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Pierre-Emmanuel Darpeix

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THÈSE DE DOCTORAT

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Préparée à
l'École des hautes études en sciences sociales

Three essays in applied economics with panel data

École doctorale n°465

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COMPOSITION DU JURY :

M. DUFRÉNOT Gilles
Université Aix-Marseille, Rapporteur

M. JEAN Sébastien
CEPII, Rapporteur

Mme MIGNON Valérie
Université Paris-Nanterre, Membre du jury

M. BOURGUIGNON François
Paris School of Economics, Membre du jury

M. IMBS Jean
PSE, Membre du jury

Soutenue par
Pierre-Emmanuel DARPEIX
le 1^{er} octobre 2018

Dirigée par
François BOURGUIGNON

Tchembé rèd pa moli

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INTRODUCTION

I discovered economics fairly late in my student life: I was 19 years old when I first came across this academic subject, in my third year as an undergraduate. As a high-school pupil, I enjoyed all courses in the curriculum, but mathematics and physics were the topics I fancied the most. I thus decided to follow the classical track to become an engineer and got accepted at the *École nationale des ponts et chaussées* (ENPC), Paris, an institution famous for training civil and urban-planning engineers.

On top of the classical engineering departments, this school also had an economics and finance department, and the common training curriculum included an intensive course in microeconomics.¹ I came to grips with economics through one of its most applied-mathematics aspects, deriving lagrangians, optimizing profit or utility functions as well as investigating the existence and uniqueness properties of equilibrium solutions. I was approaching production functions and isoquants as mere intersections between planes and a wider multi-dimensional function, trying to identify tangency points with lines that were representing various constraints applying to the system.

I was fascinated by the attempt to model individual behaviors, describe interactions through the confrontation of interests, aggregate preferences, and understand the theoretical properties of the resulting outcome. I had been studying mechanical systems, using the concept of force, or energy to translate the observable reality into computable equations, and I was then realizing that mathematics could also help describe social structures with a few stylized assumptions.

I started understanding that engineering and economics did have much in common while they complemented each other neatly. In the engineering graduate program, I eventually decided to specialize in economics, and really enjoyed extending the scope of my education to sectorial economics (such as resource and energy economics, public economics, transportation economics, new geographic economics), digging in macroeconomic theories and exploring the evolution of growth models, playing with game theory, while refining my understanding of statistics and probabilities and discovering econometrics. I am very grateful to all the Professors of the school

¹ Economics had entered the school for a very simple reason: when one builds roads or bridges, one has to think of how it should be financed. On that matter, the first research article on tolls was written by a graduate from the school, Jules Dupuit, in 1844. This essay led to the definition of the concept of consumer surplus, which is still taught in introductory microeconomics classes.

who shared their passion for mathematical modeling and economics, and especially to Joël Maurice, Pierre Jacquet, Pierre Ralle, Jean-Charles Hourcade, and Miren Lafourcade.

After a year-long internship at the French Agency for Development (*Agence française de développement*), where I worked on 1) estimating the carbon footprint of the projects funded by the institution; and 2) designing compensation schemes to mitigate the impact of forced migrations, I realized I wanted to gain international experience as well as to develop skills in policy design and evaluation. I received a Fulbright grant to pursue a two-year master's program in public policy at the University of California, Berkeley. These two years in the Bay Area were a wonderful learning experience. Aside from the core policy curriculum which got me used to dealing with the interactions between economics, law and politics, I got the opportunity to be a teaching assistant for undergraduate economics classes, and to take graduate courses in the economics department with cutting-edge researchers. During the summer break, I also had the chance to serve as a consultant for the World Bank in Nigeria, conducting the evaluation of a community based program aiming at reducing maternal mortality in a rural area. Eventually, I wrote my Master's thesis on food price volatility and stabilization schemes in support to a working group preparing the 2011 G-20 Summit in France.

My curriculum and these professional experiences helped me understand economics as a science that combines sound mathematical modeling with robust empirical measurements to design efficient policies and evaluate the extent to which the goals are reached. It also demonstrated that economics methods can be applied in a wide array of sectors, from public health to international trade, from environmental protection to social organization. My education as an engineer-economist gave me the opportunity to work on a huge variety of fascinating topics and look at issues from many different angles.

There is yet another feature that relates economics to engineering: the consciousness of the margin of error. Of course theoretical models will predict some precise solution to a problem. Yet both applied economists and engineers know for sure that this output is only a mere indication of where the truth actually lies. Real economic agents are not maximizing utility all the time, there is no such thing as pure and perfect competition, just as a flawless building does not exist. A probability is never close enough to one and you often have to make do with the second best option.

When I got back to France, I knew I wished to pursue my studies with a doctoral degree. I wanted to keep on investigating the issue of food price volatility and food crises, building on my Master's thesis. Yet funding was scarce, and I realized I would probably have to work to finance of my research. In fact, this situation was not bothering me: I was afraid of being cornered into one very specific doctoral topic, and I considered it a chance to keep my hands on operational work, and apply economic reasoning to a variety of issues.

I took up an offer to work at the ENPC as deputy director of the economics department, an administrative job which entailed some time dedicated to research. I was then working on an

extensive literature review about the consequences of food prices on growth, development and public health around the world,² attending academic conferences and prospecting for potential PhD advisors. I was lucky enough to meet Professor Bourguignon who accepted to supervise my doctoral research.

The work presented below is the result of six years of PhD enrollment in parallel of a full time professional career. While working on these articles, I served as an economist at the French Prudential Authority (*Autorité de contrôle prudentiel et de résolution, ACPR, from 2014 to 2016*) and later at the French Financial Markets Authority (*Autorité des marchés financiers, AMF*). Despite the radically different topics that were investigated in my compartmented day and evening lives, my work experience and my doctoral research did feed each other and I could not thank more my colleagues in both institutions for the enriching discussions, debates, and technical advices that helped me shape this dissertation.

The three articles that compose my dissertation relate to very different topics. One deals with international market price transmission, the second with air transportation worldwide, and the last one with life-insurance in France. The variety of issues addressed is only a pale illustration of the wide universe of topics that economists are called to work upon. Investigating multiple economic sectors, learning for each experience to bring new insights to a research question, making use of the data at hand to extract the relevant information that helps understand the world and shape innovative solutions, those features are definitely common to both engineering and economics. Despite the diversity of areas they cover, these articles build on common statistical concepts and methods. They exploit both the cross-sectional and the time-series dimension, resorting to dynamic panel methods and co-integration.

From the beginning, I wanted to devote the central article of my PhD to the issue of the consequences of food price volatility by adopting a cross-country prospective. This research question emerged from my understanding of the existing literature which consisted mostly of local micro-economic studies (see Appendix 1). Yet over time it became clear that any large scale investigation I could conceive would be limited by the data at hand. Indeed, high frequency consumer price data were not available in a standardized international format, and most existing studies used worldwide price indices computed by international organizations from US grains markets as a proxy for the prices faced by local populations.

I eventually came to investigate the issue of price transmission from international grain commodity markets down to local producers, and the results of this research are presented in the first chapter of this dissertation. Using annual local producer price series over a broad set of countries and modeling their relationship with international market price series, I was able to measure the degree of price transmission (or price pass-through) for wheat, maize and rice at the country level (or put differently, to estimate the extent to which domestic producers are exposed

² See Appendix 1 for an updated version of this paper.

to international markets), exhibit a trend towards increased integration over time, and identify determinants of the heterogeneity in pass-through.

After a thorough examination of the characteristics of the individual time series, I investigated their co-integration features to assess the existence of a long-run relationship (both with individual and panel co-integration techniques). Interestingly, I found that the presence of such a long-term relationship was much easier to prove over the most recent period (1991-2013) than in the earlier decades, thus pointing to an increased integration of world markets over time.

Building on this preliminary analysis, I estimated long- and short-run pass-through coefficients resorting to several statistical methods (from first-difference to error-correction models and heterogeneous panel dynamic models), and investigating various specifications (prices in US dollars or in local currency, in real or current terms, with or without accounting for exchange rate fluctuations) to ensure the robustness of the results. Given the relatively quick adjustment and the low frequency of the data, and understanding that the price signal generated by world commodity markets is of a nominal nature, my preferred model discards the exchange rate and uses current USD price quotes.

I exhibited a significant heterogeneity across countries and commodities with respect to their integration to world trade, and showed a noticeable increase in pass-through from the earlier period of study (1970-1990) to the latter (1991-2013), a result that can be explained by the global efforts for trade liberalization from the 1990s onwards. This phenomenon is particularly visible in the European Union where the Common Agricultural Policy reforms implemented starting in 1995 aimed at decoupling subsidies from the production level in order to reduce price distortion, and let market prices play their signaling role.

Eventually, I analyzed the cross-section of pass-through estimates in order to identify potential drivers of the observed heterogeneity. I demonstrated that richer countries tend to exhibit higher short-term pass-through (and thus their producers are better integrated to the international markets). Additionally, market integration seems more pronounced for countries that produce more than they consume than for countries that do not produce enough to meet their domestic consumption needs. This tends to indicate that price transmission to domestic producers is more easily attained through exports than through imports. Besides, I found that the importance of a given cereal in the typical domestic food consumption basket is correlated with the degree of producer price insulation, thus pointing to greater protection for the most needed commodities. Last, I showed that pass-through estimates are significantly linked with other measures of trade restrictions, such as tariff and non-tariff barriers.

My second article is a joint work with my adviser, François Bourguignon and drove me back to classical engineering concerns studied at the *École des Ponts*. It corresponds to an empirical investigation of the elasticity of air transportation relative to GDP. The level of passenger air traffic can be understood as both a catalyst and an indicator of development. Indeed, air traffic fosters economic growth and development insofar as it contributes to the integration of economies, both within countries (e.g. where land transportation would be either too long, too

costly, or even where roads and railways do not exist), and between countries. On the other hand, air transportation also reflects the economic activity and attractiveness of a given country as well as the income level of its inhabitants. A few industry-sponsored articles had attempted to measure the relationship between a country's income and its level of air-traffic. Those studies generally pointed to an income elasticity of air-traffic somewhere around two, meaning that a one percent increase in GDP per capita was associated with a two percent increase in air-traffic. The objectives of our research were twofold. At first, we wanted to test the validity of these elasticity estimates from a more academic point of view, extending the analysis beyond the group of developed countries and proposing a more refined econometric method to increase the precision of these estimates. We also aimed at studying the time stability of the relationship as well as its stability across geographic regions.

Starting with a simple analysis of regional aggregates series, we were extremely surprised to observe what appeared to be a very homogeneous relationship. Strikingly a given level of GDP per capita seemed to correspond to a given number of passengers carried, with only temporary deviations to the long run trend. Across time and regions, the apparent elasticity was about 1.36. To complement this preliminary analysis, we ran first-difference regressions on the regional aggregate series, and our results tended to concur with the industry estimates (the point estimate for OECD countries was 1.9). Interestingly, across the different regions, point estimates were not statistically different from one another. Yet the estimates obtained from this model were very imprecise and the results did not exploit the country-level information available in the datasets.

In order to refine the estimates and better capture the variations of air-traffic around the long term trend, we investigated the co-integration properties of the series and developed a panel version of an error correction model. Resorting to panel co-integration tests, we proved the existence of a common long term trend and produced more precise estimates of both the long- and short-term relationships. Excluding the possibility of an autonomous time trend in the model, our estimates were very close to those previously obtained. Even with the smaller standard errors, it was still very difficult to conclude to a heterogeneous response of air-traffic to GDP across geographic areas. Additionally, the short- and long-run parameters were of the same order of magnitude, indicating a very quick adjustment. Interestingly, the inclusion of an autonomous trend significantly reduced the elasticity estimates, down to the neighborhood of one. Indeed, other factors do intervene in the relationship between national income and passenger air-traffic that are not captured by our model (nor by the industry's cruder methods). Going beyond a simple empirical assessment of the co-evolution of the series would require disentangling the endogeneity in the relationship.

In a nutshell, our analysis documented that the elasticity of air-traffic to GDP is relatively stable over time, across regions, and for different levels of development. We developed an efficient econometric method to make use of the panel dimension of the dataset and refine the elasticity estimates. Eventually, we showed that a significant portion of the elasticity estimates provided by the industry is in fact due to autonomous trends. Our results tend to conclude to a unit-elasticity. While this result is fairly encouraging when one considers the growth opportunity

for air-carriers in developing countries, it also raises concerns with respect to the environmental sustainability of such a trajectory given the heavy carbon-dioxide emission toll of air transportation.

The last chapter of my dissertation is a joint work with two colleagues at the Banque de France (Fabrice Borel-Mathurin and Quentin Guibert) and a Professor at University Lyon-1 (Stéphane Loisel).

While at the Prudential Authority, I belonged to a multidisciplinary team (one actuary, one mathematician and one economist) that was in charge of monitoring the stress testing exercises for the French insurance industry. At the time, the main concern for insurance supervisors across the world was the likely consequences of the low yield environment for life-insurers who offered significant guarantees to their policyholders. In France, euro-denominated contracts (also labeled “with-profit” or “non-unit-linked”) represent the most widespread financial saving scheme for households (1,400 billion euros of asset under management in France in 2013). These products entail a capital guarantee, and sometimes even a guarantee on the minimum annual rate of return. Additionally, the interests generated by the product are capitalized: they will bear interest in the following years and are covered by the capital guarantee.

