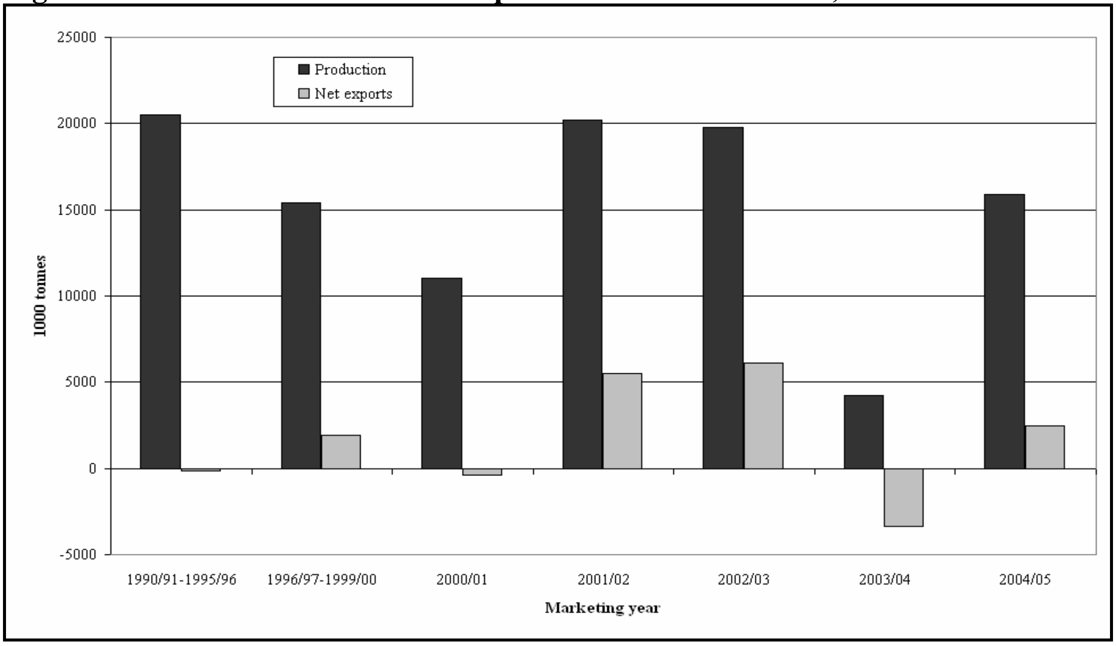
Policy makers in Ukraine actively intervene on agricultural markets. This intervention combines elements of Soviet-style agricultural policy (e.g. state purchase orders) with elements of the market and price support that characterises agricultural policy in many industrialised countries. The main forces driving this often highly contradictory policy mix have been: i) the very significant reductions in agriculture's terms of trade in Ukraine following the onset of transition (as in most transition countries – see, for example, Rozelle and Swinnen, 2004, Figure 5); ii) high hidden unemployment and the inefficiency of the agricultural production, processing and marketing structures left behind by the Soviet era; iii) a lack of the analytical capacities needed to appraise policies and their impacts in an open market economy setting;

and iv) rent seeking by policy makers/entrepreneurs in an environment characterised by major information asymmetries, a lack of transparency and weak legal and regulatory institutions.

Ukrainian grain markets – and wheat markets in particular – have always been highly politicised. Grain is considered ‘strategic’, and agricultural policy makers consider “the size of the grain harvest [as] a barometer of conditions in agriculture” (von Cramon-Taubadel, 2001: 103). Until the end of the 1990s, grain policy remained dominated by Soviet-style intervention in the form of the so-called state orders. Government bodies and parastatal enterprises supplied key inputs for the fall and spring seeding campaigns to the large collective farms, most of which had been reformed in name only and subject to little meaningful restructuring. In return, the authorities collected grain in payment for these inputs after the harvest (Striewe and von Cramon-Taubadel, 1999). In keeping with the adage ‘you pretend to pay us, and we pretend to work’, the inputs supplied were generally too little, of poor quality and often late, and in return the farms generally failed to deliver the contracted quantities and qualities of grains. Because large farms could not be permitted to go bankrupt, non-payments proliferated. This led to repeated debt write-offs (for example, in 1997 and 1998). Periodic bans on exports and movements of grain between Oblasts (the main federal sub-unit, of which there are 26) within Ukraine were imposed in an effort to force farms to deliver more grain to the state and its agents. Although they certainly affected farms unevenly and destabilised grain markets considerably, the state orders led to significant subsidies for grain production in the form of soft budget constraints that permitted many farms that would otherwise have been forced to exit the sector to continue operations.

At the same time, however, the state orders crowded out private investment in the input supply and grain marketing industries, and propped up a variety of state and parastatal monopolies in these industries. Cash-strapped farms could only purchase inputs against the next harvest, but private input suppliers and grain traders, knowing that the state would attempt to lay first claim on whatever grain was produced, were reluctant to provide credit on this basis. In a dynamic sense, therefore, the state order system stifled competition and investment in the industries up- and downstream from grain production. As a result, infrastructure (largely geared to moving grain inland to the rest of the Soviet Union, and not to world markets via the Black sea) was not modernised, and monopoly suppliers of grain storage, handling and transportation services were able to charge excessive prices, leading to very low farm gate prices in the net export situation that prevailed up to 2000. According to one estimate, farms in Ukraine received only an estimated 40% of the FOB export price for grain, compared with for example 70% in Germany (Striewe and von Cramon-Taubadel, 1999). This indirect tax on grain production outweighed the direct budget subsidies referred to above, leading to a significant net taxation of grain production in Ukraine. This, on top of the other difficulties associated with transition, contributed to a dramatic reduction in grain production in the course of the 1990s (Figure 1).

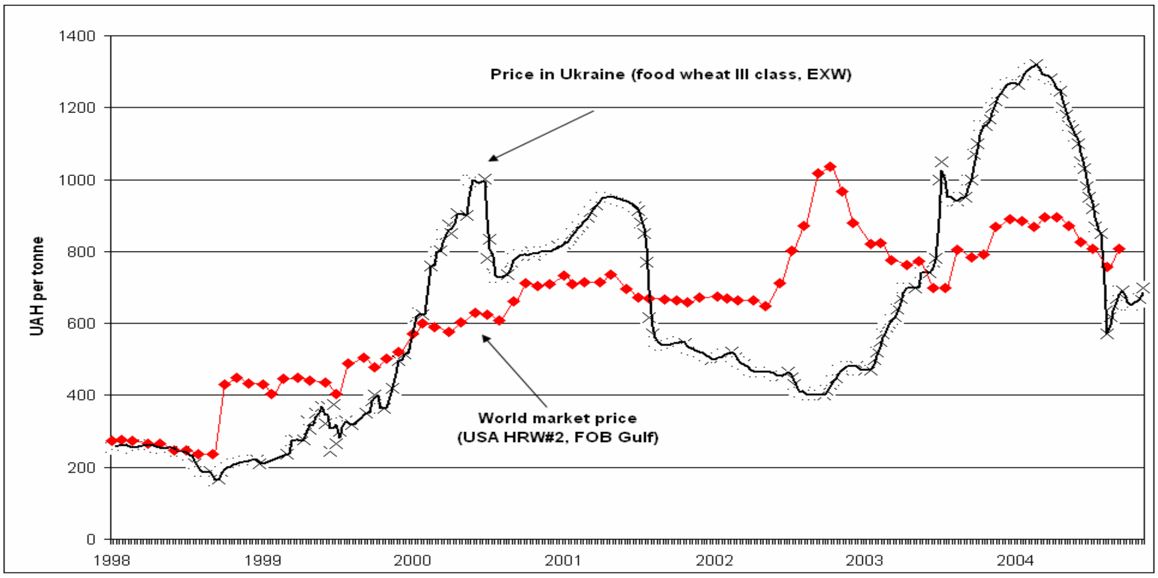
Figure 1: Production and net export of wheat in Ukraine, 1990-2004



Source: UkrAgroConsult (1998-2004) and FAS/USDA (2000-2004).

