CERDI, *Etudes et Documents*, E 2006.4

Document de travail de la série

Etudes et Documents

E 2006.4

The impact of world price instability on agricultural supply according to macroeconomic environment

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Avril 2006
29 p.

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Abstract

This paper aims at analyzing the effect of world price instability on the aggregate agricultural supply of developing countries and determining to what extent this effect depends on the macroeconomic environment. Producers of agricultural commodity-exporting countries are particularly vulnerable to the fluctuations of world prices : they are exposed to price shocks and their ability to cope with them is weak. But the effectiveness of risk coping strategies is conditional on the influence of macroeconomic factors. We test the impact of international price instability on the aggregate agricultural supply, taking account of some features of the national environment (infrastructure, inflation, and financial deepening). The analysis is based on a sample of 25 countries during the period 1961-2002. Results from panel data highlight a significant negative effect of international price instability on aggregate agricultural supply. Moreover, they show that high inflation, weak infrastructure and poorly developed financial system contribute to reinforce this effect.

L'objet de cet article est d'analyser l'impact de l'instabilité des prix réels internationaux sur l'offre agricole agrégée des pays en développement, conditionnel à l'influence de l'environnement macroéconomique. Dans les pays en développement exportateurs de produits agricoles, les producteurs sont particulièrement vulnérables aux fluctuations des prix réels internationaux : ils sont exposés aux chocs et leur capacité de gestion du risque est faible. Or celle-ci dépend de l'influence de certains facteurs macroéconomiques. Il est donc intéressant de tester l'effet de l'instabilité des prix agricoles internationaux sur l'offre agrégée selon l'environnement (infrastructures, inflation et développement financier). L'analyse concerne un groupe de 25 pays sur la période 1961-2002. Les résultats obtenus à partir de données de panel mettent en évidence un effet négatif significatif de l'instabilité des prix réels internationaux sur l'offre agricole ; ils montrent en outre qu'un niveau d'inflation élevé, un niveau d'infrastructures faible et un système financier peu développé accentuent cet effet.

1 Introduction

After years of structural adjustment during which commodity marketing boards gradually disappeared because of their inefficiency, the agricultural producers of developing countries undergo the consequences of domestic market liberalization mainly through a more direct exposure to world price instability. But their capacity to cope with price risk remains weak. Indeed, the market instruments often allows the producers to insure themselves against risks that are associated to shorter-than-one-year price variations, but year-to-year price fluctuations can not be coped with by the same way (Guillaumont et al. (2003)). Evaluating the impact of world price instability on aggregate agricultural supply then is a crucial question for poverty reduction strategies.

The effect of price instability on production decisions have been empirically studied since the pioneer works of Behrman (1968) and Just (1974) but this kind of empirical evidence is still limited. Cross-country regressions are rather few and time series regressions - as they focus on one individual commodity - do not give any aggregate result. In this paper, we complement the results of the literature estimating a model of aggregate supply response to instability, using panel data over forty years.

Moreover, we suppose this response to be conditional on domestic macroeconomic factors. The analysis makes it possible to evaluate under which conditions a stronger exposure to international market does not result in a stronger exposure to price shocks. It determines the influence on the instability-supply link of macroeconomic factors related to producers' risk management capacity. More precisely, we investigate whether better infrastructure, lower inflation and financial development decrease the adverse effects of price instability.

These hypotheses are tested by estimating an aggregate agricultural supply function combining world price instability and domestic macroeconomic environment, using the fixed-effects estimator and the GMM system estimator. A significant negative effect of world price instability on agricultural supply is evidenced. Moreover, it appears that this effect is more pronounced when macroeconomic environment is characterized by weak infrastructure, high inflation, and poorly developed financial system.

The main empirical results of literature which deals with the relationship between price instability and agricultural supply, and the expected influence of the macroeconomic environment on that relationship are the subject of section II. The hypotheses and the empirical model are developed in section III. The construction of price and production indices and price instability measurement is displayed in section IV. We comment the results in section V. We draw conclusions in section VI.

2 Main findings of the relevant literature

The influence of the macroeconomic environment on the agricultural supply response to world price instability merges two literatures : the analysis of the effect of price instability on agricultural supply and the analysis of the role of the macroeconomic environment in supply response.

2.1 The effect of price instability on agricultural supply

Since Newbery & Stiglitz (1981), risk aversion is at the heart of each empirical analysis of the effect of price instability on agricultural supply. Indeed, producers whose only source of income is agricultural income, will prefer a certain income to uncertain income with the same expected value. Moreover, the agricultural supply response to price risk depends on producers risk aversion : under increasing price instability, supply will be reduced if risk aversion is moderate, but it will be increased if risk aversion is high, the producers working more to avoid extreme situations. This result arises from a simple model of optimization, developed by Sadoulet & de Janvry (1995) among others. In this model, the producer chooses the level of production q which maximizes the expected utility of income :

$$EU(\widetilde{p}.q - w.x)$$

where $\widetilde{p}$ is the output price (a random variable), q is the output quantity, x is the labour input, and w is the input price. The only random term is $\widetilde{p}$, risk arising only from output price instability[1]. In order to simplify the analysis, production level q is supposed to be a function of labour x only. The producer's utility function is supposed to be additive in revenue and costs, that is :

$$EU(\widetilde{p}.f(x) - w.x) = EU(\widetilde{p}.f(x)) - w.x$$

Lastly, the producer has a constant relative risk aversion utility function[2] of coefficient R. The producer's maximization problem is thus :