In a nutshell, insurers receive premiums from their clients (retail savers) which they invest on the markets in assets that are safe, liquid and profitable (usually bonds). The law imposes that at least 85% of the financial profits made by the insurer on behalf of its clients be redistributed to them, either directly through the end-of-year revaluation of the contracts, or indirectly, in which case the benefits are stored in a reserve set aside for low profitability years. This scheme (whereby the insurer invests on the markets on behalf of its clients but guarantees the capital invested) implies that the insurers bear the investment risk.

The long episode of steadily declining interest rates between the 1980s and the 2010s significantly boosted the returns on insurers’ portfolios, enabling them to offer guaranteed rates of return up to 4% per annum. Yet when the interest rates started approaching the zero bound, rolling the portfolios and guaranteeing the invested capital became much more difficult. This unprecedented situation (all the more so in a post financial crisis context) raised much anxiety about the insurers’ ability to meet their liabilities.

In order to contribute to the ACPR prudential stability mandate as well as to its customer protection mission, my co-authors and I undertook an ambitious research project aiming at modeling the returns of a life-insurance product and identifying the management strategies followed by insurance executives. We compiled a unique database from the prudential reports that are submitted every year to the authority, and investigate the drivers of profit-sharing in the French life insurance sector. This regulatory database covered 89 insurers between 1999 and 2013.

Using panel data techniques, we were able to demonstrate that insurers anchor their participation rates on the prevailing 10-years government bond rate (despite the fact that their portfolio is supposedly composed of older and higher-yielding bonds).

We were surprised to observe that insurers did not actively manage their participation rate to prevent their customers from redeeming their contracts.

We also showed that the transmission of the performance to the policy-holders was far from perfect. When insurers' return on assets exceeds the sovereign bond yield (OAT-10 years) by 100 basis points, the corresponding participation rate happens to be on average only 15 basis points higher than the OAT. Eventually, we documented the importance of the capital guarantee constraint in a low yield environment.

This innovative exploratory article was the first of its kind to use regulatory data to better understand the incentives of life-insurers and describe managers' behavior over an extended period of time. It provided the Authority with sound quantitative evidence to back or question stylized facts emanating from expert judgment. It eventually contributed to feed the policy debate on consumer protection and prudential regulation.

CHAPTER 1: FROM INTERNATIONAL MARKETS TO DOMESTIC PRODUCERS – AN ANALYSIS OF GRAINS’ PRICE PASS-THROUGH³

Abstract

The degree of transmission of international food commodity market prices variations on to domestic prices is a crucial parameter to understand the extent to which an economy is affected by large external shocks, such as the food price hikes experienced in the late 2000s. Pass-through measures the integration of countries with the rest of the world and can be affected in numerous ways (including trade taxes or quotas, national inventories, consumption or production subsidies). The so-called food crises episodes generated many investigations on price transmission to domestic consumers, but much less so to domestic grains producers. As a first preliminary step, this article provides an empirical assessment of pass-through from global markets to domestic producer prices for three internationally traded cereals (wheat, maize and rice). This study reveals a wide heterogeneity of price transmission around the world, but also between commodities. The analysis builds on yearly data spanning a period of 44 years (1970-2013), and covers 52 countries (101 country-commodity pairs), thus extending the scope from previous analyses. Estimates are obtained with both first-difference and error correction models (ECM), after a thorough investigation of stationarity and co-integration, providing more robust estimates than earlier studies. Building on these estimations, our analysis demonstrates a significant increase in pass-through (both short- and long-term) by more than 20 percentage points on average over the most recent sub-period (1991-2013), indicating an improved integration of world markets (most visible for EU countries). Analyzing the cross-section of price transmission coefficients, we also prove the significant positive impact of GDP per capita, excess production and production deficit on short-term pass-through: producers in higher income, net exporting countries tend to receive a farm-gate price more closely correlated with the world commodity markets. Conversely, countries that import large volumes of cereals tend to be characterized by lower producer price pass-through. Eventually, we demonstrate a significant negative link between price transmission and trade policies (as proxied by the level of import tariffs).

Keywords: Cereals, Wheat, Maize, Rice, Price pass-through, Globalization, Error-correction model, Producer price, Market integration.

JEL classification: C21, C22, E31 F15, Q17, Q18.

³ The author wishes to thank François Bourguignon, Aurélie Darpeix, Stéphane Gallon, Philip Morris, Marian Moszoro, Alexis Poullain, and Frank van Tongeren for their helpful comments on earlier versions of this paper.

Despite significant developments in international agriculture, numerous breakthroughs in agronomy and the phenomenal increase in yields over the past century (far beyond the Malthusian projections) feeding the World's population keeps being a central stake. The 2008 and 2010 food crises dramatically reminded policy makers of this naked truth. In March 2008, the average spot market price of wheat on the leading American markets (Chicago, Kansas City, etc.) reached 439 dollars per metric ton (\$/mt), up from 199\$/mt one year earlier.⁴ Similarly, maize peaked at 287\$/mt in June from 146\$/mt eleven months before. As for rice, its nominal price almost tripled in a year to 907\$/mt in April. These rallies caused much anxiety throughout the World, and generated food riots, especially in West Africa.

Despite the widely acknowledged role of Chicago in the price discovery mechanism for cereals worldwide (see e.g. Janzen and Adjemian (2016)), the quoted prices on the American trading venues do not necessarily reflect the prices actually paid by wholesale importers (e.g. due to transportation costs, tariffs, or regional trade agreements) nor do they correspond to the final price paid by domestic consumers (e.g. because of consumption tax or subsidy). Additionally, locally produced cereals may not be of the same quality, grade, and variety as internationally traded goods.

This article provides accurate estimates of the degree of price pass-through from international grain markets to domestic producers for as many countries as possible. The first goal of this research is to test whether the increased globalization of world markets and the momentum towards agricultural trade liberalization from the 1990's onwards translated into a visible increase of producer price pass-through. The second objective is to identify potential determinants of domestic insulation from world markets.

The law of one price generally does not hold, and although influenced by international prices, local prices can display a significant degree of insulation from the world. Price variations on the international markets are not fully transmitted to domestic markets. Understanding and measuring food commodity price pass-through is an essential step towards adequately assessing the extent to which an economy is affected by international market price variations. Yet a lack of accurate domestic price data (may they be consumer or producer prices) can explain why many researchers interested in measuring the local impacts of price surges chose to resort to the market price series from Chicago or Kansas City, which are indeed characterized by the desirable features of transparency, reliability, high (daily) frequency, and longer time records. Consumer price pass-through (computed from monthly CPI or retail price series) has received much attention over the past decade, yet the price transmission to local producers from one harvest to the other has been much less investigated.

⁴ The numbers are even more striking when looking at daily quotes: for instance wheat contracts (n^o2, HRS, delivery in Kansas City) reached a peak at \$ 14.11 per bushel (518,45 \$/mt) on March 13th, 2008, while the price for contracts with deliveries in Minneapolis/Duluth had been pushed as far as \$ 22.25 per bushel (817.55 \$/mt) on Feb 25th.

Building on data from the World Bank and from the Food and Agriculture Organization of the United Nations (FAO), the first step is to measure the producer price pass-through for the countries in the sample, to assess how exposed domestic producers are to international competition, or put differently, to see how integrated the domestic agricultural sector is to world trade. Estimations are conducted with both first-difference and error correction models, to account for the potential long run relationship linking the domestic producer prices to international markets (co-integration). It is demonstrated that long-run and short-run pass-through display significant heterogeneity across countries, but also between commodities. An analysis on sub-periods (before and after 1990) makes it clear that indeed producer price pass-through significantly increased over time for each of the three agricultural commodities, thus pointing to a general movement towards the integration of domestic producers to international trade. Interestingly, the increase in pass-through is particularly visible for countries belonging to the European Union, thus highlighting the impact of the broad set of reforms of the Common Agricultural Policy implemented from 1995 and geared towards reducing producer price distortion.

Regression analyses show that heterogeneity in short-term pass-through can be attributed to the income level (producers in less developed countries are less integrated to world markets), as well as to the varying degree of importance of the specific grains for the countries, either in terms of food consumption or in terms of strategic export and contribution to GDP. Additionally, countries producing more of a commodity than they consume (excess producers) exhibit higher price transmission (they probably also contribute more to setting the international market price), while conversely, for deficit producers, the larger the gap between the quantity produced and the quantity consumed domestically, the lower the short-term pass-through.

The rest of the paper is organized as follows. Section II reviews in detail the existing literature on pass-through estimation. Section III describes the available data and its characteristics in terms of stationarity, while Section IV deals with co-integration. Section V presents the empirical framework applied to assess the transmission patterns from international market prices to domestic producer prices comments the estimates obtained over the full period of data availability (1970-2013). Section VI develops an analysis to assess whether pass-through increased in the recent period while Section VII provides an exploration of the cross-sectional heterogeneity of pass-through estimates.

II — LITERATURE REVIEW ON PASS-THROUGH ESTIMATION

This section has two objectives: on the one hand it aims at presenting the various models developed and applied in the extant literature, while on the other hand it recalls the order of magnitude of the estimates yielded by the previous analyses on pass-through, and especially those relating to price transmission from international food commodity markets to domestic

producers. The first goal calls for a review of methods beyond the limited scope of producer price pass-through (including e.g. articles on exchange rate pass-through, the law of one price, or even retail consumer prices and retail mark-ups).

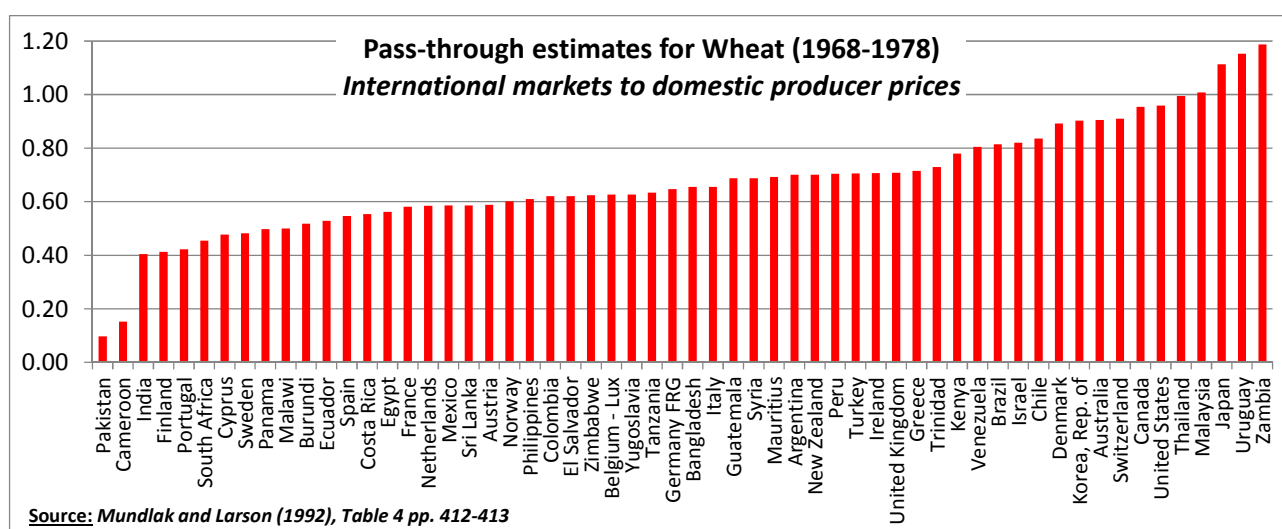
Mundlak and Larson (1992) apply country-specific regressions in log levels to link annual domestic producer prices to international prices. For each of the 58 countries in their dataset, they pool 11 years of data and up to 60 agricultural commodities to estimate an equation of the form:

$$\ln(dp_{it}) = \alpha \cdot \ln(wp_{it}) + \beta \cdot \ln(e_t) + \gamma + \varepsilon_{it} \quad (1)$$

where dp_{it} denotes the domestic price (in local currency) of commodity i at time t while wp_{it} corresponds to the world price (in dollars), and e_t stands for the exchange rate (regressions are run with both nominal and real series⁵ to check the robustness of the results to potential drifts in inflation profiles).