Following the financial crisis in 1998/99, President Kuchma installed a new reform-oriented government under (former National Bank Chairman) Prime Minister Yushchenko. This government introduced a policy of partial compensation of interest rates on commercial loans to agriculture and granted tax privileges to farmers. A decree by President Kuchma accelerated the process of farm restructuring. Most important, however, the new government immediately eliminated the state orders, greatly reducing the state's direct influence on grain markets and fostering private enterprise in the up- and downstream industries (Demyanenko and Zorya, 2004; von Cramon-Taubadel, 2001). However, due primarily to bad weather in 2000, Ukraine's wheat harvest dropped to its lowest value since independence (11 mt), and the country became a net importer of wheat. The same excessive marketing costs that had depressed export parity prices in earlier years now inflated import parity prices, which more than doubled in the course of a few months (Figure 2).

Figure 2: Ukrainian and world market wheat prices, 1998-2004, UAH/t



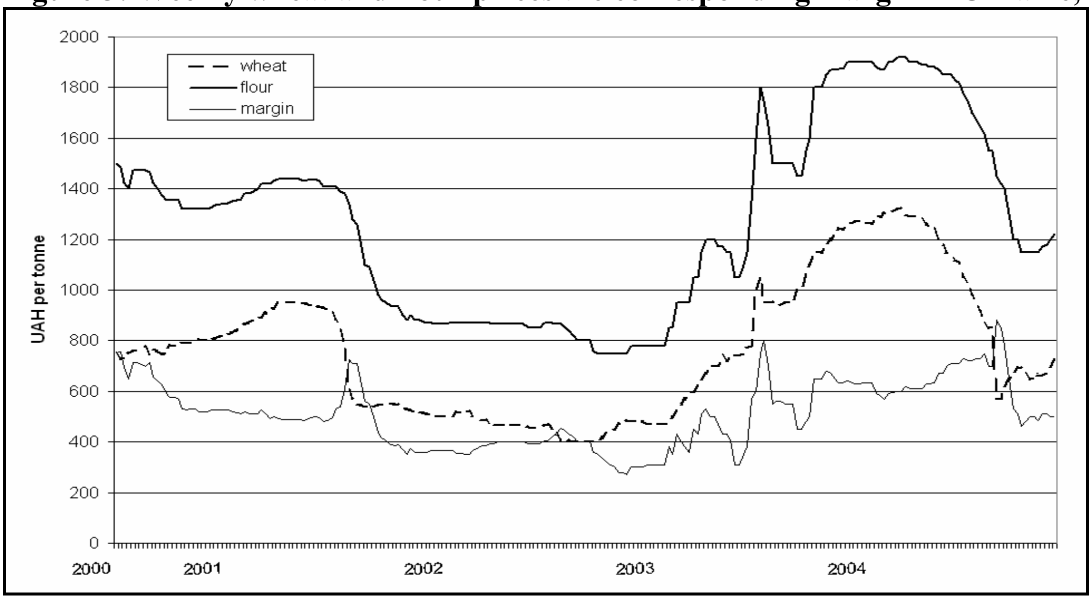
Source: UkrAgroConsult (1998-2004) and FAO (2004).

As grain prices skyrocketed, bread prices became a major concern. The policy response was *ad hoc*, populist and often counterproductive, betraying a widespread lack of understanding of market mechanisms and price formation. The government accused traders of speculation to drive up wheat prices, introduced grain export certification, fixed bread prices and announced plans to introduce a 'pledge price' system based on the US loan rate system (Presidential Decree No. 823 "On immediate measures to stimulate grain production and to develop grain market" from July 29, 2000). To increase wheat supply, wheat import duties were temporarily suspended and the wheat import regime simplified.

High wheat prices, low supply and uncertainty concerning policy developments had an impact on flour producers. Domestic production of flour fell and flour prices grew sharply, reaching new highs around 1.400 UAH/t in the 2000/01 marketing year. The evidence in Figure 3 suggests that flour producers attempted to take advantage of wheat price increases by increasing flour prices more than proportionally and thus increasing milling margins. Since bread prices were administratively fixed at low levels, bakers could not officially fully pass on flour price increases to consumers. However, anecdotal evidence suggests that a shadow market for bread flourished at the time, as supplies of bread at the fixed low prices contracted significantly.

Responding to high wheat prices, progress in reforms and favourable weather, the wheat harvest in 2001 reached the highest level in ten years, and remained high in 2002 (Figure 1). Ukraine became a major wheat exporter, exporting over 5 mt of wheat each in 2001/02 and 2002/03. Domestic prices returned to low export parity levels – falling more than 40% right after the 2001 harvest – and policy makers were once more preoccupied with the need to support wheat prices. Prices fell significantly in the first months after the harvest since farm, facing the need to repay input credits and finance the fall seeding campaign, were under pressure to sell quickly. Even where liquidity was less binding, storage was not an option since most farms had insufficient on-farm storage capacities and state-run elevators changed exorbitant fees. In response, the government reiterated its intention to implement the pledge price (loan rate) system. It also announced plans to implement an intervention system modelled along EU lines. Policy makers did not seem to be concerned (or aware) that one of these two systems was clearly redundant; in any event, sufficient budget funds were never provided for either system. The government also attempted to regulate exports by requiring that export contracts be registered on official agrarian exchanges, but this requirement was not enforced evenly over time and for all transactions. On the positive side, steps were taken to reduce marketing costs and encourage private investment in market infrastructure, especially in sea ports and elevators. On the whole, however, policy remained 'stop-and-go' and a major source of uncertainty on Ukrainian wheat markets. Over this period of time, Ukrainian flour production grew from 3.5 mt in 2000/01 to 3.65 mt on average in 2001/02 - 2002/03 (APK-Inform, 2004). Flour prices and milling margins gradually declined along with wheat prices (Figure 3), and flour imports did not exceed 2% of total flour supply.

Figure 3: Weekly wheat and flour prices the corresponding margin in Ukraine, UAH/t



Source: UkrAgroConsult (1998-2004).

In early 2003 severe winterkill damaged winter crops. "When this was followed by a prolonged drought in the late spring and early summer of that year, it became apparent that Ukraine was likely to become a net importer of food grain in 2003/04" (von Cramon-

Taubadel, 2004: 183). In the winter and spring of 2003, even before the final size of the wheat harvest was known, prices began to climb. The Ministry of Agriculture nevertheless continued to release relatively optimistic harvest forecasts, which had the effect of temporarily depressing prices in mid-2003and delaying imports. However, once it became clear that less than 5 mt would be harvested (an over 75% drop against the previous two years, Figure 1) prices jumped to new highs in excess of 1.000 UAH/t (Figure 2).