$$\underset{x}{Max} E\left[\frac{(\widetilde{p}.f(x))^{1-R}}{1-R}\right] - w.x$$

The first-order condition is :

$$E(\widetilde{p}^{1-R}).f(x)^{-R}.f'(x) - w = 0$$

Under certainty, p is always equal to its average value $\overline{p}$. If $R < 1$, $E(\widetilde{p}^{1-R}) < \overline{p}^{1-R}$, so $f(x)^{-R}.f'(x)$ under risk is higher than under certainty. As $f(x)^{-R}.f'(x)$ is a decreasing function of x, x under risk is lower than under certainty, so q under risk is lower than under certainty. On the contrary, if $R > 1$, q under risk is higher than under certainty. Therefore, the static response of producers to instability depends on their degree of risk-aversion. Nevertheless, in a more dynamic framework to which empirical analyses refer, the expected supply response is more likely to be negative, price instability discouraging investment and

[1] The model presented by Sadoulet & de Janvry (1995) also takes account of production risk. Moreover, they recall that price risk and production risk can be dependent in insulated markets where the output price is not exogenous.

[2] The utility function with constant relative risk aversion coefficient is chosen because the supply function under this hypothesis is particularly straightforward.

innovation with uncertain return.

Since Behrman (1968) and Just (1974), several time-series analysis have underlined the importance of price instability variables in production decisions. Most of the time, these analyses are devoted to one individual commodity, and aim at showing that price uncertainty has a negative impact on production decisions (Lin (1977), Hurt & Garcia (1982), Brorsen et al. (1987), Aradhyula & Holt (1989), Holt & Aradhyula (1990), Chavas & Holt (1990), Antonovitz & Green (1990), Pope & Just (1991), Guillaumont & Bonjean (1991), Holt (1993), Chavas & Holt (1996)). Those works do not give any aggregate result concerning a large sample of developing countries.

In addition, there are several analyses applied to large samples of countries which deal with aggregate supply elasticity (Binswanger & al. (1987), Chhibber (1989), Schiff & Montenegro (1997)). But their first objective is to quantify the supply response to price incentives and price instability is almost never introduced in these analyses.

Only a few work investigates the effect of price instability on aggregate agricultural supply for a sample of developing countries. Through a variance analysis, Boussard & Gérard (1994) find that commodity production's growth is stronger in countries where the output price turns to be more stable. Through a cross-country analysis over the 1970-1979 period and the 1979-1988 period, Guillaumont & Combes (1994) estimate the effect of producer price instability on supply growth for several country-commodity pairs. Their results evidence a negative impact of price instability on supply.

Thus, the issue of price instability effect on agricultural supply is often broached in the literature, but none of those analyses can give any result at an aggregate level, concerning the global supply. That is why the following analysis aims at estimating the aggregate agricultural supply response to price instability, from a sample of 51 developing countries, for which data for prices and production cover more than forty years. Moreover, using panel data, it highlights the key role of macroeconomic factors in supply response to price instability.

2.2 Macroeconomic environment and supply response

A vast literature attempts to determine the price elasticity of aggregate agricultural supply, and generally shows that it is quite weak. For this reason, many authors tried to determine which constraints prevented producers from adapting to short-term price incentives. Apart from the fixity of some factors of production, several assumptions relating to the macroeconomic environment were advanced. In a cross-country analysis applied to 58 countries over the period 1969-1978, Binswanger & al. (1987) estimate the short term elasticity of the aggregate agricultural supply, including in their models several variables likely to affect producers' technology like human capital and infrastructure. Their results show in particular the importance of the direct effect on supply of roads, public systems of irrigation, degree of literacy and life expectancy.

In a review of the main issues relating to the estimation of supply elasticity, Schiff & Montenegro (1997) explain that supply elasticity only makes sense if the conditions under which prices behave are specified. According to them, these conditions depend in particular on the expenditure in public goods and the consequences of reforms on investment, inflation and real exchange rate[3]. Their cross-country analysis applied to a sample of 18 countries over the period 1960-1985 clarifies the complementarity of prices and expenditure in public goods, by testing the interaction between a variable of public investment and a variable of relative price.

Although macroeconomic factors have often been considered in the estimation of agricultural supply functions[4], the interaction between these factors and price instability is never considered. And yet, the effect of price instability on production decisions can be modified by the macroeconomic environment. In what follows, we argue that factors which influence the risk management capacity of producers (rural infrastructure, financial development, inflation) may change their reaction to world price instability.

3 A model of conditional supply response to price instability

The reference econometric model of supply response to world price instability is :

$$Y = \alpha_0 + \alpha_1.Pw + \alpha_2.IPw + \alpha_3.X + \epsilon \tag{1}$$

where Y is the supply, Pw is the world price, IPw is the world price instability, X is a vector of non-price variables, and ϵ is the residual term.

We investigate how this model can be modified in order to integrate the influence of domestic macroeconomic environment on supply response to instability. In what follows, we relate agricultural supply to the instability of real world prices converted into local currency because world price instability is supposed to be transmitted to producers whose capacity to cope with price risk is weak. Indeed, agricultural supply is supposed to be affected by real producer price instability, this one being all the more affected by real world price instability since markets are liberalized (ITF (1999)).

We then examine which macroeconomic factors can dampen or enhance the impact of world price instability on agricultural supply in order to estimate the effect of instability conditional on such factors, in particular because they are likely to modify producers' capacity to cope with risk. The influence of three factors is examined : infrastructure, inflation

[3]The effect of foreign exchange shortage on price elasticity of supply has been examined in the context of rationed economies (Azam et al. (1991), Guillaumont & Bonjean (1991)), and it has also been tested through the real exchange rate level by Guillaumont & Combes (1994)

[4]Macroeconomic factors are also often introduced into estimates of production functions (Mundlak et al. (1997)).

and financial development. Each one is supposed to modify producers' risk management capacity : the development of rural infrastructure reduces transaction costs, inflation increases producers' vulnerability and financial development encourages self-financing and self-insurance.