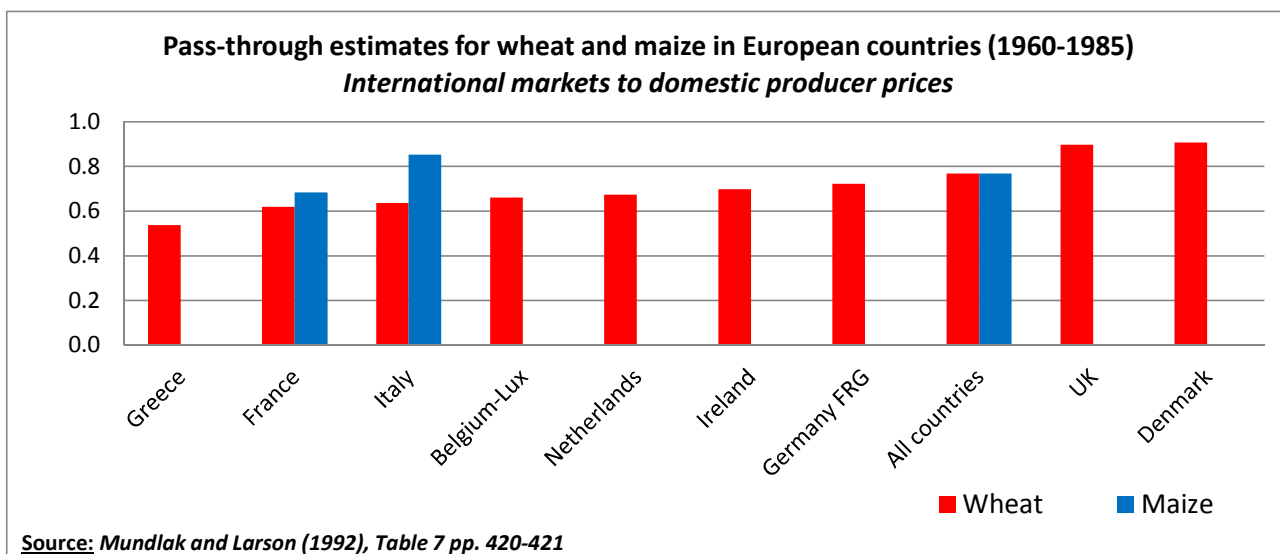
Their estimates for the country-specific α 's are stable across multiple specifications (with and without exchange rates, with real or nominal prices, with year dummies or commodity means...), and do not display much heterogeneity across countries: all estimates are close to one, ranging from slightly more than .71 in Bangladesh to more than 1.27 in Egypt. More variability and lower pass-through are obtained from within-commodity regressions. Despite the small number of observations (11), country-specific regressions were run for wheat alone, yielding estimates ranging from 0.1 in Pakistan to 1.2 in Zambia (see Graph 1). An investigation on European yearly data between 1960 and 1985 provides commodity-specific estimates for a range of foodstuffs, including wheat and maize, which are plotted in Graph 2. The main takeaway from this static evaluation of pass-through is the imperfect price transmission from international markets to domestic producers during this period, with a concentration of estimates between 40% and 80%.

Graph 1: Producer price pass-through estimates for wheat



⁵ Domestic producer prices are deflated using domestic CPI while world prices are deflated with the US CPI.

Graph 2: Producer price pass-through estimates (wheat and maize), European community



A similar model, with prices expressed in absolute levels (not in logs) had been used in Isard (1977) to test the validity of the law of one price.

These static models omit one important feature of price transmission, which is adjustment dynamics. Dynamic models were applied to measure both an immediate and a long-run pass-through. Berk et al (2009) propose a dynamic panel setup with log-level variables to investigate the pass-through from commodity to food retail prices in 184 Californian grocery stores, thus including the lagged dependent variable in the right hand side of the equation. Leaving aside several controls they include, the model they estimate is:

$$\ln(rp_{jt}) = \alpha \cdot \ln(c_t) + \rho \cdot \ln(rp_{jt-1}) + \gamma_j + \mu_t + \varepsilon_{jt} \quad (2)$$

where rp_{it} is the retail price of a good in store i at time t and c_t is the market price of the commodities entering the production process of the good. The specification includes notably stores and time fixed effects (but also time trends and other controls). The estimations are conducted with the classical dynamic panel estimator developed in Arellano and Bond (1991). In such a setup, α measures the immediate (or short-run) pass-through, while the quantity $\alpha/(1 - \rho)$ corresponds to the long-run pass-through.

Although estimating pass-through with level (or log-level) regressions can appear straightforward and appealing, these models raise (or should raise) multiple econometric issues. Ardeni (1989) provided an early criticism of the use of level regressions in case the series are non-stationary and not co-integrated. Granger and Newbold (1974) indeed showed that a regression linking two non-stationary variables is likely to be plagued with spurious correlation. In general, this problem can be dealt with by first differencing the series to retrieve stationary series. Consequently, pass-through is frequently estimated via first difference equations (see one static example alluded to in Isard (1977)). Including multiple lags of the explanatory variable

among the regressors allows us to draw a dynamic picture of price transmission with the long-term pass-through being the sum of the coefficients on the contemporary and lagged independent variables). Campa and Goldberg (2006) measure the pass-through from exchange rates to import prices for five economic sectors and 16 countries with a regression equation of the following structure:

$$\Delta \ln(ip_t) = \sum_{k=0}^K [\alpha_k \cdot \Delta \ln(e_{t-k})] + \sum_{l=0}^L [\beta_l \cdot \Delta \ln(c_{t-l})] + \gamma \quad (3)$$

where ip_t stands for the local currency import price at time t , e_t is the exchange rate and c_t accounts for the foreign production costs. The authors use quarterly data and set $K = L = 4$ in order to report cumulative (“long-term”) pass-through over a year. Similar empirical designs are applied in Rigobon (2010), Bekkers et al. (2017, n.d.), Nakamura and Zerom (2010), as well as Leibtag et al. (2007). Nakamura and Zerom (2010) suggest selecting the number of lags by adding them one at a time and stopping when the long-run elasticity no longer varies. Bekkers et al. (2017) implement a parsimonious version of the model, with much fewer lags but with an autoregressive term. They provide long-run consumer food price pass-through for 147 countries with most estimates lying below 40%. Incidentally, this result confirms that consumers end up being more insulated than producers from international markets. This can be explained by several factors: i) the “commodity content” of retail food products can be extremely small (especially in developed markets), ii) substitution can occur within the food consumption basket to mitigate the price increase in one commodity; iii) several governments actively target a stable consumer price for food (using taxes, subsidies and inventories), given its vital importance.⁶

Models in first difference are an efficient way to avoid spurious regressions with I(1) series, yet Ardeni (1989) also insisted on the limitation of such a method when the level series are co-integrated (see Granger (1981)) in which case error correction models (ECM), which account both for the long-run relationship and the short-run deviations from the equilibrium, are more appropriate (Engle and Granger (1987)).

Baquedano and Liefert (2014) apply a ECM model to monthly data to measure the pass-through from world prices to domestic consumer prices for a large set of developing countries (for wheat, maize, rice and sorghum). Their ECM specification takes the form

$$\begin{aligned} \Delta \ln(dp_t) = & \alpha \cdot \ln(wp_{t-1}) + \beta \cdot \ln(dp_{t-1}) + \eta \cdot \ln(e_{t-1}) \\ & + \delta \cdot \Delta[\ln(e)]_t + \kappa \cdot \Delta[\ln(wp)]_t + \gamma + \varepsilon_t \end{aligned} \quad (4)$$

⁶ Other refinements to the first-difference estimations were investigated: Leibtag (2009) incorporates an AR process to account for autocorrelation of the residuals (he finds a 41% pass-through rate from international wheat prices to domestic retail wheat flour price for the period 1972-2008, with monthly prices and an adjustment lasting one to two months) while Bussière (2007) includes the potentiality for non linearities in an exchange rate pass-through regression with a polynomial structure. A vector equivalent of the method can be found in Ferrucci et al. (2012), who resort to an unrestricted VAR design to model the interrelationship between commodity prices, producer prices and consumer prices in the EU (log difference) with monthly data ranging from Jan 1997 to June 2009, for 6 food goods taken individually (cereal, coffee, dairy, fats, meat, sugar). They estimate the long-term pass-through from international prices to European cereal producer prices between 50 and 69 % depending on the model, as opposed to a pass-through to consumers between 24 and 28%.

where dp_t is the real domestic price in local currency, e_t is the exchange rate and wp_t stands for the real world price in US dollars. In this framework, the long-run relationship is represented by the variables in level: the representation assumes that in equilibrium,

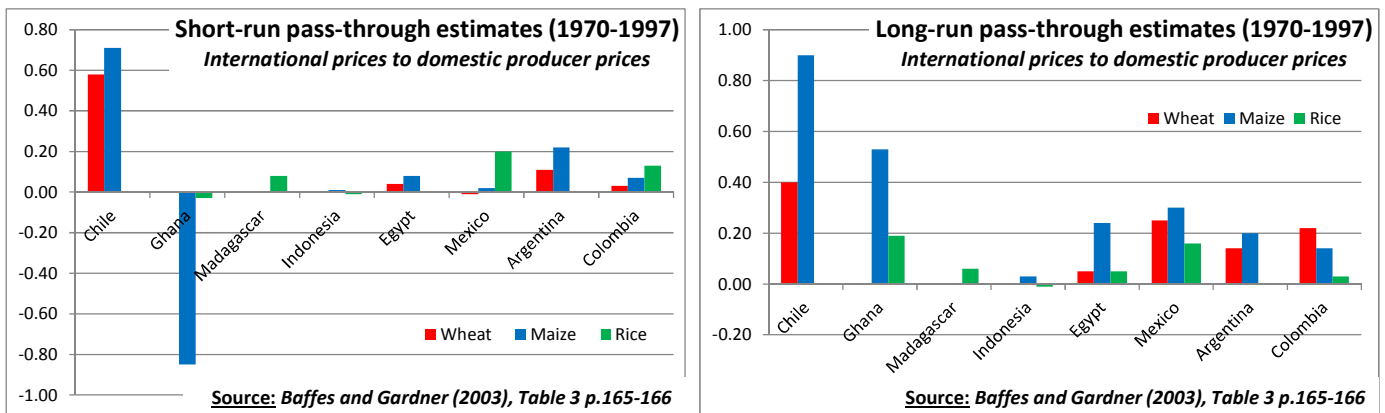
$$\ln(dp_t) - \frac{\alpha}{\beta} \cdot \ln(wp_t) - \frac{\eta}{\beta} \cdot \ln(e_t) = 0 \quad (5)$$

with α/β being the long-run pass-through.

The country- and commodity-specific pass-through estimates clearly show that price transmission (to consumers) does depend on the cereal considered, thus pointing at differential price stabilization schemes across food commodities. The authors also provide a panel estimate (country fixed effect) for the long-run relationship worldwide of .32 for wheat, .30 for maize and .24 for rice across the world.

Baffes and Gardner (2003) rely on annual data to assess the pass-through from international markets to domestic producer prices for 31 country/commodity pairs. They apply an ECM model (as well as a regression in log levels when co-integration does not work). Their co-integration analysis focuses on the stationarity of the difference between domestic and world prices, thus assuming unit co-integration.

Graph 3: Short- and long-run pass-through estimates for producer prices



Further refinements of the error-correction approach include threshold ECMs (see Myers and Jayne (2012) on multiple regimes of maize price transmission between Southern African markets), asymmetric ECMs (as in Chou et al. (2013), Bettendorf et al. (2003), Borenstein et al. (1997) or Bachmeier et al. (2003) on the asymmetric pass-through of oil price shocks) or panel ECMs as in Ahn et al (2016) who investigate input-output price transmission for different sectors of the Korean economy.

The single equation model implicitly assumes that the variables to the right are exogenous, and ignores the fact that the regressors could be themselves affected by the variable of interest (endogeneity bias). To account for the potential co-determination of the variables, vector structures of the error correction model are developed based on VARs. Under this framework,

Johansen (1988, 1992, 1995) propose several likelihood-based tests for co-integration. Jalil and Tamayo-Zea (2011) implement the co-integrated VAR approach to look at the impact of international food prices on domestic inflation in five Latin American countries. This method is also applied by Gilbert (2011).⁷

Surprisingly, the co-integration tests that underpin the error-correction representation are often missing or inconclusive as in Cudjoe et al. (2010) or Myers and Jane (2012).

Going further than simply assessing pass-through, some authors looked at the driving forces behind the heterogeneity observed in price transmission. After measuring the pass-through from commodity prices to domestic price indices for a wide array of countries, Rigobon (2010) regresses the estimates on country and sector dummies (the focus is put on variance decomposition). Another attempt is made by Bekkers et al (2017) who, after estimating the long-run food price pass-through for 147 countries (without ECMs) regresses the results on several variables (GDP per capita, regional or income dummies and trade integration variables). In an undated companion paper, the authors also conduct a panel analysis of pass-through with a country fixed effects estimator (for several income groups).

This article thus belongs to a significant body of empirical literature aiming at measuring pass-through. The review provides us with hints as to the most appropriate methods to implement, namely first difference regressions for non-stationary series and error-correction models when the series are shown to be co-integrated. Our results on price transmission from international grain markets to domestic producers complement and update the results of Mundlak and Larson (1992), going beyond level regressions. They also extend the scope of Baffes and Gardner (2003) and provide insights as to the evolution of pass-through over time. Eventually, they build on Rigobon (2010) and Beckers et al (2017) to identify the factors explaining the heterogeneity of producer price pass-through in a large cross-section of countries.

III — DATA: SOURCES AND CHARACTERISTICS OF THE SERIES

This study focuses on measuring the pass-through from international markets to domestic producer prices in a wide array of countries, and assessing whether price transmission increased over time, as a consequence of globalization. This section describes the series that were used for this purpose.

The variable of interest in the regressions that will follow corresponds to the *domestic producer price*. Annual crop-by-crop domestic producer price data are made available by the FAO from 1991. Resorting to the archives and using official exchange rates (also from FAO), a

⁷ An asymmetric version of the vector error correction model (VECM) can be found in Gomez and Koerner (2009). The authors investigate the pass-through to the retail price of coffee in France, Germany and the US, after a thorough description of the integration and co-integration tests run on the series.

domestic producer price series in current USD, was reconstructed back as far as 1970 but only for a limited set of countries.