In response to this 'agricultural crisis', and as in 2000, the government responded with a flurry of populist measures. Individual agricultural policy makers at the central and regional levels were declared 'responsible' for the shortage of wheat and some were even arrested; investigations were launched into traders' activities; and regional authorities were empowered to monitor wheat movements and bread prices (see, for example, the Cabinet of Ministers Resolution No. 1150 "On failures of some executive branches to ensure the food security and measures to stabilize the markets of main staple foods" from July 24, 2003). Agreements reached with Russia and Kazakhstan for the supply of roughly 2 mt of wheat at 'reasonable prices' were announced. The prospect of this influx of low-priced wheat made private traders wary of importing, thus exacerbating the shortage. While wheat import duties and value added tax on wheat imports were eventually eliminated, this took several months. It is rumoured that this delay was partly due to attempts by powerful interests in Parliament to maintain import duties and open (suitably allocated) tariff rate quotas instead. The overall impression was that "it may be more appropriate to speak of a crisis in agricultural policy making in 2003 than of a 'crisis' in Ukrainian agriculture" (von Cramon-Taubadel 2004: 185). Prices finally peaked at over 1.300 UAH/t after roughly 3 mt were imported in the last three months of 2003 (UkrAgroConsult, 1998-2004). As imports continued and the outlook for the 2004 harvest remained promising, wheat prices began to fall, reaching 600-700 UAH/t by the end of 2004.

The poor wheat harvest in 2003 led to a sharp fall in flour stocks and a consequent rise in flour prices. While the flour price averaged 900 UAH/t in 2001/02, it reached 1.800 UAH/t in June 2003 and peaked at close to 2.000 UAH/t in November 2003 (Figure 3). Flour imports, mainly from Russia and Kazakhstan, increased so that in 2003/04 Ukraine imported 207.000 t or 5% of its total flour supply (APK-Inform, 2004). In addition, the State Material Reserve of Ukraine began to finance milling and to sell flour in large quantities. This 'state' flour, however, was only made available to certain large regional mills, thus crowding out private mills and increasing uncertainty concerning flour stocks and prices. Milling margins increased as they had during the last ‘crisis’ in 2000/01, and they became considerably more volatile (Figure 3). In the course of 2004, the flour prices stabilised and gradually decreased.

3 Methods and data

The Markov-switching vector error correction model (MSVECM) is a special case of the general Markov-switching vector autoregressive model, which was initially proposed by Hamilton (1989) for analysing the US business cycle. Krolzig et al. (2002) and Krolzig and Toro (2001) use the MSVECM to analyse business cycles with a special emphasis on employment. The MSVECM is, however, not restricted to business cycle analysis but can be viewed as a general framework for analysing times series with different regimes whenever the corresponding state variable is not observed. Here, we use a MSVECM for analysing vertical market integration between the markets for wheat and wheat flour in Ukraine.

If wheat and flour markets in Ukraine are integrated, there should exist a long-run relationship between their prices. Indeed, examination of these prices in Figure 3 suggests that they do tend to move in parallel. Hence, the familiar VECM might provide an appropriate representation of the underlying data generating process. However, given the frequent policy adjustments, the changes in Ukraine’s net wheat trade position and the volatility of the milling margin discussed above, it is reasonable to hypothesise that the underlying data generating process is characterised by structural changes over time. If this is true, a MSVECM – i.e., a VECM with shifts in some of the parameters according to the state of the system - will be a more appropriate representation. In our setting the MSVECM takes the following form:

$$\Delta \mathbf{p}_t = \boldsymbol{\alpha}_\mathbf{0}(s_t) + \boldsymbol{\alpha}(s_t)(\boldsymbol{\beta}' \mathbf{p}_{t-1}) + D_1(s_t)\Delta \mathbf{p}_{t-1} + D_2(s_t)\Delta \mathbf{p}_{t-2} + \ldots + D_k(s_t)\Delta \mathbf{p}_{t-k} + \boldsymbol{\varepsilon}_t \tag{1}$$

where $\mathbf{p}_\mathrm{t} = (p^f_t\ ,\ p^m_t)'$ is a vector of market prices for wheat flour (superscript f) and wheat (superscript w), respectively, $\boldsymbol{\alpha}_\mathbf{0}$ is a vector of intercept terms, $\boldsymbol{\alpha}$ is a vector of adjustment coefficients, $\boldsymbol{\beta}$ is the cointegrating (long-run equilibrium) vector, Δ is the first difference operator, and $D_1, D_2, \ldots, D_k$ are matrices of short-run coefficients. The vector $\boldsymbol{\varepsilon}_\mathbf{t}$ contains the residual errors of the flour and the wheat equation, which are subject to the usual assumptions. The state variable $s_t = 1, \ldots, M$ indicates which of the M possible regimes governs the MSVECM at time t. However, the state of the system is not observed; the most general specification would make the probability of being in state s_t dependent on the entire history of regimes S_{t-1}, and on the history of all the variables on the RHS of Equation (1). This general specification would leave the system unidentified unless some structure is imposed. The basic idea of a

Markov-switching model is to assume an ergodic Markov process for the probability of observing a certain state, so that the probability of s_t depends only on s_{t-1} and a matrix Π of transition probabilities.

$$Pr(s_t \mid S_{t-1}, \Delta P_{t-1}, \boldsymbol{\beta}' P_{t-1}) = Pr(s_t \mid s_{t-1}, \Pi) \tag{2}$$

Each element π_{ij} of Π gives the transition probability from state *i* to state *j*. Hence, the sum of each row of Π must equal one so that the number of unknowns in Π is equal to *M (M-1)*. Note that the vector **β** does not vary between systems since the long-run equilibrium relation is assumed to be constant over time. However, the intercept term in (1) can change over time to capture regime-dependent changes in the margin.

Estimation of the MSVECM is based on the maximum likelihood principle. The maximands of the likelihood function consist of the parameters in (1), a set of parameters corresponding to dummy variables indicating the value of the state variable s_t, and the transition probabilities π_{ij}. Krolzig (1997) advocates the use of a variant of the Expectation-Maximisation algorithm (Dempster et al., 1977). This iterative procedure breaks the maximisation down into two steps. First, the state parameters and transition probabilities are estimated conditional on a set of starting values for the coefficients in (1). In the second step, these values are updated using the first order conditions for the maximisation of the likelihood function with respect to the ECM parameters. This sequence is repeated until the procedure converges, i.e., the state parameters do no longer change between two subsequent iterations. The estimation procedure is available in the MSVAR package (Krolzig, 2004) for the matrix programming language Ox (Doornik, 2002).

The results reported below are based on 227 weekly observations from June 2000 to November 2004 (Figure 3). The average price for III class milling wheat and the wholesale price for top quality flour in Ukraine, both in natural logarithms, are used.

4 Empirical results

4.1 Unit root tests

As a prerequisite for the cointegration analysis, we first establish the time series properties of the price series. In addition to the ADF test an additional unit root test for processes with level shifts (Lanne et al., 2002) in used. For the latter test, the unknown break point is determined by a search over all possible break dates with a sufficiently large lag order. The date which gave the minimal residual sum in the auxiliary regression is chosen. The null hypothesis of a unit root in the undifferenced series is not rejected by either test for both wheat and flour prices. However, the tests provide strong evidence in favor of rejecting the null hypothesis of a unit root in both the flour and wheat price series in first differences (Table 1). Even when structural change is taken into account, both price series appear to be I(1).