3.1 Infrastructure

Several authors have the view that public investment in infrastructure has a positive impact on agricultural supply by strongly influencing productivity (Binswanger & al. (1987)). In an analysis of agricultural policies in 18 countries between 1960 and 1983, Krueger et al. (1991) explain that performances of the agricultural sector can be influenced by the macroeconomic environment and the supply of public goods. They stress that the effect of the complementarity between the development of infrastructure and the implementation of favourable agricultural policies was considerable in South East Asia and China : investment in rural infrastructure, associated with social services and viable systems of credit for small producers, allowed agricultural production to grow rapidly and reduced poverty. In the same way, Heath & Binswanger (1996) notice that, in Kenya where infrastructures support the access to markets, agricultural production growth more than compensated for the growth of rural population, while in Ethiopia, a country deprived of infrastructures favourable to producers, the strong population density implied significant degradation of lands.

As the level of infrastructure supports the growth of supply, it is also likely to modify supply response to price instability in at least three ways : by reducing transport costs, by improving access to public services (health and education), and by supporting risk sharing networks. Some authors suggested that the level of infrastructure could improve supply response to price changes (Faini (1991)) - if high costs of delivering the locally produced commodity to the border for export are reduced by the development of road networks for example. We here argue that infrastructure development can also attenuate supply response to world price instability. Indeed, as shown below, if the development of roads allows the reduction of transport costs, then producer price instability with respect to its trend value becomes lower than world price instability.

We suppose that the difference between world prices and producer prices expressed in the same currency is equal to unit transport costs Z. The instability of the domestic price, measured by the difference to the trend value $\widehat{Pp}$, is then equal to :

$$IPp = \frac{(Pw - Z) - (\widehat{Pw} - Z)}{\widehat{Pw} - Z} = \frac{Pw - \widehat{Pw}}{\widehat{Pw} - Z}$$

Therefore, when transport costs increase, domestic price instability IPd becomes higher than world price instability IPw :

$$\frac{Pw - \widehat{Pw}}{\widehat{Pw} - Z} > \frac{Pw - \widehat{Pw}}{\widehat{Pw}}$$

It follows that domestic price instability is a function of world price instability :

$$IPp = IPw.\frac{\widehat{Pw}}{\widehat{Pw} - Z}$$

If we suppose that unit transport costs are a given fraction of the trend level of world price, $z = \frac{Z}{\widehat{Pw}}$, we get :

$$IPp = IPw.\frac{1}{1 - z}$$

Let us have a supply function to be estimated with regard to producer prices :

$$Y = \beta_0 + \beta_1.Pp + \beta_2.IPp + \beta_3.X + \epsilon \qquad (2)$$

where X is a vector of non-price variables and ϵ is the residual term.

Replacing producer prices by the corresponding world prices, the function becomes :

$$Y = \beta_0 + \beta_1.Pw + \frac{\beta_2}{1 - z}.IPw + \beta_3.X - \beta_1.Z + \epsilon \qquad (3)$$

When infrastructure improves, z decreases, and the supply response to world price instability $\frac{\beta_2}{1-z}$ is likely to decrease. Thus, if infrastructure development allows the reduction of transaction costs, it attenuates the supply response to world price instability. In the following econometric estimates, this effect is taken into account by the infrastructure variable interacting with real world price instability.

Moreover, infrastructure development can influence producers' response to risk by improving efficiency of public expenditure in education and health services. Agénor & Moreno-Dodson (2006) argue that investment in infrastructure interacts with social public services, affecting growth through a complementarity effect. In addition, some works also clarify the role of education and health services in the reduction of producers' risk aversion (Knight et al. (2003), Weir & Knight (2004)). Rural infrastructures are thus likely to contribute to reduce the producers' response to prices instability, by allowing a better access to education and health services.

Lastly, the development of infrastructure can support the formation of risk sharing networks. Binswanger & Deininger (1997) explain that isolated producers are not able to form interest groups - whose objective is the accumulation of factors of production - and that possibilities of concentrated collective action is limited. For the same reason, the development of infrastructures can support the constitution of risk sharing groups (Dercon (2002), Fafchamps (2003)) and thus help reducing risk aversion[5].

3.2 Inflation

The direct effect of inflation on production has already been studied by Mundlak et al. (1997) in a cross-country analysis of the determinants of the production function concerning

[5]It implies however that members of the risk sharing group are not exposed to a common price risk.

37 countries over the period 1970-1990. Inflation is supposed to influence agricultural productivity directly as an incentive and indirectly through investment. But it can also affect producers' capacity to cope with price risk by reducing real producer prices and the real value of their savings.

Inflation reduces the real value of producers' assets and discourages the constitution of precautionary savings. Thus, producers who did not constitute precautionary savings before shocks can be forced to reduce their supply, because their work capacity is affected or because they have the possibility to turn towards less risky activities. Moreover, if producers subject to violent price shocks do not have any precautionary savings, they can choose to liquidate their productive assets - land, cattle, bullock, tools - although inflation also makes the liquidation of the productive assets less profitable[6]. Thus, producers response to price instability is all the more strong since they have to liquidate their productive assets[7].