The prime regressor in the analysis is the prevailing world market price. International commodities market price and price index data come from the World Bank's Global Economic Monitor Commodities website (GEMC). Monthly market price series are available for rice, wheat and maize from 1960.⁸ The series correspond to the price observed on major international commodity markets, mostly in North America, and prices are quoted in current dollars per metric ton of grain. Assuming that these prices correspond to border prices observed in each country is a simplifying assumption that ignores transportation costs, as well as the timing of international trade arrangements of each country over the calendar year. Additionally, there exist other secondary grain markets in different regions of the world, yet the dominance of American markets in commodity price discovery seems to be widely acknowledged (see e.g. Janzen and Adjemian, 2016 in the case of wheat). There are two methods to convert these monthly series into yearly ones (in order to fit the frequency of the producer price data): the first one is to take the average of the monthly prices over the calendar year (this is actually the method used by the World Bank to construct annual indices). Yet accounting for country-specific crop calendar could make more sense. We thus compute a country-specific world price series corresponding to the average of the prevailing world price during the country-specific harvesting months (and the following month, thus accounting for up to one month of on-site inventories, i.e. marketing delays). For the sake of simplicity, we used the international crop calendar for wheat, maize and rice compiled by de Winne and Peersman (2016) and kindly made available by the authors in their online appendix (see Appendix 2 for a graphical depiction of the harvest months for a selection of countries). The advantage of using these country-specific international price series instead of the broader average of prices over the calendar year is that it more accurately reflects the actual price that prevails on the international markets at the time when domestic producers sell their grains.⁹

International market prices (as recorded by the World Bank or the US Department of Agriculture) are quoted in US dollars per bushel or per metric ton, thus reflecting the standards of the largest grain commodity markets. Domestic prices, on the other hand, are reported by FAO in current USD, in current local currency units (LCUs) and in current standard local currency (SLC). The three series broadly have the same informational content, as the conversion

⁸ More precisely, the series referred to in this article are:

- for wheat: U.S. No. 1 hard red winter, ordinary protein, Kansas City;
- for maize: U.S. No. 2 yellow, prompt shipment, FOB Gulf of Mexico ports;
- for rice: Export Prices (FOB) of Thailand 5% Grade Parboiled Rice.

These series were selected as they offer the longest coverage, yet one needs to be aware that there exists many different varieties and qualities of grains. Nowadays, the reference for wheat price is traditionally the Soft Red Winter on the Chicago market rather than the Hard Red Winter from Kansas City (but the corresponding price series would only start in 1979). Similarly, the yellow maize is mostly used for animal feed or biofuel production, while the human food is mostly composed of white maize (but the series are not available). This said, the correlation between the prices of the different varieties within one cereal family is considered sufficiently large to ignore this issue.

⁹ A mixed frequency model (mixed data sampling regression model) along the lines of Ghysels et al (2004) could also have been considered to combine monthly commodity price data with annual producer prices. This refinement is left for further research.

from LCU to USD is basically obtained with current nominal exchange rates (the SLC series provides for corrections when the local currency happens to be devalued or rebased). Selecting the current USD producer price series presents the significant advantage of comparability of the results across the different countries, since it enables not to account for the exchange rate in the pass-through estimation.

This setup implicitly considers that the price adjustment takes place in US dollars, and in nominal terms: dollar price information is made available on the commodity market. Import and exports are supposedly paid for in current US dollars, and domestic producers will set their local prices in such a way that the local price times the current exchange rate (thus the producer price in current USD) relates to the international market price. Of course, should price transmission not be triggered immediately, the subsequent differential variations of the exchange rate relative to the nominal prices in LCU could affect the estimates. The estimations including the exchange rate were used rather as robustness checks, and indeed proved to be very close to the more parsimonious models excluding it: price transmission is quick enough to be only marginally affected by yearly evolutions of the exchange rate.

Having chosen to use USD prices, there still remains the issue of whether real or current prices should be resorted to. Considering that the international US dollar price signal is provided in nominal dollar terms, and assuming that the local price setting mechanism is directly affected by this nominal price via international trade, it seemed reasonable to assume that price transmission was not affected by a potential differential between international and local inflation patterns. Again, a more sophisticated model measuring a pass-through in real terms was tested as a robustness check, with only limited variations from the base case.

As a consequence of the above analysis, the baseline investigations presented in this paper consists in investigating the relationship between local and international price series, both being expressed in current USD. The emphasis is thus made on measuring pass-through in USD and in nominal terms.

For the purpose of the analysis, the data limitation clearly comes from the domestic producer prices. They are indeed reported with gaps in the time series, and the elimination of unreasonable data points reinforces this issue. Over the 44 years period under review (1970-2013), we have a full series of producer prices for 39 countries in the case of wheat, 37 countries for maize and 25 countries for rice, i.e. 101 country-commodity pairs. The number of countries with more than 30 data points is 51 for wheat, 65 for maize and 50 for rice.¹⁰

¹⁰ In terms of production, the countries for which an analysis is possible represent:

- for wheat: 286 million tons over a global production of 622 million tons in 2005 (46% of world production). The major missing countries are, in descending order, China, India, Russia, Pakistan and Ukraine (for a total of 254 million tons).
- for maize: 409 million tons of the 712 million tons produced in 2005 (57% of world production). The largest missing producers are China, Brazil, Argentina, and India (for a total of 210 million tons).
- for rice: 77 million tons out of the 423 million tons produced in 2005 (18% of the world production). The largest missing producers are China, India, Indonesia, Bangladesh and Viet-Nam (representing a total of 300 million tons).

As the final goal is to assess whether pass-through increased over time, two sub-samples of the data are investigated, with the pivotal date corresponding to 1990-1991, starting point of the more comprehensive data collection by the FAO. The first period thus extends from 1970 to 1990 (21 years) and the second one from 1991 to 2013 (23 years). Other break points around that date were tested with similar results. In order to keep a reasonable number of observations in each sub-period though (twenty being already rather small), the break points were investigated at the beginning of the 1990's.

The number of countries with full coverage before 1990 (21 data points) is 55 for wheat, 66 for maize and 54 for rice. As for the more recent period, there are respectively 42, 42 and 28 countries with full coverage (23 data points) for wheat, maize and rice. A table broadly summarizing the availability of the data at the country and commodity level is displayed in Appendix 3.

Unit root tests (ADF) are run for the various annual country-specific price series over the full period as well as over the two sub-periods. Similar tests were also run on the first difference variables. The results of the tests (approximate MacKinnon p-values) are reported in Appendix 4 (ADF with trend and no lag for the log-level variables, simple DF tests for the first difference variables).¹¹

Over the full period, it is possible to conclude that the price and exchange rate variables display $I(1)$ features for almost all countries in the sample.

A few exceptions to this general conclusion can be found though: indeed some log-level series appear stationary (Bangladesh, Bolivia and Cyprus for wheat; Bolivia, Chile, Dominical Republic, Egypt, Kenya, Paraguay and Philippines for maize; Myanmar, Greece and Thailand for rice). Knowing that the world price series happen to be integrated of order one, this result already points to effective price insulation from the international markets in those limited cases.

Additionally, two exchange rate series exhibited levels of integration higher than one (namely Chile and Colombia), meaning that the first difference series were still not deemed stationary. The reason for this is probably to be found in the hyperinflation periods faced by those countries (e.g. around 20% per year between 1973 and 1998 in Colombia).

When looking at the first sub-period, the conclusions on the characteristics of the series are less clear-cut. Due to the limited number of observations (21 years), the test results appear less conclusive. Yet again, for the vast majority of countries, the producer prices expressed in current dollars are found to be $I(1)$. Producer price series are found to be (trend) stationary in eight cases: Bangladesh for all three cereals, Bolivia and Chile for maize, Nigeria and Rwanda for wheat and Malawi for rice. Conversely, eight series are found to be integrated of order larger than one (Honduras and Hungary for wheat, Greece and Cambodia for maize, Cameroon, Kenya, Cambodia, Rwanda for rice).

¹¹ ADF tests were run systematically for each variable, with and without trend and with up to 3 lags. The other tests specifications are available upon request.

Eventually, one finds much fewer exceptions to the standard $I(1)$ case over the second sub-period, despite the approximately equal number of observations per country (23 years). Local producer price series are found to be $I(0)$ in three cases (Jordan for wheat, Paraguay and China for maize), and integrated of order larger than one for rice in Costa-Rica.

A full summary of the unit-root test conclusions (for all series) is available in Appendix 5.

IV — CO-INTEGRATION TESTS FOR THE SERIES

Having shown that most series exhibited $I(1)$ features leads us to assess co-integration. Indeed, the presence of unit-roots in the times series implies that regressions in log-levels could be flawed by spurious correlation. This would not be the case however should there be a long-term relationship between the dependent variable (domestic producer price) and its regressors (world price). Co-integration was tested with two methods:

- ADF tests were run on the residuals from the regression in log levels (OLS), following Engle and Granger (1987):

$$\ln(pp_t) = \alpha \cdot \ln(wp_t) + \beta + \varepsilon_t \quad (6)$$

where pp_t denotes the domestic producer price and wp_t stands for the world price. The test procedure was applied to prices expressed in current dollars as well as to prices expressed in local currency units (LCUs). Exhaustive results of this test are displayed in Appendix 6.

- the bounds testing procedure for level relationships, developed by Pesaran, Shin and Smith (2001), was applied. The idea behind this method is to investigate the existence of a relationship in level without having to care about the precise structure of the data. Two tests are run in parallel, one based on the F statistic and one on the t statistic, with critical values being derived for the case where all series are stationary, and others for the case where they are all $I(1)$, forming upper and lower bounds covering all possible cases. For each test, the null hypothesis of no level relationship is rejected when test statistics are larger (in absolute value) than the upper bounds (the $I(1)$ case), while it is accepted should the statistics be smaller than the lower bound (the $I(0)$ case). The existence of a long-run relationship is validated when both tests reject the null. The detailed results of this test are displayed in Appendix 7.

These two methods generally point to similar conclusions and fail to identify a general co-integration feature between the series. This could be due to real lack of long-run relationships between domestic and international price series for a non-negligible number of countries, but this could also stem from the small number of data points in the series (at most 44). Interestingly though, it is less difficult to conclude to co-integration over the most recent sub-period, which can be considered an anecdotal evidence for more market integration.

In order to circumvent the limitations induced by the small number of data points in the time series, panel co-integration techniques were investigated. More specifically, we computed the seven tests proposed by Pedroni (1999, 2004) for heterogeneous panels. The test statistics have to be compared to a $N(0,1)$ distribution. In these tests, the null hypothesis corresponds to the absence of intra-individual co-integration (see Hurlin and Mignon (2007) for a detailed review).¹²

Table 1 below reports the seven test statistics for each of the series in current dollars, in current LCU, with and without including the exchange rate series. The statistics above 1.645 (the 10% critical value for a 2 tailed Z-test) are highlighted in red. They indicate a failure to reject the null of no co-integration. These results confirm the general trend obtained from the country-level tests: there seems to be more doubts as to the co-integration of the series in the former period (indicating more price insulation behaviors at that time).

Pedroni (1997) indicates that in terms of power the “group ADF generally [does] best, followed by the panel ADF and the panel rho” for small time dimensions ($T < 100$).¹³ Following this insight, one can conclude to panel co-integration over the full period as well as over the most recent one for all three commodities and all specifications. The case of the earlier period is less straightforward, but the hypothesis of no panel co-integration should probably be rejected as well, except when prices are expressed in LCUs (the exchange rate probably played a more significant role in that period).

Table 1: Pedroni’s panel co-integration tests results

time period	model	cereal	Pedroni's panel cointegration tests							panel units	# obs	avg obs / unit
			Panel v	Panel rho	Group rho	Panel t	Group t	Panel adf	Group adf			
1970-2013	\$	wheat	4.54	-8.70	-7.44	-8.08	-8.43	-6.47	-6.24	39	1716	44
	\$	maize	4.87	-10.53	-9.01	-10.13	-11.21	-7.71	-8.20	37	1628	44
	\$	rice	1.15	-3.19	-2.43	-4.06	-4.31	-2.59	-2.77	25	1100	44
	LCU	wheat	7.66	-10.35	-9.27	-9.22	-10.16	-7.89	-8.69	39	1716	44
	LCU	maize	8.57	-13.77	-11.76	-11.76	-12.66	-10.54	-10.92	37	1628	44
	LCU	rice	4.02	-6.47	-6.08	-6.08	-7.16	-5.25	-5.97	25	1100	44
1970-1990	\$	wheat	0.17	-0.23	1.48	-0.28	0.36	4.32	6.48	55	1155	21
	\$	maize	-0.30	-0.97	0.93	-2.55	-2.39	4.50	7.62	66	1386	21
	\$	rice	-2.11	1.78	3.36	0.33	1.33	4.46	8.33	54	1134	21
	LCU	wheat	3.93	-3.01	-0.76	-4.09	-3.96	0.60	0.78	55	1155	21
	LCU	maize	2.93	-3.59	-0.71	-5.85	-5.52	1.35	4.06	66	1386	21
	LCU	rice	1.60	-1.84	0.16	-3.74	-3.49	-0.47	2.53	54	1134	21
1991-2013	\$	wheat	1.64	-6.19	-3.42	-9.45	-9.49	-6.50	-6.04	42	966	23
	\$	maize	2.62	-6.97	-4.72	-9.70	-10.46	-7.13	-7.17	42	966	23
	\$	rice	2.97	-4.49	-2.80	-6.14	-6.69	-3.96	-4.54	28	644	23
	LCU	wheat	2.13	-5.82	-3.13	-9.46	-9.51	-6.52	-4.43	42	966	23
	LCU	maize	3.48	-7.02	-4.17	-9.26	-9.45	-5.89	-3.49	42	966	23
	LCU	rice	1.84	-3.39	-1.75	-4.57	-4.50	-2.33	-2.80	28	644	23

Note: Pedroni’s heterogeneous panel co-integration test statistics follow a central normal distribution. Statistics beyond the 1.645 critical value (10% confidence level for a two-tailed Z-test) in both directions are highlighted in red, thus indicating a failure to reject the null of no co-integration. The tests are computed over the full period, as well as over the two sub-periods, for several different specifications (prices in current dollars, in current LCUs, with or without including the nominal exchange rate in the system).