Table 1. Results of the unit root tests

	Augmented Dickey-Fuller Test			**Unit root test with level shift (Lanne et al., 2002)**		
Series	Test statistic	Specification	5% critical value	Test statistic	Specification	5% critical value
ln p^f_t	-1.556	(6 lags, constant)	-2.86	-1.161	(8 lags, trend, shift dummy)	-3.03
ln p^w_t	-1.336	(3 lags, constant)		-1.468	(3 lags, trend, shift dummy)	
Δln p^f_t	-4.452	(5 lags)	-1.94	-4.473	(7 lags, constant, impulse dummy)	-2.88
Δln p^w_t	-6.639	(2 lags)		-6.636	(2 lags, constant, impulse dummy)	

Source: Own calculations.

4.2 Cointegration analysis

To test for cointegration we apply the Johansen trace test, based on a reduced rank regression of the vector autoregressive representation with 4 lags. The first test, with null hypothesis of no cointegrating relations, is rejected against the alternative of at least one cointegraing relation with a p-value of less than 0.1 % (LR^{trace} = 30.048). The next test, with the null hypothesis that the number of cointegrating vectors is one against the alternative that the number of cointegrating vectors is larger than one cannot be rejected (LR^{trace} = 1.922, p-value = 0.167). The resulting cointegrating relationship is given in Equation (3) (standard errors in parentheses):

$$\begin{aligned}\ln p_t^f &= 1.5976 + 0.8368 \ln p_t^w + u_t \\ &\quad\ (0.200)\qquad (0.030)\end{aligned} \tag{3}$$

The corresponding adjustment coefficients (standard errors in parentheses) are α^f = - 0.1274 (0.026) for the flour equation, and α^w = 0.0211 (0.041) for the wheat price equation, respectively. Since the deviations from the long-run equilibrium are obtained from the cointegrating vector normalised with respect to the flour price, both adjustment coefficient have the expected sign. The adjustment coefficient in the wheat price equation, however, is not statistically significant. Hence, adjustment towards the long-run equilibrium takes place through changes in flour prices, with half of a unit deviation from the long-run equilibrium being corrected within 5 weeks.

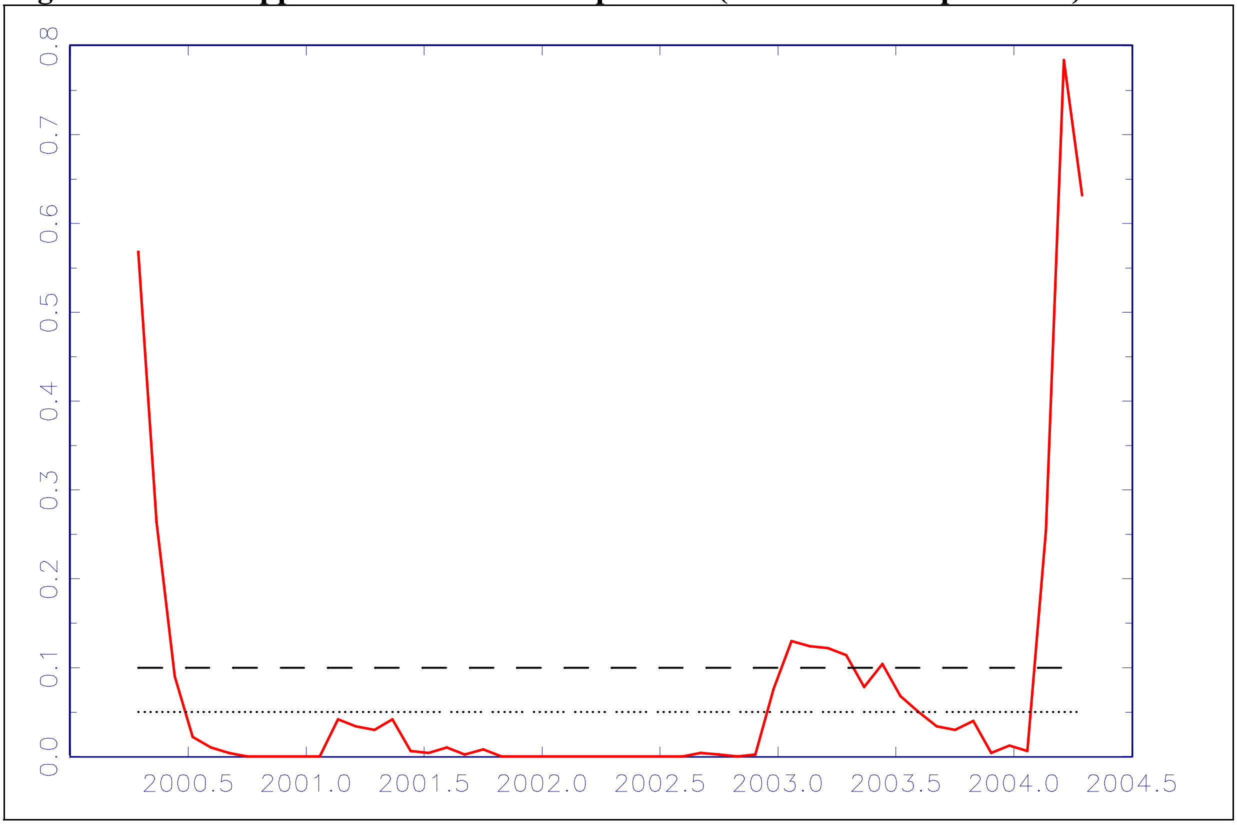
Diagnostic tests of the corresponding VECM reveal several problems. First, autocorrelation was checked by means of a vector autocorrelation test up to lag order 12. The resulting Lagrange multiplier test statistic is 52.648, which compares to a critical 5% χ^2 with 48 degrees of freedom of 65.17. Hence, the residuals of the system do not seem to be affected by a significant autocorrelation. However, the situation is worse with regard to the vector tests for heteroskedasticity and non-normality. The full White test for vector heteroskedasticity yields a test statistic of 268.35, which exceeds the critical χ^2 value with 105 degrees of freedom (129.92) substantially. A similar picture arises for the non-normality test, which rejects the null hypothesis of normally distributed residuals with a p-value of less than 0.01 %.

Fat tails in the distribution of the residuals and heteroskedasticity could both be caused by instability in the underlying price series. Hence, the system is checked for stability by means of a Chow forecast test which tests the null hypothesis that all parameters of the system remain constant over time against the alternative that all coefficients except β plus the residual covariance matrix change. The Chow test statistic is asymptotically χ^2 distributed; however, since the actual distribution under the null is non-standard (Candelon and Lütkepohl, 2000) we employ a bootstrap procedure implemented in JmulTi (http://www.jmulti.org) to calculate empirical p-values for different breakpoints. Figure 4 shows the bootstrapped p-values of the Chow forecast test for the sample; every 4th week was used as a possible break date. The p-values for the vast majority of the break dates lie substantially below the 5 % level (dotted line in Figure 4). Hence, the system would appear to be affected by structural breaks, and the representation of the price movements on Ukrainian wheat flour and wheat markets using a single, time-invariant ECM is not appropriate.