3.3 Financial development

Better access to the credit market makes it possible to increase productivity, through increased savings and investment (Levine (2004)). It is also supposed to attenuate the supply response to price shocks, allowing the producers to cope with violent downfalls in their income. As recalled by Besley (1995), producers who want to borrow must generally turn to informal mechanisms of credit and insurance. Indeed, in developing countries, there are few formal institutions and the guarantees the producers can offer in case of default are weak. Thus, constraints on credit being too strong, the direct effect of formal private credit on producers capacity to cope with price risk should be weak - even if a very well developed and robust financial system may choose to bear the high costs of small credits (Rajan & Zingales (2003), Mosley (1999)).

However, the development of formal credit institutions can influence the risk coping capacity of the producers in an indirect way. Guillaumont-Jeanneney & Kpodar (2005) recall that the development of informal credit, which is often the only source of borrowing for poor people, is made easier by the growth of the formal financial system which offers opportunities of profitable investments to informal financial institutions that are not directly offered to small producers (Beck et al. (2004)). Moreover, the formal financial system offers to producers financial opportunities for their savings. Producers who are forced to self-financing and self-insuring can have access to remunerated deposits, which is an incentive to save (McKinnon (1973)). Thus, by facilitating the constitution of precautionary savings,

[6] Deaton (1991) highlights the advantages of the self-insurance when credit market is imperfect. Nevertheless, as noted by Dercon (2002), the return of productive assets is itself risky and self-insurance strategy can not prove very profitable if the real value of the assets falls.

[7] Rosenzweig & Wolpin (1993) describe the liquidation of the productive assets as an ex post risk management strategy frequently adopted by producers subjected to violent price shocks that have no liquid saving. However, Fafchamps (2003) notices that producers may prefer to reduce their consumption, when the consequences of the liquidation of the productive assets are likely to be disastrous.

financial development contributes to the reduction of the supply response to price instability.

3.4 The econometric model

We design a supply function that involves a variable of export price instability and also takes into account the influence of factors relating to the capacity of producers facing price instability. To do so, we augment the reference model with an interaction term between macroeconomic environment and real world price instability :

$$Y_{it} = \gamma_0 + \gamma_1.Pw_{it} + \gamma_2.IPw_{it} + \gamma_3.X1_{it} + \gamma_4.X2_{it} + \gamma_5.X2_{it}.IPw_{it} + \epsilon_{it} + u_i \quad (4)$$

where Y is the supply, Pw is the world price, IPw is the world price instability, $X1$ is a vector of non-price variables, $X2$ is a vector of macroeconomic variables likely to influence the impact of price instability on supply, $X2.IPw$ is an interaction term, ϵ is the residual term, and u represents unobservable country specific characteristics.

4 Designing price index and measuring instability

The first step consists in constructing price and production indices and an appropriate measure of price instability.

4.1 Constructing price and production indices

We construct a country-specific index that represents the real price of exported commodities measured in local currency. According to a classification borrowed from Dehn (2000), our countries are labelled as exporters of a particular type of commodity (agricultural food-stuffs or agricultural non-foods) as their exports of that particular type of commodity constitute 50% or more of their total commodity exports. For each country, according to the type of mainly exported agricultural commodity, we build a world price index following Deaton & Miller (1995)[8]. Classification of our countries according to their type is displayed in table 2. Table 3 gives the 25 commodities used in the index construction. The world price series are extracted from the IFS 2004 database. The indices are weighted by the share of each commodity in the total value of the agricultural production in 1990. The data used to weight the price series are extracted from FAOSTAT 2004 database (table 4). The world price index is adjusted for the OCDE export unit value (WDI 2004). Lastly, the real price index in local currency is constructed from the real world price index converted into local

[8]This index is constructed as follows :

$$P\$ = \prod_i p_i^{w_i}$$

where w_i is the weighting item and p_i is the dollar international commodity price for the commodity i. Since w_i is country specific, each country's aggregate commodity price index is unique.

currency :

$$Pr = \frac{P\$}{EUV} * RER$$

with

$$RER = NER * \frac{EUV}{CPI}$$

Pr is the real price index local currency, $P\$$ is the world price index, it is deflated by the export unit value index (EUV) of the OECD countries, NER is the nominal exchange rate (WDI 2004), CPI is the consumer price index, RER is the bilateral real exchange rate.

Note that our price variable is a proxy of the real export unit value in local currency (Figure 1) as the real world price is supposed to closely follow the real export unit value. Moreover, the fixed-effects method makes it possible to take into account country specific features relating to domestic policies and transaction costs, which makes our model remain close to a traditional function where the supply is affected by the real producer price.

As for production indices, quantities are weighted by world prices in 1990. Commodities involved in the price index match with commodities involved in the production index.

4.2 Price instability measurement

The choice of the measurement of price instability depends on the statistical properties of our series. The most widely used indicator of variability is the standard deviation[9], but it entails that the series is stationary, and yet price series are usually not. Here, we choose to measure price instability, over each sub-period T, as the average percentage of the quadratic difference between the price and its trend value $\hat{P}$ over 1961-2002 :

$$Inst(P)_T = 100 * \sqrt{\frac{1}{n}\sum_{k=0}^{n}\left(\frac{(P_{t+k} - \hat{P})}{\hat{P}}\right)^2}$$

with

$$P_t = \alpha + \beta.P_{t-1} + \delta.t + \epsilon_t$$

and

$$\hat{P}_t = \hat{\alpha} + \hat{\beta}.P_{t-1} + \hat{\delta}.t$$

For each country, we check that the residual price ϵ_t is a stationary process, by applying the standard Augmented Dickey-Fuller test. Results show in each case that ϵ_t follows a stationary process[10].