¹² According to Hurlin and Mignon (2007) the alternative hypothesis of the test is that there exist a co-integration relationship for each individual, and that the parameters of this relation are not necessarily the identical from one individual to the other. « Ainsi, sous l’hypothèse alternative, il existe une relation de cointégration pour chaque individu, et les paramètres de cette relation de cointégration ne sont pas nécessairement les mêmes pour chacun des individus du panel. » (p. 252)

¹³ Pedroni (1997), p.22

This preliminary analysis of the time series characteristics yields two intermediary conclusions:

First, most annual price series exhibit unit-roots features while the first difference series are generally stationary. Unless co-integration is demonstrated, this means that simple regressions in log-levels could turn out to be spurious. Consequently, the appropriate approaches to estimate price transmission are either first-difference regressions (assuming no co-integration) or error-correction models (assuming co-integration).

Second, the hypothesis of co-integration proves difficult to validate across the different countries and crops, taken individually. Over the full period of analysis, it is possible to conclude to co-integration in between 64% and 100% of the cases, depending on the commodity and specification. This proportion falls when considering the first sub-period alone (sometimes below 50%). This can be due either to a low power of the tests due to the small number of data points in the time series, but could also be explained by a larger disconnect between the international and domestic prices in the former period. Panel tests confirm that the price series can be considered co-integrated in general over the full period and over the second sub-period, but are less conclusive concerning the first sub-period.

V — PASS-THROUGH ESTIMATES OVER THE FULL PERIOD (1970-2013)

Given these preliminary results, and according to the extant literature, two types of models are used to measure the level of pass-through from international prices to domestic producer prices:

- a model in first-difference, considering that the series in level have unit roots, but assuming that they are not co-integrated; and
- an error correction model, assuming the series are indeed co-integrated.

1. A model with first-differences

We first consider a model in first-difference.

$$\Delta \ln(pp_t) = \sum_{k=0}^K [\theta_k \cdot \Delta \ln(wp_{t-k})] + \gamma \tag{7}$$

Where pp_t stands for the domestic producer price, wp_t represents the world market price. International market prices are expressed in current US dollars, and the domestic prices are converted into the same unit using current exchange rates. The minimization of the Schwarz Bayesian Information Criteria (SBIC) for a VAR model generally points to a lag order of zero, and in some cases up to two. Other information criteria tend to select higher lag orders, yet given the limited time depth of the series we chose to consider at most 3 lags of the world price variation.

2. A single equation error correction model (ECM)

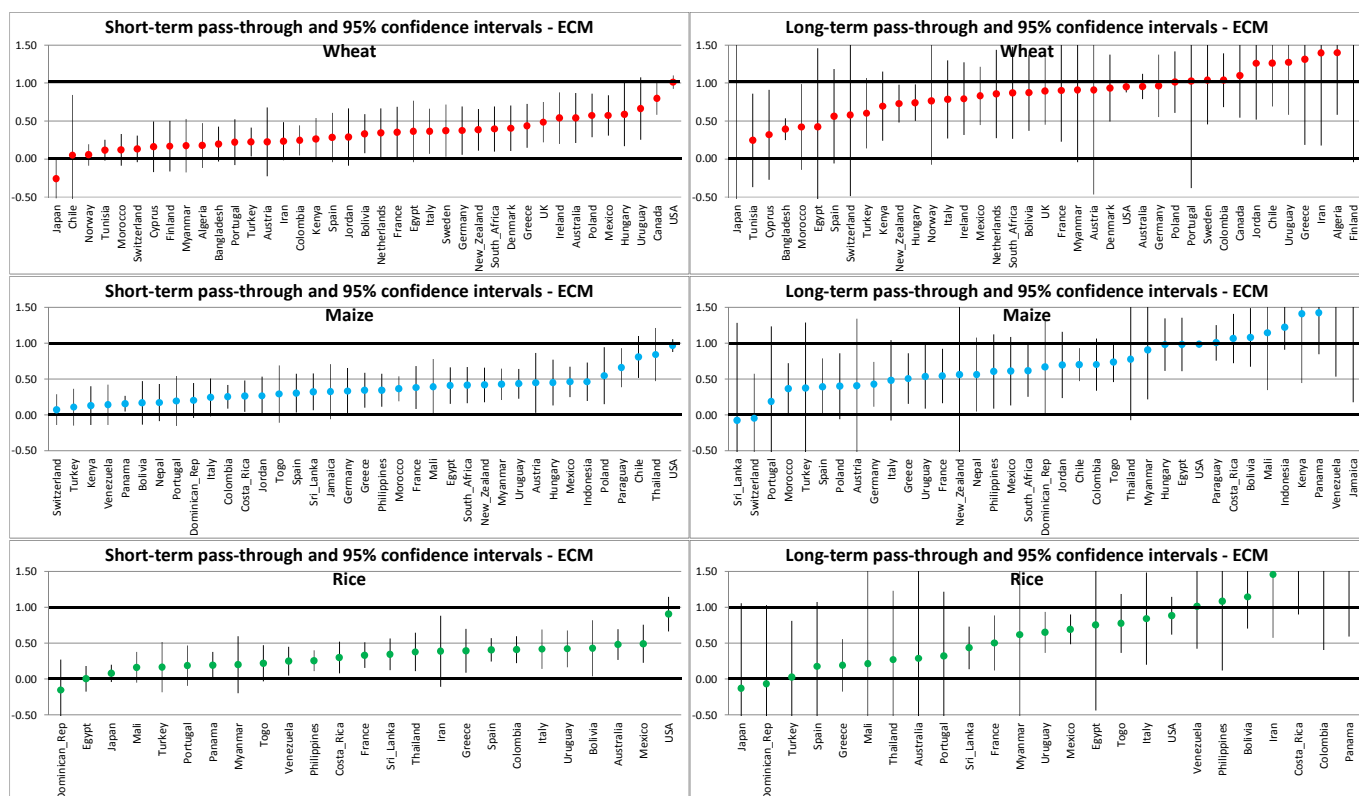
In line with the structure developed in Baquedano and Liefert (2014), we propose the following error-correction model, without accounting for the exchange rate.

$$\Delta \ln(pp_t) = \alpha \cdot \ln(pi_{t-1}) + \beta \cdot \ln(pp_{t-1}) + \delta \cdot \Delta[\ln(pp)]_{t-1} + \eta \cdot \Delta[\ln(pi)]_{t-1} + \kappa \cdot \Delta[\ln(pi)]_t + \gamma \quad (8)$$

Under this framework, the short-run pass-through corresponds to the coefficient κ while the long-run pass-through is given by $-\alpha/\beta$. The co-integrating vector is $(1; -\alpha/\beta)$.

The full set of results (with estimates from the error correction model, the static first difference and the first difference model with one lag) at the country level for each commodity is tabulated in Appendix 8. Graph 4 below provides a clearer visual depiction of the ECM estimates specifically. Note that alternative specifications for the ECM (including exchange rates, or using real prices instead of nominal prices) are reported in Appendix 9, with roughly similar results.¹⁴

Graph 4: Pass-through (short- and long-run) as estimated by the ECM over 1970-2013



Graph 4 thus reports the short- (left column) and long-term (right column) pass-through estimates obtained with the ECM model considering current US dollar prices for all the countries

¹⁴ One notes however that the specifications with real prices can sometimes yield abnormal long term coefficients (much larger than unity with very large standard errors). Additionally, missing values for the CPI series lead to dropping several countries from the sample. The paper thus mostly focuses on the simplest specification, with all prices expressed in nominal dollar terms.

in the sample. In each case, the point estimates are represented by a colored dot, and the whiskers indicate the 95% confidence interval, as approximated by 1.96 times the standard error in both directions. In each graph, the estimates are ranked in ascending order. It clearly appears that the long-term pass-through estimates are larger than the short-term ones, thus confirming that the adjustment does take some time. When looking at the confidence intervals, one can but see that long-term pass-through are much less precisely estimated than short-term ones. It seems very difficult to conclude that these long-run estimates are statistically different from one, even if the point estimates can lie rather far from this value. In the case of wheat, one notes that most long-term point estimates are concentrated around the value of one, reflecting a more integrated market than the other commodities. Actually, the difference between the short-term and the long-term pass-through should theoretically reflect the speed of adjustment; however we do not investigate this further given the low level of precision for our long-term estimates.

Before moving forward, it is worth stressing the difference between these estimates and those from earlier studies. Compared to the results obtained on wheat by Mundlak and Larson (1992) and recalled in Graph 1, our short-run estimates from the error correction are much smaller: indeed, they are below .6 for the vast majority of countries (five exceptions being Ireland, Poland, Uruguay, Canada and the US), while they reported estimates larger than .6 for 38 countries (65% of their sample). This might be a result of the spurious correlation stemming from applying level-regressions to non-stationary series.

The results from the error correction model were confronted with those from alternative specifications in first difference, to insure the robustness of the estimates. In Table 2 below, we report the simple pairwise correlation between the pass-through (short-term and long-term) as estimated by the various methods described above: the error-correction model (noted ECM) and the models in first-difference (noted Δ) with up to three lags (static corresponds to no lag).

Table 2: Pairwise correlation between the various pass-through estimates

Pairwise correlations between the pass-through estimated with the various methods

Correlation between the short term pass-through estimates

Wheat	PT_ECM_ST	PT_Δ_ST_1L	PT_Δ_ST_2L	PT_Δ_ST_3L	PT_Δ_static
PT_ECM_ST	1.0000				
PT_Δ_ST_1L	0.9026	1.0000			
PT_Δ_ST_2L	0.8954	0.9727	1.0000		
PT_Δ_ST_3L	0.7145	0.8176	0.8282	1.0000	
PT_Δ_static	0.8542	0.9795	0.9344	0.8407	1.0000

Maize	PT_ECM_ST	PT_Δ_ST_1L	PT_Δ_ST_2L	PT_Δ_ST_3L	PT_Δ_static
PT_ECM_ST	1.0000				
PT_Δ_ST_1L	0.9111	1.0000			
PT_Δ_ST_2L	0.8906	0.9613	1.0000		
PT_Δ_ST_3L	0.8163	0.8794	0.9203	1.0000	
PT_Δ_static	0.9145	0.9953	0.9655	0.8794	1.0000

Rice	PT_ECM_ST	PT_Δ_ST_1L	PT_Δ_ST_2L	PT_Δ_ST_3L	PT_Δ_static
PT_ECM_ST	1.0000				
PT_Δ_ST_1L	0.9152	1.0000			
PT_Δ_ST_2L	0.9275	0.9767	1.0000		
PT_Δ_ST_3L	0.8301	0.8185	0.8801	1.0000	
PT_Δ_static	0.8996	0.9885	0.9601	0.7918	1.0000

Correlation between the long term pass-through estimates

Wheat	PT_ECM_LT	PT_Δ_LT_1L	PT_Δ_LT_2L	PT_Δ_LT_3L
PT_ECM_LT	1.0000			
PT_Δ_LT_1L	0.4627	1.0000		
PT_Δ_LT_2L	0.5583	0.9067	1.0000	
PT_Δ_LT_3L	0.4890	0.7396	0.7209	1.0000