4.3 Markov-switching vector error correction model

The number of lags and the number of regimes in the MSVECM are selected according to the AIC. A formal test for M regimes against the alternative M+1 regimes is difficult because a number of parameters in the unrestricted model are not identified under the null hypothesis, leading to a non-standard distribution of the usual likelihood-based test statistics. Nevertheless, the AIC turned out to be strongly in favour of a specification with 4 regimes and 3 lags The residual diagnostics for this specification indicate that autocorrelation, heteroskedasticity and non-normality are not present.

Figure 4: Bootstrapped Chow forecast test p-values (based on 500 replications)



Source: Own calculations.

The estimated parameters of this MSVECM specification are presented in Table 2. One interesting feature is the drop in the adjustment coefficients compared with the simple VECM. The magnitude of the significant coefficient in the flour equation is reduced by factors of 3 (regimes 1-3) and 6 (regime 4). The adjustment coefficient in the wheat equation remains statistically insignificant in all regimes. Another intriguing feature is the distinct variation in the residual standard errors σ_ε^f and σ_ε^w between the regimes. Speed of adjustment, residual standard errors and the resulting margin in the long-run relation (which may be calculated using the estimated coefficients for the regime-specific constant and the corresponding speed of adjustment) allow for a more detailed interpretation of the single regimes.

Regime 1 **'Normal integration'** is characterised by relatively small values for the residual standard errors σ_ε^f and σ_ε^w; both the margin and the speed of adjustment parameter in the flour equation are at their normal levels (α^f = -0.04).

Regime 2 **'Calming'** exhibits increased residual standard errors (relative to regime 1, σ_{ε}^{f} increases by a factor 1.5 and σ_{ε}^{w} by a factor 3); the margin and α^{f} remain at their normal levels.

Regime 3 **'Alert'** is characterised by a strong increase in the variability of the errors for flour (σ_{ε}^{f} increases 7-fold and σ_{ε}^{w} 2-fold relative to regime 1); the margin is slightly reduced by about 12 %, and α^{f} remains unchanged.

Regime 4 **'Disarray'** has the highest residual standard errors in both equations (σ_{ε}^{f} increases 10-fold and σ_{ε}^{w} 12-fold relative to regime 1); the margin is exceptionally high, and the speed of adjustment in the flour price change equation is halved.

Table 2. The estimated MSVECM (MS(4)-VECM(3))

Variable	Regime 1		Regime 2		Regime 3		Regime 4	
	ΔP^{f}	ΔP^{w}	ΔP^{f}	ΔP^{w}	ΔP^{f}	ΔP^{w}	ΔP^{f}	ΔP^{w}
Const.	0.063*	-0.013	0.063*	-0.013	0.063*	-0.013	0.063*	-0.013
	(0.011)	(0.021)	(0.011)	(0.021)	(0.011)	(0.021)	(0.011)	(0.021)
ΔP^{f}_{t-1}	-0.030	-0.299*	0.236*	-0.173	0.233*	0.110*	0.240	0.877*
	(0.034)	(0.055)	(0.064)	(0.206)	(0.092)	(0.051)	(0.221)	(0.417)
ΔP^{f}_{t-2}	0.051*	0.043	0.097	-0.035	-0.124	0.051	0.789*	0.592
	(0.026)	(0.043)	(0.057)	(0.177)	(0.117)	(0.061)	(0.251)	(0.452)
ΔP^{f}_{t-3}	-0.221*	-0.295*	0.001	-0.224*	0.163	0.075	0.431	1.054
	(0.030)	(0.048)	(0.035)	(0.111)	(0.094)	(0.057)	(0.366)	(0.662)
ΔP^{w}_{t-1}	0.293*	0.619*	-0.039*	0.038	0.308*	0.329*	-0.351	-0.999*
	(0.063)	(0.105)	(0.018)	(0.056)	(0.107)	(0.061)	(0.220)	(0.421)
ΔP^{w}_{t-2}	-0.017	-0.208*	0.048	0.410*	-0.361*	0.096	1.275*	1.450*
	(0.011)	(0.018)	(0.035)	(0.121)	(0.109)	(0.064)	(0.361)	(0.661)
ΔP^{w}_{t-3}	0.044	0.432*	0.068	0.508*	0.222*	-0.026	0.160	2.941*
	(0.032)	(0.054)	(0.040)	(0.130)	(0.056)	(0.032)	(0.395)	(0.725)
ECT_{t-1}	-0.041*	0.008	-0.041*	0.004	-0.044*	0.014	-0.026*	-0.027
	(0.007)	(0.013)	(0.007)	(0.013)	(0.007)	(0.013)	(0.010)	(0.018)
$\sigma_{\varepsilon}^{f/w}$	0.0034	0.0056	0.0052	0.0170	0.0229	0.0123	0.0368	0.0631
Constant restricted in the ECT term	-1.5604		-1.5301		-1.4489		-2.4179	

*Note: Standard errors in parentheses. * indicates statistical significance at 1%.*
Source: Own calculations using MSVAR for Ox (Krolzig, 2004, Doornik, 2002).

Table 3 presents the matrix of transition probabilities from regime s_{t-1} to regime s_t. The values on the main diagonal indicate the probability of no change from a regime. Regimes 1 and 2 are found to be the most persistent, which is also indicated by the average duration of each regime. While regimes 1 and 2 both last for about 4 weeks on average, regimes 3 and 4 lasts only 2 and 1,5 weeks on average, respectively. From either regime 1 or 2, if a regime change takes place, regime 3 is the most likely outcome in the subsequent period (probabilities of 14 and 15 %, respectively). From regime 3, the system might either calm down (regime 2: 24 %; regime 1: 12 %), or the uncertainty in the market might culminate in disarray (regime 4: 12 %). Once in regime 4, the calming takes place via regime 3 as an intermediate step (37 %) or directly into regime 1 (19 %). Note, however, that regime 4 is also quite persistent, with a 37 % probability of no change.