Table 1 gives the mean value of the instability of real prices in local currency over six sub-periods. We note that agricultural price instability reached a peak (around 10% of the trend level) over the periods 1975-1981, 1982-1988 and 1996-2002. This observation matches

[9] Moschini & Hennessy (2001) give the usually used methods of conditional variance measurement in static supply models.

[10] Results are not displayed here.

Table 1: Mean value of the instability of real prices in local currency (51 developing countries)

Period	Instability(%)
1961-1967	6.34
1968-1974	6.15
1975-1981	10.15
1982-1988	9.41
1989-1995	10.74
1996-2002	6.97

with the results of Dehn et al. (2003) of an increase in real world price instability since the seventies.

5 Results

5.1 Data

Annual data of production, prices and price instability available for 51 countries between 1961 and 2003, are first used to highlight a significant effect of world price instability on agricultural supply. Thereafter, the effect of the macroeconomic environment on this effect is examined using the fixed effects method and the GMM system estimator - the scarcity of the data then forces to work on a reduced sample, from averages calculated over sub-periods.

Data of infrastructure are extracted from the Database of World Infrastructure Stocks (Canning (1998)). The index is an average of four measures (per inhabitant) : kilometers of roads, kilometers of paved roads, kilometers of railway lines, and number of telephones. The other variables are described in appendix.

5.2 The unconditional effect of real world price instability

The results obtained from the broader sample are displayed in table 5. Price instability is calculated each year compared to the trend value measured over the seven previous years. For this reason, data used for the estimate are available only from 1967. The series are first-differenced so that all the variables of the model are stationary. The column (1) displays the results of the estimate by the random effects method. The presence of random effects is corroborated by the tests of Breusch & Pagan (1980) and Hausman (1978). The variables of price and instability appear significant at the 5% threshold, but the R^2 is close from zero. Thereafter the lagged production is introduced like explanatory variable because of high time series persistence.

The column (2) displays the results of the regression where the change in lagged production is instrumented by its lagged values. The Sargan test does not reject the validity of the instruments. The R^2 amounts to 76%. Finally the column (3) displays the results obtained with the *GMM system* estimator. The effect of a change in price instability proves again significant. In terms of elasticity, the effect is close to 0.012%. Thus, these first results tend to reveal a significant although weak negative effect of world price instability on agricultural supply. The following step consists in testing how the macroeconomic environment interacts with this effect.

5.3 The effect of the macro-environment on the instability impact

The reduced sample counts 25 countries for which six mean observations are available. The six periods considered are : 1961-1967, 1968-1974, 1975-1981, 1982-1988, 1989-1995 and 1996-2003. Results are displayed in tables 6 and 7.

The first column of table 6 gives the results of the estimate, before the introduction of the variables of environment likely to influence the impact of price instability[11]. Instability has a negative and significant effect, which is the expected result. It is interesting to note that real world price instability influences agricultural supply, which suggests that producers exposure to world price risk is important enough to make world price instability be transmitted to them and affect the production decisions. Nevertheless, the size of this effect remains weak since the supply elasticity is only 0.1%.

The second column displays the results relating to the interaction between the level of infrastructure and price instability. An improvement of the level of the infrastructure can be interpreted in terms of reduction in transaction costs. For the mean value of the infrastructure, the instability elasticity of supply is close to 0.1%. This result also suggests that the effect of instability can be divided by ten if the mean value of infrastructure is multiplied by two. This confirms that the impact of price instability is reduced when infrastructure improves, which suggests a positive effect of the reduced transaction costs and improved access to education and health facilities on the producers' capacity to cope with price instability.

The results displayed in the third column highlight the interaction between inflation and price instability. The influence of the consumer price index on the effect of instability is evidenced, leading to an instability elasticity close to 0.13% (taking the mean value of CPI). The producers' capacity to cope with price instability seems to be influenced by the possibility of constituting a precautionary saving : if the level of inflation impoverishes the producers or simply does not encourage them to save, they reduce their supply when price instability increases.

[11] Coefficients of tables 5 and 6 are not comparable, variables in the first estimates not being in logarithms.

The fourth and fifth columns display the results relating to the influence of the financial development on the instability-supply relationship. The assumption of an effect of private credit through the development of informal institutions is tested by the interaction between instability and importance of the private credit in the banking structure. The effect obtained is positive, which lets suppose that financial development can influence the production decisions of the poorest, although indirectly. In addition, the more general assumption of an effect of savings is tested through the interaction between the variable of instability and the variable measuring the monetary aggregate M3 reported to the GDP. However, no significant effect can be measured.

Table 7 displays the results of the estimate of the supply function by the *GMM system* estimator, which makes it possible to take account of the possible endogeneity of the regressors (due to a simultaneity bias for example) and the effect of the lagged dependent variable. The results obtained with this estimator prove relatively concordant with those obtained with the fixed effects method. In particular, they highlight a significant effect of instability on supply, close to 0.23%, which is higher than what was suggested with the fixed-effects method. Moreover, the influence of the level of infrastructure and the level of inflation appear to be significant again. In particular, the results suggest that the effect of instability can be reduced by 35% if the mean value of infrastructure is multiplied by two.