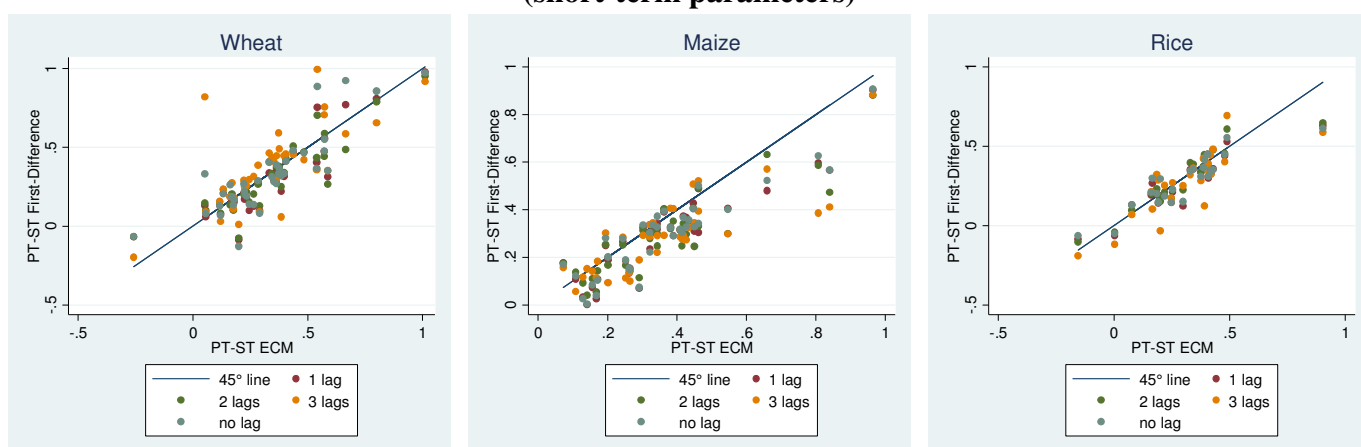
Maize	PT_ECM_LT	PT_Δ_LT_1L	PT_Δ_LT_2L	PT_Δ_LT_3L
PT_ECM_LT	1.0000			
PT_Δ_LT_1L	-0.1788	1.0000		
PT_Δ_LT_2L	0.2813	0.3557	1.0000	
PT_Δ_LT_3L	0.3090	0.3438	0.5774	1.0000

Rice	PT_ECM_LT	PT_Δ_LT_1L	PT_Δ_LT_2L	PT_Δ_LT_3L
PT_ECM_LT	1.0000			
PT_Δ_LT_1L	-0.0591	1.0000		
PT_Δ_LT_2L	0.2779	0.7347	1.0000	
PT_Δ_LT_3L	0.4973	0.3389	0.6632	1.0000

The tables report the pairwise correlation coefficients (Pearson's) between the pass-through estimates from the different methods

The correlations are fairly high for the short-term parameters (see also Graph 5), yet much lower for the long-term ones. Indeed, long-term pass-through parameters are much less precisely estimated than short-term ones. The estimates either come from linear (first-difference models) or non-linear (ECM) combinations of coefficients, providing larger standard errors. Additionally, one sees that the more lags are included in the first difference model, the more correlated the long-term pass-through estimates are to the ECM (this is especially true for maize and rice). Increasing the number of lags in the first difference models might enable to get closer to ECM estimates, at the expense of losing more and more observations.¹⁵

Graph 5: Plots of the various first-difference PT estimates against the ECM estimates (short-term parameters)



Asymmetric short-term responses were also investigated, resorting to an asymmetric error correction model, such as the ones in Bettendorf et al. (2003) or Borenstein et al. (1997). Under this specification, the long run equilibrium relationship is maintained, but the positive and negative variations of the international market price are treated separately.¹⁶ Unfortunately, contrary to the studies referred to above (which dealt with gasoline price, at a higher frequency), the low number of data points makes it difficult to obtain precise estimates, and it is generally not possible to conclude that the upward and downward pass-through are statistically significantly different. Appendix 11 provides graphical depictions of the results from this model, but asymmetric reactions to international price variations are not investigated further in this article.

¹⁵ To offer a complementary view on the matter, Pedroni's Panel dynamic OLS (PDOLS) method for heterogeneous panels was applied to the data. This framework only provides for long-term pass-through estimates, which turn out to be even more imprecisely estimated (see Appendix 10 for complete results and discussion).

¹⁶ Chou et al. (2013), or Bachmeier et al. (2003) use alternative models that are supposed to account to asymmetry of the long-run pass-through, yet the theoretical link with the ECM is unclear. The former considers separately positive and negative deviations from the level equation (although they do not necessarily correspond to the sign of the first differenced explanatory variable), while the latter decomposes the long-term deviation term according to whether the corresponding first-differenced explanatory variable was positive or negative.

VI — CAN WE OBSERVE A CHANGE IN PASS-THROUGH REGIMES?

In order to assess whether there have been a change in price transmission, the error correction framework (*eq. 8*) was adapted with $1_{t \geq 1991}$ (a dummy variable equal to one from 1991 onward, and to zero before) that was interacted with each term in the regression (the additions to the previous ECM are indicated in red below).

$$\begin{aligned}
 \Delta \ln(pp_t) = & \alpha \cdot \ln(pi_1) + \alpha' \cdot \ln(pi_1) \cdot 1_{t \geq 1991} + \beta \cdot \ln(pp_{t-1}) + \beta' \cdot \ln(pp_{t-1}) \cdot 1_{t \geq 1991} \\
 & + \delta \cdot \Delta[\ln(pp)]_{t-1} + \delta' \cdot \Delta[\ln(pp)]_{t-1} \cdot 1_{t \geq 1991} \\
 & + \eta \cdot \Delta[\ln(pi)]_{t-1} + \eta' \cdot \Delta[\ln(pi)]_{t-1} \cdot 1_{t \geq 1991} \\
 & + \kappa \cdot \Delta[\ln(pi)]_t + \kappa' \cdot \Delta[\ln(pi)]_t \cdot 1_{t \geq 1991} \\
 & + \gamma + \gamma' \cdot 1_{t \geq 1991}
 \end{aligned} \tag{9}$$

Under this new framework, the short-term pass-through is equal to κ before 1991, and to $(\kappa + \kappa')$ after. Testing for changes in short-term price transmission thus simply requires checking the significance of κ' in the regression.

As for the long-run pass-through, it corresponds to $\frac{-\alpha}{\beta}$ before 1991, and to $\frac{-(\alpha + \alpha')}{(\beta + \beta')}$ afterward. The significance of the difference between the two is also tested. Table 3, Table 4 and Table 5 below report the results from this estimation respectively for wheat, maize and rice. They display, for each country, the short-term coefficients and the long-term coefficients, as well as the test statistics for equality of the long-run pass-through.

Table 3: PT estimates based on ECM with sub-period dummies, wheat

WHEAT		Pass-through estimates based on the ECM with sub-period dummies																			
		Algeria	Australia	Austria	Bangladesh	Bolivia	Canada	Chile	Colombia	Cyprus	Denmark	Egypt	Finland	France	Germany	Greece	Hungary	Iran	Ireland	Italy	Japan
WHEAT	κ	0.091	0.727***	0.156	-0.024	0.708***	0.735***	0.212	0.181	0.016	0.191	0.002	0.178	0.202	0.244	0.385**	0.203	0.35	0.441*	0.156	-0.165
	$\Delta ST-PT$	(0.130)	(0.213)	(0.252)	(0.215)	(0.252)	(0.173)	(0.563)	(0.129)	(0.185)	(0.198)	(0.368)	(0.176)	(0.187)	(0.202)	(0.179)	(0.122)	(0.215)	(0.224)	(0.216)	(0.216)
	$\kappa+\kappa'$	0.173	0.451**	0.454	0.180	0.328***	0.892***	-0.008	0.326***	-0.289	0.583***	0.497**	0.241	0.633***	0.626***	0.483***	0.774***	0.284**	0.740***	0.416***	-0.311
	$ST-PT$	(0.132)	(0.200)	(0.301)	(0.160)	(0.093)	(0.152)	(0.448)	(0.092)	(0.256)	(0.141)	(0.206)	(0.207)	(0.195)	(0.184)	(0.166)	(0.184)	(0.137)	(0.185)	(0.148)	(0.208)
	$LT-PT$	0.063	1.242***	-0.174	0.451**	1.249***	0.650	1.691***	0.877***	-0.543	0.077	-0.220	0.874	0.181	0.314	0.406	0.422***	1.288**	0.363	0.059	-1.143
$-(\alpha+\alpha')/(\beta+\beta')$	(1.189)	(0.140)	(1.127)	(0.201)	(0.294)	(0.467)	(0.435)	(0.198)	(0.815)	(0.544)	(0.820)	(2.113)	(0.420)	(0.299)	(0.981)	(0.130)	(0.527)	(0.778)	(0.778)	(1.814)	
$-(\alpha+\alpha')/(\beta+\beta')$	1.270***	0.911***	1.020**	0.544***	0.763***	1.123***	1.320	1.131***	0.467**	0.992***	1.171***	1.193**	1.073***	0.973***	1.015***	1.121***	1.027***	0.898***	0.873***	-3.493	
$LT-PT$	(0.189)	(0.088)	(0.520)	(0.117)	(0.109)	(0.271)	(1.022)	(0.181)	(0.213)	(0.162)	(0.256)	(0.546)	(0.207)	(0.165)	(0.369)	(0.065)	(0.229)	(0.175)	(0.179)	(4.281)	
R^2	0.6279	0.8371	0.3452	0.6127	0.6443	0.7811	0.5566	0.6129	0.5731	0.6197	0.3248	0.4149	0.5004	0.5864	0.5522	0.7345	0.2925	0.5557	0.5757	0.4266	
WHEAT	κ'	0.082	-0.276*	0.299	0.203	-0.38	0.157	-0.22	0.145	-0.305	0.392*	0.495	0.063	0.431**	0.382**	0.098	0.571***	-0.066	0.299	0.26	-0.146
	$\Delta ST-PT$	(0.158)	(0.138)	(0.266)	(0.176)	(0.246)	(0.164)	(0.308)	(0.096)	(0.296)	(0.199)	(0.395)	(0.208)	(0.187)	(0.182)	(0.197)	(0.157)	(0.169)	(0.217)	(0.248)	(0.297)
	$\Delta LT-PT$	1.207	-0.331***	1.195	0.093	-0.487*	0.473	-0.372	0.253	1.009	0.915	1.391	0.319	0.892	0.659*	0.609	0.699***	-0.26	0.535	0.814	-2.35
	$-(\alpha+\alpha')/(\beta+\beta')$	(1.131)	(0.161)	(1.186)	(0.245)	(0.281)	(0.552)	(1.054)	(0.208)	(1.823)	(0.569)	(0.851)	(2.228)	(0.480)	(0.351)	(1.012)	(0.148)	(0.501)	(0.471)	(0.802)	(4.695)
	$\Delta LT-PT$	0.081	0.626	0.603	0.948	0.794	0.012	0.087	0.274	0.488	0.19	0.9	0.067	0.019	0.389	0.219	0.176	0.026	0.154	0.756	0.093
κ'	0.35*	0.16	0.106	-0.015	-0.099	0.465**	0.214*	0.164	0.147	0.22	-0.038	0.354*	0.387**	0.205	0.175	0.219	0.086**	0.229	-0.093	-0.565	
$\Delta ST-PT$	(0.194)	(0.325)	(0.202)	(0.234)	(0.376)	(0.175)	(0.121)	(0.148)	(0.209)	(0.164)	(0.298)	(0.186)	(0.156)	(0.235)	(0.139)	(0.158)	(0.037)	(0.157)	(0.298)	(0.645)	
$-(\alpha+\alpha')/(\beta+\beta')$	0.955*	0.72	-0.037	-0.326	-0.28	0.842**	1.817	0.973	0.37	1.473	-0.131	1.07	0.679**	1.298	1.762	0.393	0.078	0.702	-0.565	-0.565	
$\Delta LT-PT$	(0.560)	(1.053)	(0.205)	(0.540)	(0.822)	(0.407)	(2.891)	(0.915)	(0.255)	(1.665)	(0.531)	(0.780)	(0.294)	(1.824)	(2.868)	(0.287)	(0.056)	(0.640)	(0.645)	(0.645)	

Short- and long-term pass-through estimates over the two sub-periods obtained with ECM. Robust standard errors and indicated below the estimates, in parenthesis. Stars denote the statistical significance of the coefficients: * p<0.1, ** p<0.05, *** p<0.01. Coefficients in red are long-term pass-through estimates that do not differ significantly from one at the 5% confidence level.