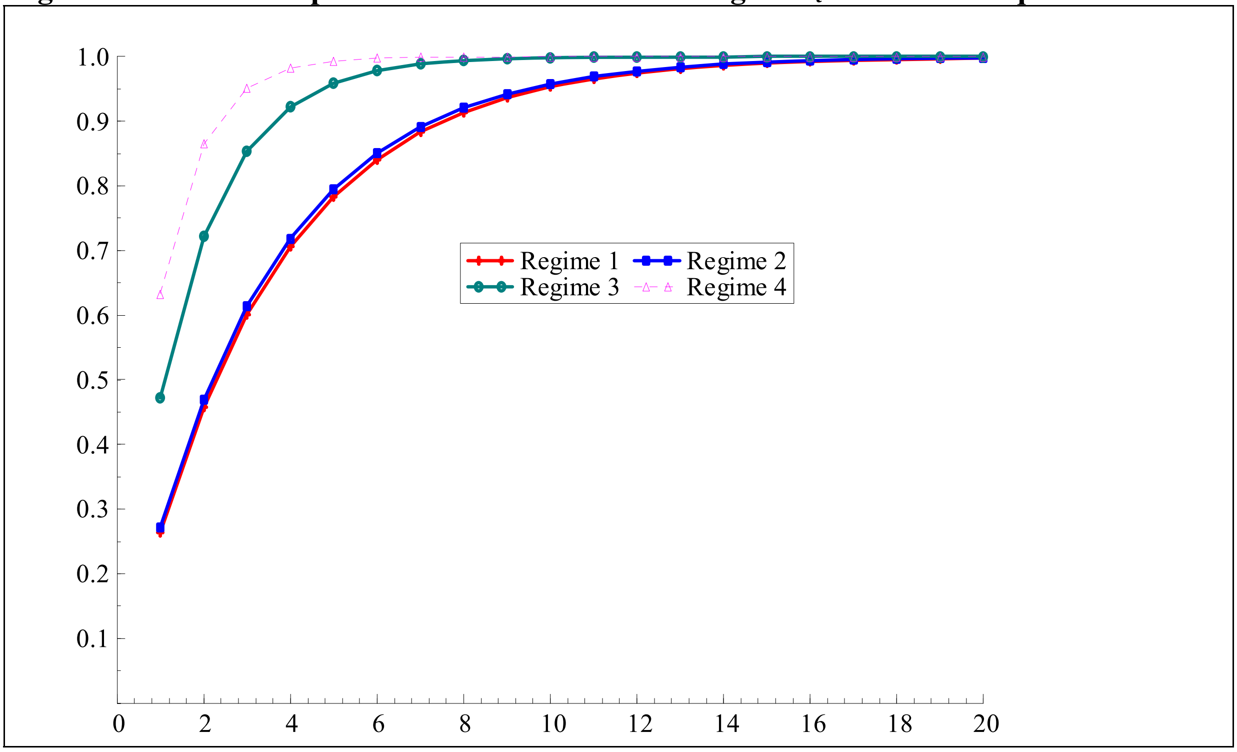
Table 3. Transition matrix for the MSVECM with 4 regimes

to regime … / from regime …	1	2	3	4
1	0.736	0.067	0.142	0.055
2	0.121	0.728	0.151	0.000
3	0.117	0.236	0.528	0.119
4	0.194	0.069	0.370	0.367

Source: Own calculations

Figure 5 presents more information on the duration of each regime. The graph plots the cumulative probability on the y-axis against the duration of the regime on the x-axis. Regimes 1 and 2 follow virtually undistinguishable routes, while regime 3 is substantially shorter-lived. The 'disarray' regime 4 is not very stable; the probability of observing it over more than 3 subsequent weeks is less than 5 %.

Figure 5: Cumulative probabilities for duration of regime s_t less than or equal to *t* weeks

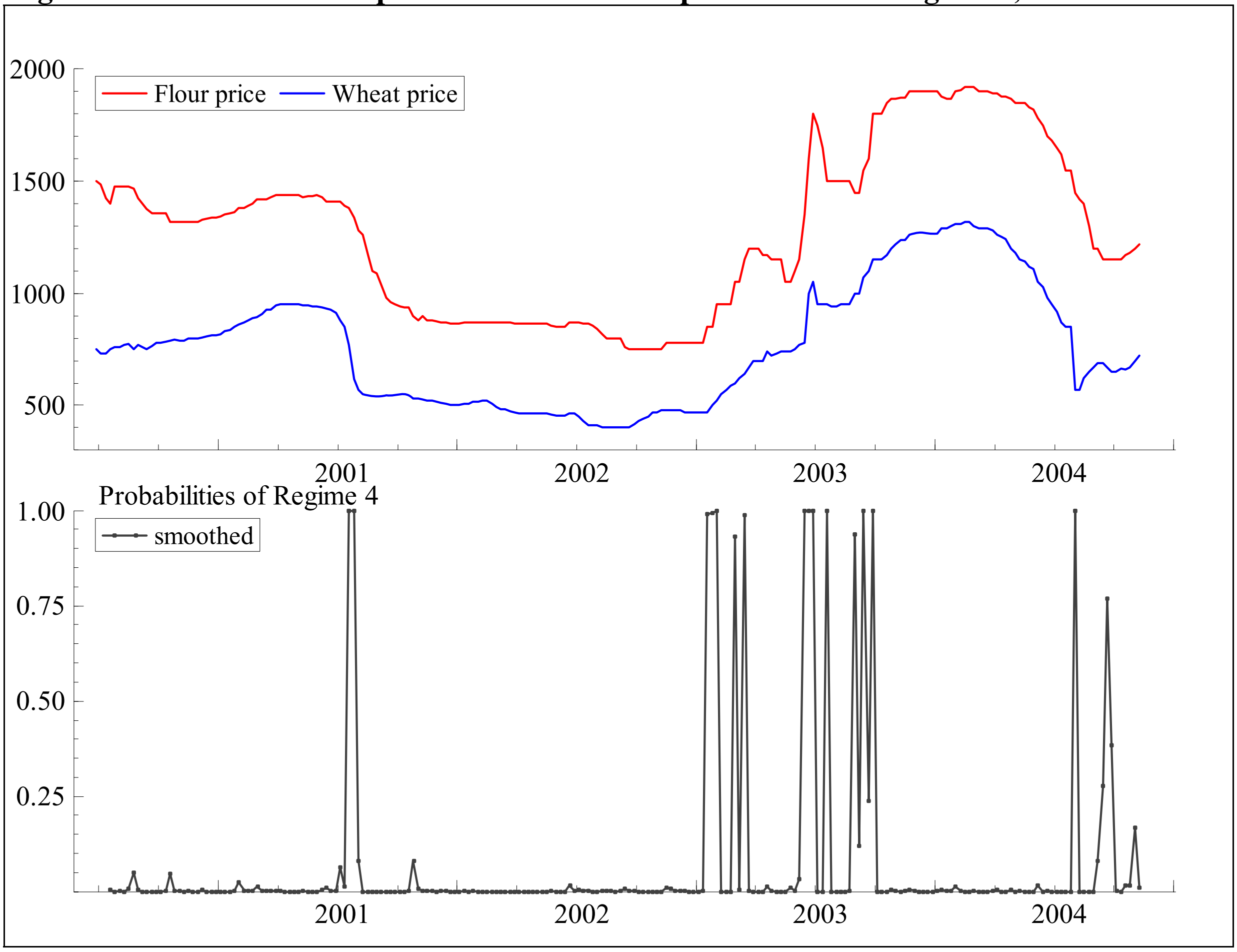


Source: Own calculations.

5 Discussion

In this section we attempt to link the results of the MSVECM to the market and policy developments discussed in section 2. Of the four regimes identified above, regime 4 is the most interesting, because the lack of adjustment and the inflated uncertainties in the price equations imply a substantial social cost for the Ukrainian wheat economy. In Figure 6, the development of the two price series in the top panel is compared with the smoothed probabilities for regime 4 in the bottom panel. The latter indicate the probability that the system state is in regime 4 at time t. The distinct peaks of the graph highlight distinct episodes of regime 4, even though it is the least likely of the four regimes.

Figure 6: Flour and wheat prices in Ukraine and probabilities of regime 4, 2000-2004



Source: Own calculations.

Note that the peak probabilities of observing regime 4 coincide with periods of important shocks to flour and wheat markets in Ukraine. The first peak occurs in the second half of July 2001, when a bumper crop returned Ukraine from a net import to a net export situation for wheat and the price of wheat dropped more rapidly than the price for wheat flour, leading to an above-average margin (Figure 3). The next peak occurs in January, 2003, when the first news of severe winterkill in the Ukrainian wheat crop began to spread. The subsequent one-period occurrences of regime 4 in the 9th and 11th weeks of 2003 can be attributed to the same cause and may have be related to conflicting information and rumours about the full extent of the damage caused by winterkill.