In order to evaluate more precisely to what extent the effect of instability can be modified by macroeconomic factors, we calculate the elasticity according to several value of the macroeconomic variables (Table 8). The upper side of the table gives the results we get from the *within* estimates. For the median value of the infrastructure level, the elasticity of supply is close to 0.1%. As we slip to the lower quartile, the effect of instability becomes stronger. The difference between the lower and the higher quartiles is quite important as the effect of instability is 2.7 times stronger for the lower quartile. The lower part of the table displays the results we get from *GMM system* estimates. For the median value, the elasticity of supply is close to 0.2%. The difference between the lower and the higher quartile is again important as the effect of instability is 1.5 times stronger for the lower quartile. Results concerning the inflation variable show that the difference between the lower and the higher quartile is less important.

Finally, we test a different specification of our model taking into account the possibility of a different response of the supply to price instability according to the level of instability. Table 9 displays the results of the estimates for a semi-log specification:

$$lnY_{it} = \gamma_0 + \gamma_1.lnPw_{it} + \gamma_2.IPw_{it} + \gamma_3.X_{it} + \epsilon_{it} + u_i$$

The results show that the effect of instability on supply according to the semi-log specification is close to what we get with the log-log specification for relatively high levels of instability. In both cases, the results from the *GMM* estimates indicate a decrease in supply close to 23% when instability shifts from 10% to 20% (the results from the *within* estimates indicate a 10% decrease). On the other hand, the results for the semi-log specification indicate a decrease of 2.4% in the supply when instability shifts from 1% to 2% whereas the decrease in the supply for the log-log specification remains close to 23%. These results suggest a possible threshold in the supply response to instability. Indeed, producers may be more sensitive to an increase in instability when it goes up from 10% to 20% than when it goes up from 1% to 2%.

6 Conclusion

Although there is an important empirical literature concerning the impact of price variability on agricultural supply, analyses of the aggregate supply response to world price instability based on panel data are scarce. Moreover, the influence of the macroeconomic environment on the supply response to world price risk is rarely studied at the aggregate level. However, several features of the national macroeconomic environment are likely to influence the producers' capacity to cope with world price risk.

The estimates of an aggregate supply function, based on panel data concerning a sample of 25 commodity exporting developing countries over a long period running from 1961 to 2002, display a negative and significant effect of world price instability on supply. Thus, the analysis suggests that producers' exposure to price risk is important enough to make world price instability be transmitted to them. Indeed, it is likely that errors and drifts of the public organizations of price instability management and years of markets liberalization contributed to increase the vulnerability of producers whose capacity to cope with risk is weak.

But above all, it appears that producers' response to price instability depends on macroeconomic factors which influence their capacity of risk management. The results show that this effect is likely to be accentuated by a high level of inflation, a low level of infrastructure and a poorly developed financial system.

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Variables description and source of data

Variable's name : $Prod$
Description : Agricultural production index (Laspeyres). The items are weighted by world prices in 1990. Mean value for each sub-period. Variable in logarithms.
Source : FAOSTAT 2004, IFS 2004.

Variable's name : $Pr\$$
Description : World real price index (Deaton-Miller). The items are weighted by the share of each commodity in the total value of the agricultural production in 1990. Index is adjusted by the export unit value of the OCDE countries.
Source : FAOSTAT 2004 and IFS 2004.

Variable's name : Pr
Description : Real price index in local currency (converted real world price index). Mean value for each sub-period. Variable in logarithms.
Source : IFS 2004 and WDI 2004.

Variable's name : $Instab$
Description : Instability of real prices in local currency. Mean value of the absolute difference between the price and its trend value during the period 1961-2002.
Source : Author's calculations.

Variable's name : $clim$
Description : Climate risk. Mean value of the absolute difference between the production and its trend value during the period 1961-2002.
Source : Author's calculations.

Variable's name : $infra$
Description : Infrastructures index. Arithmetical average of four variables : kilometres of roads, kilometres of paved roads, kilometres of rail track and number of telephone lines per inhabitant. Mean value for each sub-period.
Source : Canning (1998).

Variable's name : CPI
Description : Consumer price index (GDP implicit deflator for two countries of the sample). Mean value for each sub-period. Variable in logarithms.
Source : WDI 2004.

Variable's name : *credit*

Description : Private credit by deposit money banks to GDP. Mean value for each sub-period. Variable in logarithms.

Source : Financial Structure Database 2003.

Variable's name : $M3$

Description : Liquid liabilities (M3) as % of GDP. Mean value for each sub-period. Variable in logarithms.

Source : WDI 2004.

Table 2: Samples

Country	Agricultural Type	Small Sample
Argentina	food	*
Bangladesh	non-food	
Barbados	food	
Belize	food	
Benin	non-food	
Botswana	food	
Brazil	food	
Burkina Faso	non-food	
Burundi	food	
Central African Rep.	food	
Chad	non-food	
Colombia	food	*
Costa Rica	food	*
Côte d'Ivoire	food	*
Dominica	food	
El Salvador	food	*
Fiji	food	
Gambia	food	*
Guatemala	food	*
Guyana	food	
Haiti	food	*
Honduras	food	*
India	food	*
Kenya	food	*
Lesotho	non-food	
Liberia	non-food	
Madagascar	food	*
Malawi	non-food	
Mali	non-food	
Mauritius	food	
Myanmar	non-food	*
Nepal	food	
Niger	non-food	*
Pakistan	non-food	*
Panama	food	*
Paraguay	food	*
Philippines	food	*
Rwanda	food	
Samoa	food	*
Senegal	food	*
Salomon Island	non-food	
Sri Lanka	food	*
Ste Lucia	food	
St Vincent and G.	food	
Sudan	non-food	*
Swaziland	food	
Thailand	food	*
Turkey	non-food	*
Uruguay	food	*
Zimbabwe	food	