Table 4: PT estimates based on ECM with sub-period dummies, maize

		Pass-through estimates based on the ECM with sub-period dummies																		
		Austria	Bolivia	Chile	Colombia	Costa_Rica	Dominican_Rep	Egypt	France	Germany	Greece	Hungary	Indonesia	Italy	Jamaica	Jordan	Kenya	Mali	Mexico	Morocco
MAIZE	κ	0.262	0.336	1.100***	0.065	0.145	0.402**	0.215	0.094	0.208	0.522	0.535**	0.004	0.216	0.285	0.028	0.247	0.553***	0.388*	
	$ST-PT_{1970-1990}$	(0.328)	(0.533)	(0.279)	(0.152)	(0.224)	(0.184)	(0.218)	(0.300)	(0.266)	(0.360)	(0.235)	(0.222)	(0.254)	(0.298)	(0.126)	(0.375)	(0.175)	(0.223)	
	$\kappa+\kappa'$	0.612**	0.142	0.857***	0.312***	0.26**	0.165	0.46***	0.53***	0.35**	0.427**	0.461**	0.3*	0.229	0.325*	-0.033	0.098	0.464***	0.353***	
	$ST-PT_{1991-2013}$	(0.276)	(0.142)	(0.126)	(0.083)	(0.125)	(0.157)	(0.178)	(0.193)	(0.165)	(0.202)	(0.206)	(0.155)	(0.232)	(0.179)	(0.153)	(0.291)	(0.110)	(0.109)	
	$-\alpha/\beta$	-0.269	1.358**	0.751***	-0.148	0.813*	1.23	-0.054	-0.08	-0.024	0.866	1.207***	-0.926	0.287	0.771	0.519	0.172	1.109**	0.251	
	(0.113)	(0.542)	(0.268)	(0.690)	(0.423)	(0.772)	(0.714)	(0.549)	(0.677)	(1.167)	(0.341)	(1.365)	(2.148)	(0.781)	(0.377)	(2.114)	(0.454)	(0.906)		
	0.812***	1.364*	0.667***	0.792***	1.063***	0.667***	0.885***	0.840***	0.767***	0.541***	0.914***	1.066***	0.748***	1.429**	0.860***	0.840***	0.807***	0.684***	0.396***	
	(0.316)	(0.207)	(0.060)	(0.271)	(0.359)	(0.217)	(0.118)	(0.183)	(0.157)	(0.204)	(0.175)	(0.169)	(0.209)	(0.688)	(0.233)	(0.139)	(0.196)	(0.229)	(0.120)	
	0.4609	0.4734	0.7844	0.3899	0.3961	0.5184	0.4267	0.5043	0.4715	0.4798	0.5135	0.4852	0.3272	0.2908	0.6637	0.4627	0.6203	0.538		
	(0.375)	(0.453)	(0.209)	(0.167)	(0.226)	(0.201)	(0.276)	(0.243)	(0.327)	(0.263)	(0.372)	(0.209)	(0.251)	(0.350)	(0.157)	(0.440)	(0.165)	(0.241)		
	1.081	0.005	-0.083	0.94	0.25	-0.563	0.939	0.792	0.048	0.591	0.048	-0.141	1.674	0.089	0.321	0.636	-0.425	0.145		
	(1.048)	(0.909)	(0.279)	(0.733)	(0.516)	(0.791)	(0.719)	(0.585)	(0.654)	(0.960)	(1.201)	(0.347)	(1.384)	(0.769)	(0.377)	(2.108)	(0.526)	(0.910)		
MAIZE continued	κ'	0.35	-0.194	-0.243	0.247	0.115	-0.237	0.245	0.436	0.143	-0.095	-0.074	0.296	0.013	0.04	-0.061	-0.149	-0.088		
	$\Delta ST-PT$	(0.375)	(0.453)	(0.209)	(0.167)	(0.226)	(0.201)	(0.276)	(0.243)	(0.327)	(0.263)	(0.372)	(0.209)	(0.251)	(0.350)	(0.157)	(0.440)	(0.165)		
	$-(\alpha+\alpha')/(\beta+\beta') - (-\alpha/\beta)$	1.081	0.005	-0.083	0.94	0.25	-0.563	0.939	0.792	0.048	0.591	0.048	-0.141	1.674	0.089	0.321	0.636	-0.425		
	$\Delta LT-PT$	(1.048)	(0.909)	(0.279)	(0.733)	(0.516)	(0.791)	(0.719)	(0.585)	(0.654)	(0.960)	(1.201)	(0.347)	(1.384)	(0.769)	(0.377)	(2.108)	(0.526)		
		0.422**	0.04	0.273	0.107	0.623***	0.052	-0.069	0.18	0.481**	0.112	0.172	0.004	0.703**	-0.012	0.845***	-0.028	0.307*		
	(0.204)	(0.144)	(0.173)	(0.064)	(0.223)	(0.186)	(0.385)	(0.297)	(0.227)	(0.275)	(0.251)	(0.234)	(0.298)	(0.187)	(0.118)	(0.159)	(0.172)			
	0.394***	0.410**	0.583***	0.163**	0.605***	0.374***	0.839***	0.283	0.450***	0.394***	0.354***	0.167	0.899***	0.19	1.019***	0.425***	0.02			
	(0.098)	(0.179)	(0.150)	(0.069)	(0.217)	(0.105)	(0.188)	(0.205)	(0.134)	(0.126)	(0.132)	(0.124)	(0.181)	(0.139)	(0.050)	(0.110)	(0.202)			
	0.791	0.144	0.097	1.103**	1.016***	-0.259	-0.714	0.194	0.4	-0.463	-0.108	-0.935	-0.086	0.055	0.87***	-0.789	2.219***			
	(0.661)	(0.376)	(0.581)	(0.527)	(0.303)	(0.790)	(0.450)	(0.883)	(0.668)	(0.952)	(0.359)	(1.698)	(0.845)	(0.622)	(0.100)	(1.741)	(0.556)			
	0.821***	0.837***	0.921***	1.53**	0.972***	0.831**	0.611***	0.591	0.621***	0.623***	0.148	0.274	0.910***	0.402	1.000***	-0.312	1.362***			
	(0.227)	(0.121)	(0.165)	(0.641)	(0.172)	(0.357)	(0.189)	(0.454)	(0.104)	(0.221)	(0.277)	(0.520)	(0.059)	(0.636)	(0.032)	(10.363)	(0.522)			
	0.5437	0.4291	0.5041	0.5913	0.6401	0.6719	0.53	0.3664	0.4457	0.4571	0.4764	0.4568	0.662	0.5091	0.9449	0.5451	0.3783			
	(0.316)	(0.404)	(0.631)	(0.555)	(0.291)	(0.889)	(0.470)	(0.978)	(0.667)	(0.980)	(0.455)	(1.829)	(0.845)	(0.860)	(0.098)	(10.355)	(0.749)			
	-0.028	0.369***	0.31*	0.057	-0.018	0.321*	0.908**	0.104	-0.031	0.282	0.182	0.163	0.196	0.203	0.175*	0.453***	-0.286			
	(0.199)	(0.132)	(0.155)	(0.084)	(0.287)	(0.171)	(0.344)	(0.302)	(0.204)	(0.283)	(0.224)	(0.250)	(0.220)	(0.189)	(0.102)	(0.140)	(0.220)			
	0.03	0.693*	0.824	0.427	-0.044	1.091	1.325***	0.396	0.221	1.086	0.256	1.209	0.996	0.346	0.131	0.477	-0.858			
	(0.639)	(0.404)	(0.631)	(0.655)	(0.291)	(0.889)	(0.470)	(0.978)	(0.667)	(0.980)	(0.455)	(1.829)	(0.845)	(0.860)	(0.098)	(10.355)	(0.749)			

Short- and long-term pass-through estimates over the two sub-periods obtained with ECM. Robust standard errors and indicated below the estimates, in parenthesis. Stars denote the statistical significance of the coefficients: * p<0.1, ** p<0.05, *** p<0.01. Coefficients in red are long-term pass-through estimates that do not differ significantly from one at the 5% confidence level.

Table 5: PT estimates based on ECM with sub-period dummies, rice

RICE		Pass-through estimates based on the ECM with sub-period dummies												
		Australia	Bolivia	Colombia	Costa_Rica	Dominican_Rep	Egypt	France	Greece	Iran	Italy	Japan	Mali	Mexico
RICE	K	0.600*** (0.153)	0.528 (0.313)	0.437*** (0.146)	0.209 (0.221)	0.346* (0.177)	-0.22 (0.216)	0.288** (0.136)	0.399 (0.250)	0.265 (0.354)	0.186 (0.146)	0.021 (0.123)	0.298*** (0.103)	0.638*** (0.200)
	K+K'	0.532*** (0.135)	0.329** (0.163)	0.333** (0.136)	0.338*** (0.108)	-0.414** (0.185)	0.179 (0.135)	0.437*** (0.145)	0.339** (0.133)	0.224 (0.348)	0.574*** (0.147)	0.073 (0.080)	0.078 (0.173)	0.442** (0.180)
	$-\alpha/\beta$	0.759*** (0.105)	1.401** (0.699)	1.522 (0.979)	0.964 (0.708)	2.247 (2.922)	-0.251 (0.671)	0.381 (0.408)	-0.323 (1.309)	0.718 (0.991)	-0.127 (0.471)	-1.278 (1.540)	1.492 (5.086)	0.845*** (0.250)
	$-(\alpha+\alpha')/(\beta+\beta')$	0.528** (0.315)	1.076*** (0.223)	1.105*** (0.281)	1.588*** (0.564)	-0.358 (0.348)	0.783*** (0.113)	0.676** (0.285)	0.296 (0.193)	0.982*** (0.267)	1.155*** (0.287)	0.2 (0.412)	0.481 (0.531)	0.621*** (0.090)
R ²	0.57	0.5668	0.5307	0.4553	0.3571	0.3579	0.4698	0.5827	0.4692	0.4504	0.4049	0.4112	0.6715	
RICE continued	K	-0.068 (0.176)	-0.199 (0.279)	-0.104 (0.141)	0.129 (0.187)	-0.76*** (0.252)	0.398 (0.302)	0.15 (0.169)	-0.06 (0.219)	-0.041 (0.353)	0.388** (0.186)	0.052 (0.149)	-0.219 (0.162)	-0.196 (0.210)
	K+K'	-0.231 (0.326)	-0.325 (0.686)	-0.417 (0.994)	0.624 (0.875)	-2.605 (2.923)	1.034 (0.656)	0.295 (0.449)	0.619 (1.382)	0.264 (1.004)	1.282** (0.533)	1.477 (1.622)	-1.011 (5.144)	-0.224 (0.244)
	$-\alpha/\beta$	0.611*** (0.209)	1.664* (0.885)	0.09 (0.281)	-0.157 (1.118)	-1.44 (4.414)	0.081 (0.211)	-0.125 (0.512)	0.373 (0.460)	-0.879 (1.087)	0.624* (0.347)	0.199 (0.529)	0.474** (0.238)	0.361*** (0.118)
	$-(\alpha+\alpha')/(\beta+\beta')$	0.487*** (0.139)	-15.918 (209.377)	0.861*** (0.128)	0.543 (0.453)	0.508 (0.328)	0.623*** (0.072)	0.878*** (0.075)	0.767*** (0.150)	0.538 (0.299)	0.966*** (0.077)	0.737*** (0.136)	1.163*** (0.389)	0.4152
R ²	0.6059	0.5646	0.5593	0.2597	0.6184	0.6067	0.4728	0.5211	0.4186	0.6702	0.5369	0.4152	0.4152	
RICE continued	K	-0.336 (0.314)	0.056 (0.164)	0.221* (0.109)	0.073 (0.239)	0.005 (0.155)	0.09 (0.179)	0.35** (0.135)	0.096 (0.210)	0.294 (0.440)	0.265 (0.227)	0.118 (0.183)	0.242* (0.129)	0.689 (0.437)
	K+K'	-0.124 (0.255)	-17.582 (209.239)	0.771** (0.310)	0.7 (1.189)	1.947 (4.415)	0.542** (0.213)	1.004* (0.518)	0.394 (0.458)	1.417 (1.103)	0.342 (0.350)	0.538 (0.533)	0.689 (0.437)	0.689 (0.437)
	$-\alpha/\beta$	0.487*** (0.139)	-15.918 (209.377)	0.861*** (0.128)	0.543 (0.453)	0.508 (0.328)	0.623*** (0.072)	0.878*** (0.075)	0.767*** (0.150)	0.538 (0.299)	0.966*** (0.077)	0.737*** (0.136)	1.163*** (0.389)	0.4152
	R ²	0.6059	0.5646	0.5593	0.2597	0.6184	0.6067	0.4728	0.5211	0.4186	0.6702	0.5369	0.4152	0.4152

Short- and long-term pass-through estimates over the two sub-periods obtained with ECM. Robust standard errors and indicated below the estimates, in parenthesis. Stars denote the statistical significance of the coefficients: * p<0.1, ** p<0.05, *** p<0.01. Coefficients in red are long-term pass-through estimates that do not differ significantly from one at the 5% confidence level.

Table 6 and Table 7 below summarize the previous results in terms of the evolution of pass-through estimates from the first sub-period (1970-1990) to the second one (1991-2013).