In the further course of 2003, additional episodes of regime 4 can be observed. These are of particular interest, as they can be linked to direct policy interventions on the markets for wheat and flour. The first set of these occurs in the summer and begins with a block of three weeks duration (24th – 26th week of 2003), and is followed by a one-period observations in week 29. These dates coincide with heavy political activity; on June 29 and July 24 important cabinet resolutions were issued which set out the intended government reaction to the low harvest and the emerging shortage of wheat. Regime 4 is observed two weeks in advance of these dates, which might be explained by the intense public discussion preceding the official resolutions. The interventionist character of many of the proposed measures – e.g., allowing for regional administrative control of physical grain shipments, or regulating bread prices – destabilised markets, as signalled by the high probability for regime 4.

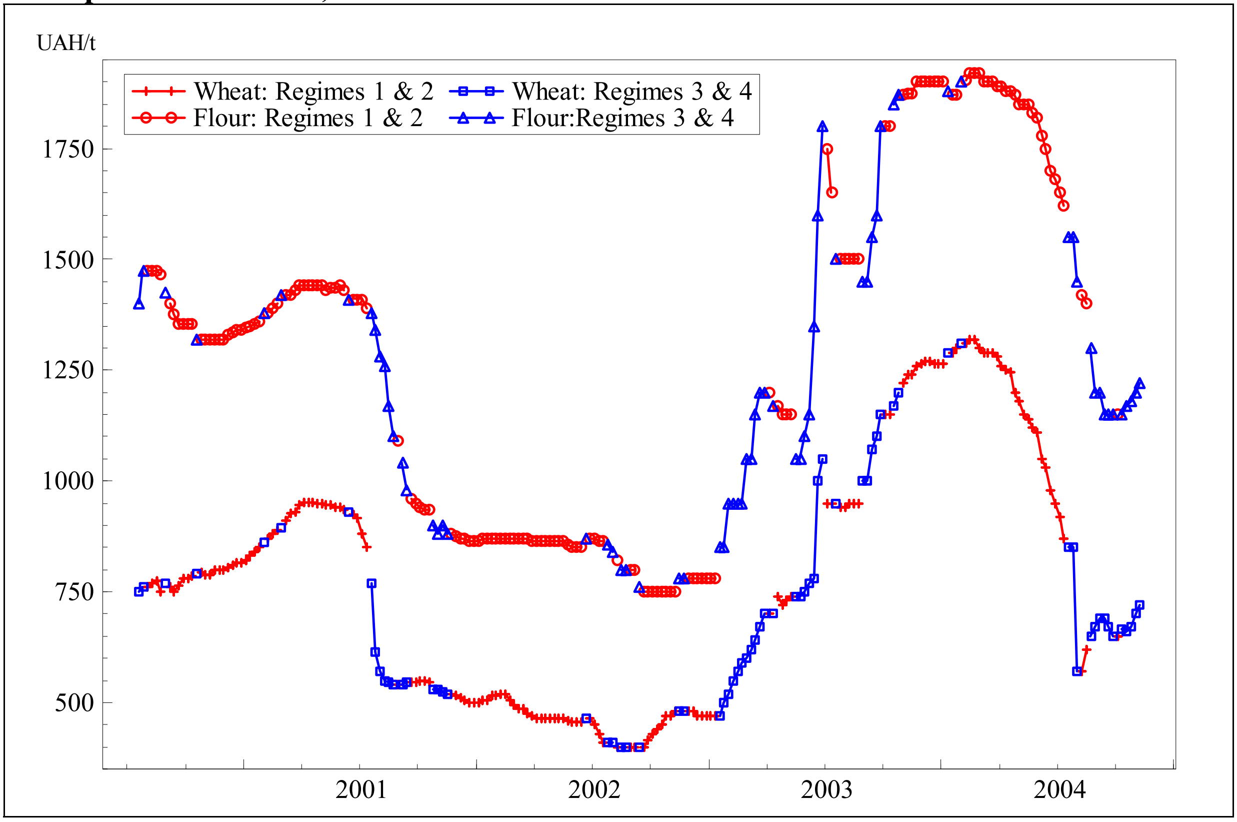
Following a brief 'calming' of four weeks duration, episodes of regime 4 flared up again in the fall of 2003. Official announcements of low-priced wheat imports from Kazakhstan and Russia coincide with observations of regime 4 in weeks 35, 37, and 39. Beginning in October 2003, grain markets and policies in Ukraine began to stabilise as imports began to enter the country.

Figure 7 provides a more aggregated view by only distinguishing between 'normal' regimes (1 and 2), which are characterised by relatively low residual standard errors, and 'alert' regimes (3 and 4), which exhibit much higher residual standard errors. According to this graph, most of the 2003 can be viewed as a period in which wheat and flour markets were destabilised. Figure 6 and 7 indicate that the prevalence of regimes 3 and 4 increased in July 2004. These more recent episodes of instability might be attributable to the presidential election campaign in Ukraine, in which both leading candidates explicitly referred to the regulation of wheat trade and bread price controls in their election programmes.

6 Conclusions

In this paper we analyse vertical market integration between wheat and flour in Ukraine over the years 2000-2004. Interference on these markets by policy makers, especially in response to changes in Ukraine's net wheat trade balance over this period, has been varied, intense and often contradictory, leading to considerable uncertainty and making it difficult for private actors such as farmers, traders and mills to make consistent plans.

Figure 7: 'Normal' (1&2) and 'alert' (3&4) regimes of the MSVECM for wheat and flour prices in Ukraine, 2000-2004



Source: Own calculations.

We therefore hypothesise that the relationship between wheat and flour prices in Ukraine was not constant over this period. Our 'suspicion' is fueled by the results of a Chow forecast test that rejects the null hypothesis that all parameters of a standard VECM involving wheat and flour prices remain constant over time. As an alternative we explore the usefulness of the Markov-switching vector error correction model (MSVECM). The MSVECM has been applied in the business cycle literature in recent years. A MSVECM estimated using 228 weekly observations of wheat and flour prices in Ukraine between June 2000 and November 2004 with three lags (in differences) and four regimes is found to perform well.

The endogenously estimated regimes can be interpreted as different conditions governing the price relationship between flour and wheat at different point in time. Differences in the residual standard errors, the milling margin, and the magnitude of the speed of adjustment to disequilibrium distinguish the regimes from one another. The most imprecise regime, i.e., the one with the highest residual variance and most volatile margins, is regime 4. The prevalence of this regime over time can be linked to market shocks such as changes in Ukraine's wheat trade balance and the policy reactions triggered by these shocks. In particular, in 2003 and the latter part of 2004 *ad hoc* policy interventions and high probabilities of regime 4 coincide. This suggests that much policy intervention in response to shocks to Ukraine's wheat and flour markets actually increased rather than reduced instability.

The MSVECM approach employed here could be extended by the direct incorporation of policy variables. For example, an index of new market information due to shocks or policy intervention might be constructed based on a rigorous screening of newspapers and other media, and included in the estimation. Applications to other settings and further investigation of the robustness of the results of MSVECM estimation (number of regimes, number of lags) would help to increase the confidence with which these results can be interpreted in the context of actual market developments.