Table 3: Commodities used in international price index

Agricultural food stuffs		
BANANAS LAT/AMER.US.P.	IFS 24876U.DZ...	Latin America (US Ports)
BEEF ALL ORIG.US PORTS	IFS 19376KBDZF...	Australia-NZ (US Ports)
CACAO NY & LONDON-3FUTURE MONTH	IFS 65276R.DZFM44	New York and London
COCONUT OIL PHILIPP. NY	IFS 56676AIDZF...	Philippines (New York)
COFFEE OTHER MILDS (NEW YORK)	IFS 38676EBDZF...	Other Milds (New York)
GROUNDNUT OIL CIF EUROPE	IFS 69476BIDZF...	Any Origin (Europe)
GROUNDNUTS NIGERIA/LONDON	IFS 69476BHDZF...	Nigeria (London)
LAMB N.ZEALAND (LONDON)	IFS 19676PFDZF...	New Zealand (London)
MAIZE US(GULF PORTS)	IFS 11176J.DZFM17	United States (US Gulf Pts
PALM KERNEL OIL	CNUCED	Malaysia, CIF Rotterdam
PALM OIL MALAYSIA (U.K.)	IFS 54876DGDZF...	Malaysia (N.W.Europe)
RICE THAILAND (BANGKOK)	IFS 57876N.DZFM81	Thailand (Bangkok)
SORGHUM U.S.(ROTTERDAM)	IFS 11176TRDZF...	US (US Gulf Ports)
SOYBEAN OIL US(ROT'DAM)	IFS 11176JIDZF...	All Origins (Dutch Ports)
SOYBEANS US(ROTTERDAM)	IFS 11176JFDZF...	United States (Rotterdam)
SUGAR EEC IMPORT PR.	IFS 11276I.DZF...	EU Import Price
TEA AVERAGE AUCTION (LONDON)	IFS 11276S.DZF...	Average Auction (London)
WHEAT U.S.GULF PORTS	IFS 11176D.DZF...	US (US Gulf Pts)
Agricultural non-foods		
COTTON US LIVERPOOL	IFS 11176F.DZFM40	Liverpool Index
JUTE BANGLADESH(CHITT-CHAL)	IFS 51376X.DZF...	Bangladesh (Chitta.-Chalna)
LINSEED OIL (ANY ORIGIN)	IFS 00176NIDZF...	Any Origin
RUBBER MALAYSIA(SINGAPORE)	IFS 54876L.DZF...	Malaysia (Singapore)
SISAL E.AFR UG LONDON	IFS 63976MLDZF...	East Africa (Europe)
TOBACCO	CNUCED	unmanufactured, US iuv
WOOL AUSTRALIA-N.ZEAL(UK)50S	IFS 11276HDDZF...	Australia-NZ(UK) 48's

Table 4: Commodities used in production index

Agricultural food stuffs	
BANANAS	code FAO 486
BEEF and BUFFALO MEAT	code FAO 1806
COCOA BEANS	code FAO 661
COCONUTS	code FAO 249
COFFEE, GREEN	code FAO 656
OIL OF GROUNDNUTS	code FAO 244
GROUNDNUTS in SHELL	code FAO 242
PALM KERNELS	code FAO 256
MUTTON and LAMB	code FAO 977
MAIZE	code FAO 56
OIL OF PALM	code FAO 257
RICE, PADDY	code FAO 27
SORGHUM	code FAO 83
OIL OF SOYBEANS	code FAO 238
SOYBEANS	code FAO 236
SUGAR	code FAO 162
TEA	code FAO 667
WHEAT	code FAO 15

Agricultural non-foods	
SEED COTTON	code FAO 328
JUTE	code FAO 780
OIL OF LINSEED	code FAO 334
NATURAL RUBBER	code FAO 836
SISAL	code FAO 789
TOBACCO LEAVES	code FAO 826
WOOL GREASY	code FAO 987

Figure 1: From world price to producer price

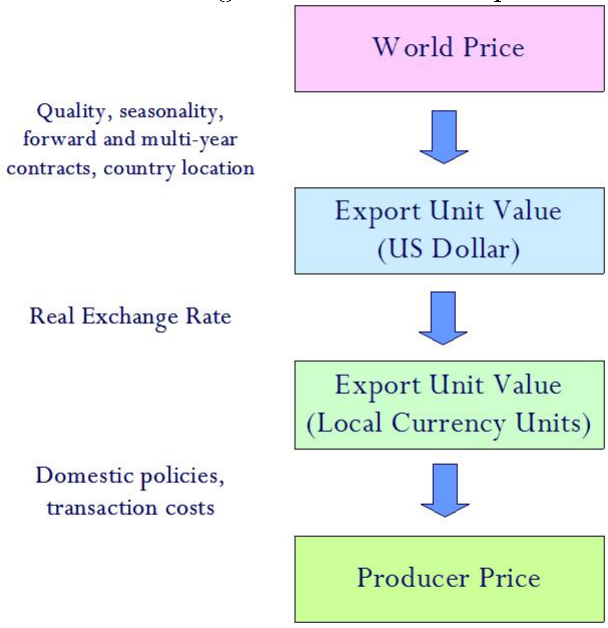

Table 5: Results with large sample

Dependent var. :	(1)	(2)	(3)
$\Delta Prod_{(t)}$	RE	2SLS	GMM
		Robust	
$\Delta Prod_{(t-1)}$		0.236**	-0.197***
		(0.110)	(0.035)
$\Delta Pr_{(t-1)}$	0.039***	0.042***	0.039***
	(0.014)	(0.016)	(0.013)
$\Delta Instab_{(t-1)}$	-0.138**	-0.206**	-0.255*
	(0.072)	(0.086)	(0.151)
c	1.128	0.779	1.290***
	(0.382)	(0.440)	(0.318)
Nb obs.	1800	1693	1765
Nb countries	51	51	51