7 References

APK-Inform (2004). Ukrainian Grain Market. Weekly Analytical and Statistical Report. APK Inform, Kyiv, Ukraine, July.

Bakucs, L.Z. and I. Fertö (2005). Marketing Margins and Price Transmission on the Hungarian Pork Market. In: Brosig, S. and H. Hockmann (eds.): *How Effective is the Invisible Hand? Agricultural and Food Markets in Central and Eastern Europe*. Studies on the Agricultural and Food Sector in Central and Eastern Europe, Vol. 31, Institute of Agricultural Development in Central and Eastern Europe (IAMO): 134-149.

Barrett, C. (2001). Measuring Integration and Efficiency in International Agricultural Markets. *Review of Agricultural Economics*, Vol. 23(1): 19-32.

Baulch, B. (1997). Transfer Costs, Spatial Arbitrage and Testing for Food Market Integration. *American Journal of Agricultural Economics*, Vol. 79: 477-487.

Berkowitz, D. and D.N. DeJong (2000). Economic Consequences of Russia's Internal Border. In: Wehrheim, P, E.V. Serova, K. Frohberg and J. von Braun (eds.): *Russia's Agro-food Sector: Towards Truly Functioning Markets*. Kluwer Academic Publishers: 185-201.

Bojnec, Š. and G. Peter (2002). *Price Transmission and Marketing Margins in the Slovenian Beef and Pork Markets during Transition*. Paper presented at the 10th EAAE Congress 'Exploring Diversity in the European Agri-food System', Zaragoza, August 28-31, 2002.

Candelon, B. and Lütkepohl, H. (2000). On the Reliability of Chow Type Tests for Parameter Constancy in Multivariate Dynamic Models. Discussion Paper, Humboldt-Universität Berlin.

von Cramon-Taubadel , S. (2002). Grain Market Regulation in Ukraine: Options and Evaluation. Insti-tute for Economic Research and Policy Consulting in Ukraine, Advisory Paper S6, www.ier.kiev.ua.

von Cramon-Taubadel , S. (2004). The 2003 wheat harvest: Crisis! What crisis? In: S. von Cramon-Taubadel, S. Demyanenko and A. Kuhn (eds.). Ukrainian Agriculture - Crisis and Recovery. Aachen: Shaker Verlag: 183-200.

von Cramon-Taubadel, S., Ed. (2001). Price determination and government policy on Ukrainian grain markets. In: S. von Cramon-Taubadel, S. Zorya and L. Striewe (eds). Policies and Agricultural Development in Ukraine. Aachen: Shaker Verlag.

Dempster, A.P., N. M. Laird and D. B. Rubin. Maximum likelihood from incomplete data via the EM algorithm (with discussion). Journal of the Royal Statistical Society B 39: 1-38.

Demyanenko, S. and S. Zorya (2004). Taxation and Ukrainian agriculture. In: S. von Cramon-Taubadel , S. Demyanenko and A. Kuhn (eds.). Ukrainian Agriculture: Crisis and Recovery. Aachen: Shaker Verlag: 25-39.

Doornik, J.A. (2002), Object-Oriented Matrix Programming Using Ox, 3rd ed. London: Timberlake Consultants Press and Oxford: www.nuff.ox.ac.uk/Users/Doornik.

Fackler, P.L. and B.K. Goodwin (2001). Spatial Price Analysis. In: Gardner, B. and G. Rausser (eds.): *Handbook of Agricultural Economics*, Vol. 1B. Elsevier: 971-1024.

FAO (2004): World market prices of wheat. UN Food and Agriculture Organisation. http://www.fao.org.

FAS/USDA (2000-2004). Grain Market Reports. Foreign Agricultural Service, US Department of Agriculture, Kyiv Post.

Goodwin, B.K. and N.E. Piggott (2001). Spatial Market Integration in the Presence of Threshold Effects. *American Journal of Agricultural Economics*, Vol. 83: 302-317.

Krolzig, H.-M. (2004). MSVAR – an Ox package designed for the econometric modelling of univariate and multiple time series subject to shifts in regime. Version 1.31k: http://www.economics.ox.ac.uk/research/hendry/krolzig/msvar.html.

Krolzig, H.-M. and J. Toro (2001). A New Approach to the Analysis of Business Cycle Transitions in a Model of Output and Employment. Department of Economics discussion paper series No. 59, University of Oxford: Oxford.

Krolzig, H.-M., M. Marcellino and G.E. Mizon (2002). A Markov-switching vector equilibrium cor-rection model of the UK labour market. Empirical Economics 27(2): 233-254.

Kuhn, A. (2000). Regional (Dis-)Integration of Russia's Agro-food Markets. In: Wehrheim, P, E.V. Serova, K. Frohberg and J. von Braun (eds.): *Russia's Agro-food Sector: Towards Truly Functioning Markets*. Kluwer Academic Publishers: 203-219.

Lanne, M., Lütkepohl, H. and Saikkonen, P. (2002). Comparison of unit root tests for time series with level shifts. Journal of Time Series Analysis 23(6): 667-685.

Loy, J.-P. and P. Wehrheim (1999). Spatial Food Market Integration in Russia. In: Peters, G.H. and J. v. Braun (eds): *Food Security, Diversification, and Resource Management: Refocusing the Role of Agriculture*. Proceedings of the 23. International Association of Agricultural Economists (IAAE) Conference in Sacramento. Ashgate Publishing Limited: 421-431.

McNew, K. and P.L. Fackler (1997). Testing Market Equilibrium: Is Cointegration Informative? *Journal of Agricultural and Resource Economics*, Vol. 22(2): 191-207.

Meyer, J. (2004). Measuring Market Integration in the Presence of Transaction Costs – a Threshold Vector Error Correction Approach. *Agricultural Economics*, Vol. 31(2-3): 327-334.

Meyer, J. and S. von Cramon-Taubadel (2004). Asymmetric Price Transmission: A Survey. *Journal of Agricultural Economics*, Vol. 55(3): 581-611.

Rozelle, S. and J.F.M. Swinnen (2004). Success and Failure of Reform: Insights from the Transition of Agriculture. *Journal of Economic Literature*, Vol. XLII(2): 404–456.

Sephton, P.S. (2003). Spatial Market Arbitrage and Threshold Cointegration. *American Journal of Agricultural Economics*, Vol. 85(4): 1041-1046.

Striewe, L. and S. von Cramon-Taubadel (1999). Die Getreideproduktion der Ukraine: Verpasste Chancen und dringender Handlungsbedarf. In: S. von Cramon-Taubadel and L. Striewe (eds.). Die Transformation Der Landwirtschaft in Der Ukraine: Ein Weites Feld. Wissenschaftsverlag Vauk Kiel KG: 74-87.

UkrAgroConsult (1998-2004). Agrinews. Weekly Issues, Kyiv.

Yahshilikov, Y. and S. Brosig (2005). *Interregional Integration of Wheat Markets in Kazakhstan*. Poster paper presented at the 2005 Institute of Agricultural Development in Central and Eastern Europe (IAMO) Forum: How Effective is the Invisible Hand? Agricultural and Food Markets in Central and Eastern Europe. Halle, June 2005.