*** (resp.**,*): reject of H0 at 1% (resp. 5%, 10%)
Standard errors into parenthesis.
$\Delta Prod_{(t-1)}$ is the change in lagged production,
$\Delta Pr_{(t-1)}$ is the change in real world price,
$\Delta Instab_{(t-1)}$ is the change in real world price instability

Table 6: Results with small sample (*within*)

Dependent var. : *ln Prod*	(1)	(2)	(3)	(4)	(5)
ln Pr	0.073**	0.101**	0.031	0.061**	0.057**
	(0.028)	*(0.028)*	*(0.037)*	*(0.026)*	*(0.027)*
ln Instab	-0.098*	-0.184***	-0.095*	-0.162	-0.428
	(0.054)	*(0.066)*	*(0.057)*	*(0.134)*	*(0.292)*
t	0.280***	0.317***	0.299***	0.243***	0.256***
	(0.064)	*(0.066)*	*(0.063)*	*(0.061)*	*(0.065)*
t^2	-0.018**	-0.024**	-0.021**	-0.012	-0.015*
	(0.009)	*(0.009)*	*(0.009)*	*(0.008)*	*(0.008)*
clim	-0.014*	-0.015**	-0.014*	-0.012*	-0.017***
	(0.007)	*(0.007)*	*(0.008)*	*(0.006)*	*(0.006)*
$infra$		-0.242			
		(0.419)			
$infra * ln\ Instab$		0.371**			
		(0.178)			
ln IPC			0.022		
			(0.018)		
$ln\ IPC * ln\ Instab$			-0.014*		
			(0.008)		
ln credit				0.088	
				(0.091)	
$ln\ credit * ln\ Instab$				0.104*	
				(0.055)	
$ln\ M3$					-0.113
					(0.164)
$ln\ M3 * ln\ Instab$					0.116
					(0.090)
c	-0.926***	-1.056***	-0.749***	-1.143***	-0.524
	(0.173)	*(0.207)*	*(0.202)*	*(0.278)*	*(0.482)*
Nb obs.	150	144	150	141	142
Nb countries	25	24	25	25	25
$adjustedR^2$	0.62	0.64	0.63	0.69	0.66

*** (resp.**,*) : reject of H0 at 1% (resp. 5%, 10%)

Standard errors into parenthesis.

Table 7: Results with small sample (*GMM system*)

Dependent var. : *ln Prod*	(1)	(2)	(3)	(4)	(5)
$ln\ Prod_{t-1}$	0.383***	0.413***	0.353***	0.359***	0.338***
	(0.093)	*(0.093)*	*(0.089)*	*(0.081)*	*(0.115)*
$ln\ Pr$	0.039**	0.038*	0.026*	0.045**	0.167*
	(0.020)	*(0.022)*	*(0.014)*	*(0.020)*	*(0.102)*
$ln\ Instab$	-0.226***	-0.311***	-0.119*	0.085	-0.889***
	(0.052)	*(0.094)*	*(0.067)*	*(0.088)*	*(0.274)*
$infra$		-0.839			
		(0.522)			
$infra * ln\ Instab$		0.349*			
		(0.204)			
$ln\ IPC$			0.019		
			(0.013)		
$ln\ IPC * ln\ Instab$			-0.010*		
			(0.005)		
$ln\ credit$				-0.069	
				(0.071)	
$ln\ credit * ln\ Instab$				0.079**	
				(0.040)	
$ln\ M3$					-0.273
					(0.190)
$ln\ M3 * ln\ Instab$					0.222**
					(0.088)
c	0.365***	0.568***	0.269**	-0.439**	0.598
	(0.126)	*(0.206)*	*(0.127)*	*(0.222)*	*(0.583)*
Nb obs.	125	124	125	117	117
Nb countries	25	24	25	25	25

*** (resp.**,*) : reject of H0 at 1% (resp. 5%, 10%)

Standard errors into parenthesis.

Table 8: Instability elasticity of supply according to macroenvironment values

Sample values	Infrastructure	Inflation	Financial development
Within estimates			
Lower quartile	-0.16%	-0.12%	
Median	-0.13%	-0.14%	
Higher quartile	-0.06%	-0.16%	
Difference between LQ and HQ	0.1 pts	0.04 pts	
GMM system estimates			
Lower quartile	-0.28%	-0.14%	-0.19%
Median	-0.25%	-0.15%	-0.15%
Higher quartile	-0.19%	-0.16%	-0.17%
Difference between LQ and HQ	0.1 pts	0.02 pts	0.12 pts

Table 9: Semi-log specification versus Log-log specification

Dependent var: *ln Prod*	(1)	(2)	(3)	(4)
	FE	FE	GMM	GMM
Specification	log-log	semi-log	log-log	semi-log
$ln\ Prod_{t-1}$			0.383***	0.399***
			(0.093)	*(0.089)*
$ln\ Pr$	0.073**	0.111**	0.039**	0.048**
	(0.028)	*(0.049)*	*(0.020)*	*(0.020)*
$ln\ Instab$	-0.098*		-0.226***	
	(0.054)		*(0.052)*	
$Instab$		-0.008**		-0.024***
		(0.004)		*(0.007)*
Nb obs	150	150	125	125
Nb countries	25	25	25	25