Table 6: List of countries with a significant change in pass-through estimates (both short- and long-term)

wheat		maize		rice	
significant increase in short term pass-through $\kappa' > 0$	significant increase in long term pass-through $-(\alpha + \alpha') / (\beta + \beta') - (-\alpha / \beta) > 0$	significant increase in short term pass-through $\kappa' > 0$	significant increase in long term pass-through $-(\alpha + \alpha') / (\beta + \beta') - (-\alpha / \beta) > 0$	significant increase in short term pass-through $\kappa' > 0$	significant increase in long term pass-through $-(\alpha + \alpha') / (\beta + \beta') - (-\alpha / \beta) > 0$
Denmark		New Zealand		Italy	Italy
France		Nepal	Nepal	Philippines	Philippines
Germany	Germany	Philippines		Sri Lanka	
Hungary	Hungary	Poland	Poland	Thailand	Thailand
Jordan	Jordan	USA		Venezuela	
Netherlands	Netherlands	Uruguay		4 countries out of 25	4 countries out of 25
New Zealand		6 countries out of 37	2 countries out of 37		
Spain					
Sweden	Sweden				
USA					
10 countries out of 39	5 countries out of 39				
significant decrease in short term pass-through $\kappa' < 0$	significant decrease in long term pass-through $-(\alpha + \alpha') / (\beta + \beta') - (-\alpha / \beta) < 0$	significant decrease in short term pass-through $\kappa' < 0$	significant decrease in long term pass-through $-(\alpha + \alpha') / (\beta + \beta') - (-\alpha / \beta) < 0$	significant decrease in short term pass-through $\kappa' < 0$	significant decrease in long term pass-through $-(\alpha + \alpha') / (\beta + \beta') - (-\alpha / \beta) < 0$
Australia	Australia			Dominican Republic	
	Bolivia				

Table 7: Number of countries which failed the tests of equality of the PT estimates to either 0 or 1

	wheat		maize		rice	
	1970-1990	1991-2013	1970-1990	1991-2013	1970-1990	1991-2013
Short term PT $\neq 0$	10	29	11	28	9	17
Long term PT $\neq 0$	14	33	9	32	7	17
Long term PT $\neq 1$	6	4	5	6	6	5

Let's first look at the case of wheat. The κ' are statistically significant for 10 countries (over 39), on the positive side, thus indicating an increase in short-term pass-through in the recent period. This significant increase of immediate price transmission is associated with a significant increase in long-term pass-through for 5 of these countries. This result indicates a significant increase in the degree of market integration for domestic producers in a third of the countries under analysis. Most of those countries belong to the European Union (exceptions being Jordan, New-Zealand, and the US). This result can be straightforwardly explained if one remembers the evolution of European Common Agricultural Policy (CAP) in the late 20th century. In particular, the Mac Sharry reform of 1992 has initiated a move towards less insulation of producer prices from market prices in an attempt to limit overproduction.

Yet the trend towards greater integration of domestic markets with international trade is definitely more general (see Table 7): indeed, over the first sub-period (1970-1990), only 10 out of 39 countries had short-term pass-through estimates significantly different from zero, while this was the case for 29 countries in the second sub-period (1991-2013).¹⁷ As for the long-term pass-through, they were significantly different from zero in 14 countries in the first period and in 33 countries in the second one. Besides, the estimates cannot be distinguished from one in 33

¹⁷ Out of the countries whose short-term pass-through becomes significantly different from zero in the second sub-period, eleven are European (Denmark, France, Germany, Hungary, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland). Another five belong to the Middle East / Northern Africa region (Egypt, Iran, Jordan, Tunisia, Turkey), while the remaining three are New-Zealand, South Africa and Colombia.

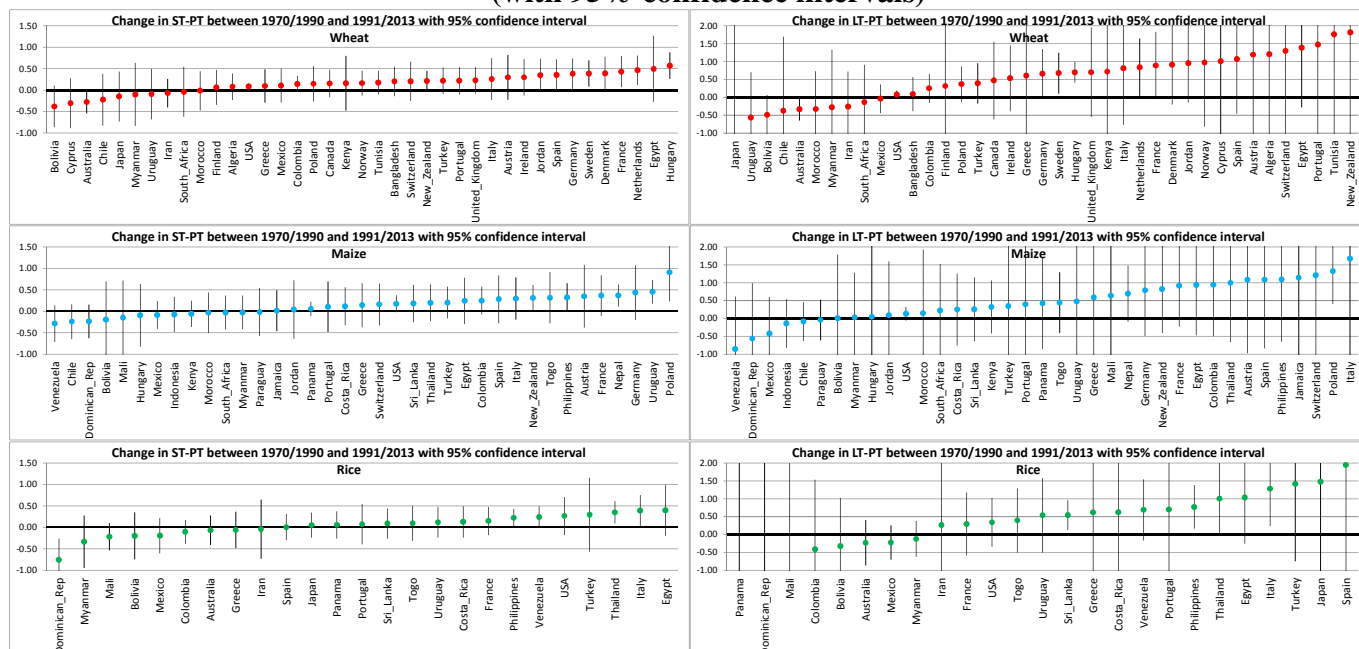
countries over 1970-1990 and in 35 countries in the following period¹⁸. Stated otherwise, after 1990, there are more countries whose domestic producer price reacts instantaneously to international price variations (more countries for which we reject that the short-term pass-through is zero), and in the meantime, almost all countries end up passing on international price variations in the long run (only four countries have a long-term pass-through significantly different from one in the second sub-period). These results thus point to less domestic price insulation and reinforce the preliminary results on the co-integration feature of the series.

Similar observations can be made for maize. A significant increase in short-term pass-through is found for 6 countries (with 2 of them exhibiting also a significant increase in the long-term parameter). And there again, we find that coefficients that were not different from 0 over the first sub-period turn out being significant over the second one.

As for rice, significant increases in short-term pass-through are observed for four countries, with only one case of significant decrease. More significant pass-through estimates were also found over the most recent period.

Graph 6 below provides a visual depiction of the previous results: for each country and commodity, the estimated change in pass-through is plotted as a colored dot while the whiskers indicate the 95% confidence interval (approximated as 1.96 times the standard errors).

Graph 6: Change in pass-through estimates between 1970-1990 and 1991-2013 (with 95% confidence intervals)

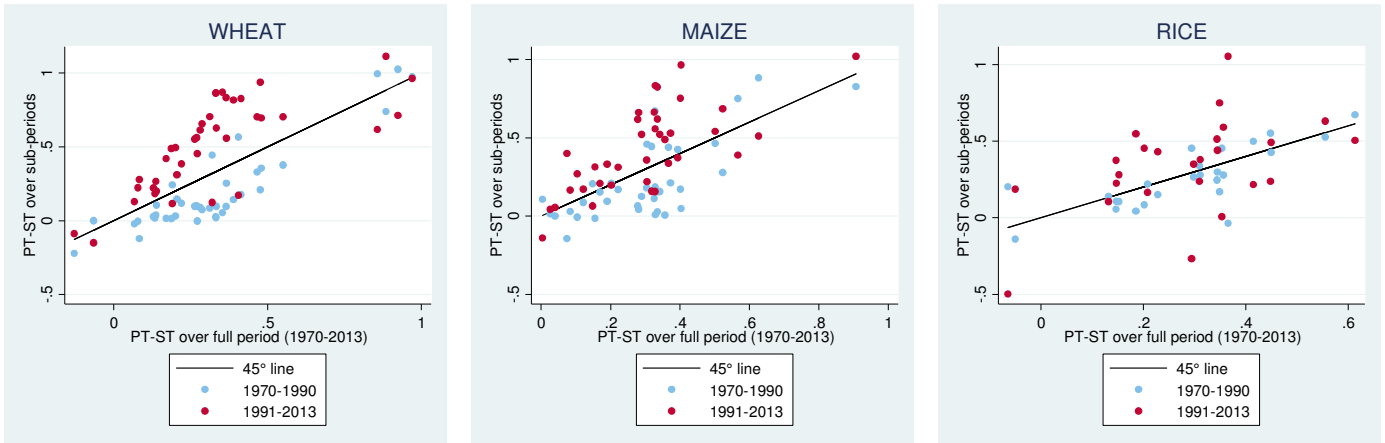


In order to check the robustness of this result to alternative specifications, a second method was used in complement to the estimation of eq.9. It consisted in simply estimating eq.7 and

¹⁸ These numbers are obtained by subtracting the figures in the last row of Table 7 from 39, the total number of countries in the sample.

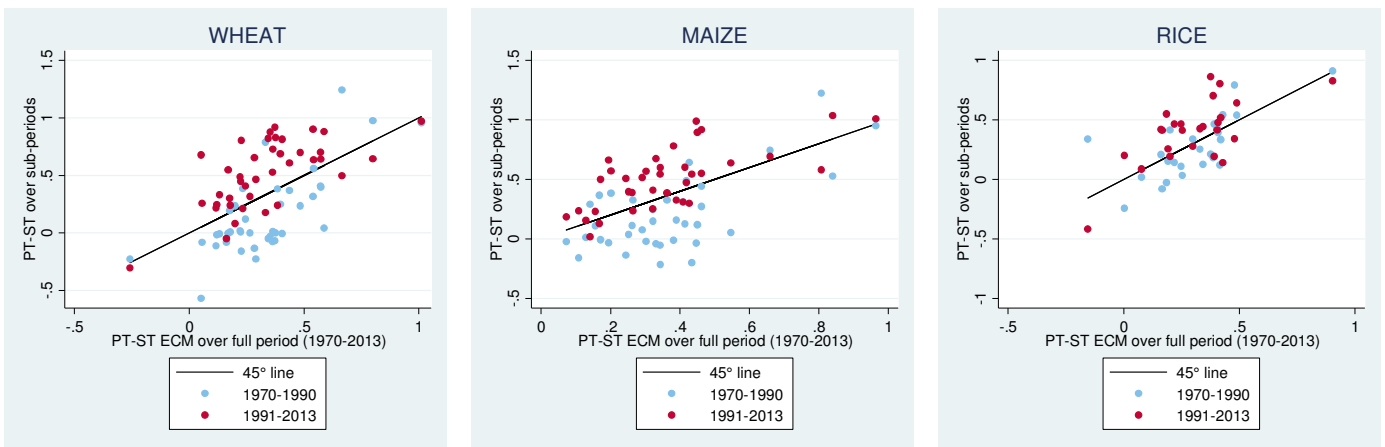
eq. 8 (i.e. the first-difference and error-correction models) for each country over each of the two sub-periods. Graph 7 and Graph 8 below plot the estimates obtained over the sub-periods (1970-1990 and 1991-2013, on the y-axis) against the estimates for the full period (1990-2013, on the horizontal axis). The solid line marks the 45° line, which means that it reports on the y-axis the value of the x-axis.

Graph 7: Graphical depiction of pass-through estimates - first difference model (no lag)

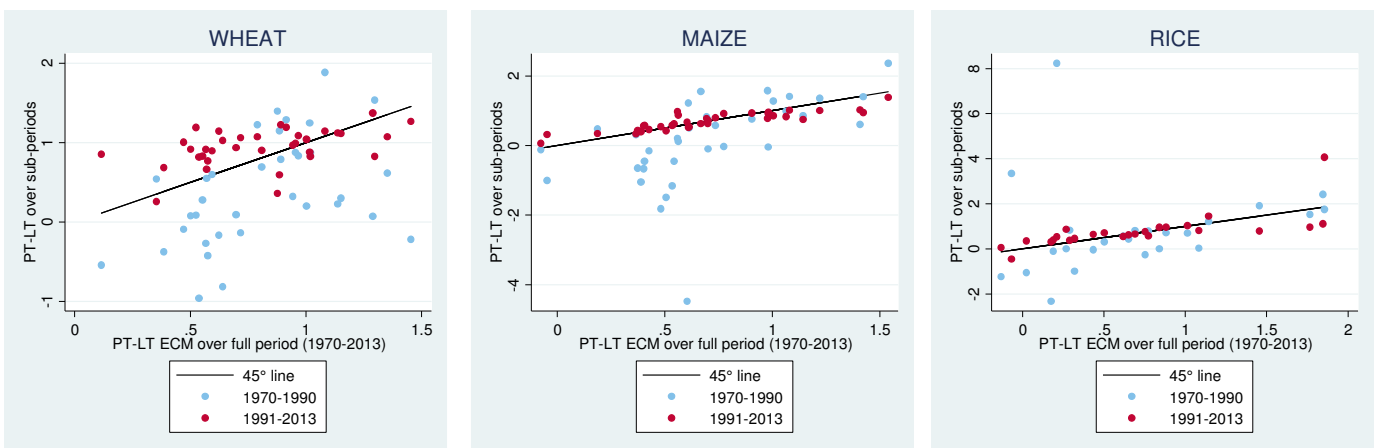


Graph 8: Graphical depiction of pass-through estimates with the ECM model

a) Short-term pass-through



b) Long-term pass-through



Those various graphs show a quite consistent increase of the point estimates of the pass-through across the board between the two sub-periods (the red dots generally lay above the blue ones). This result stands up for models accounting for co-integration (ECM) as well as for simpler models in first difference. It thus appears reasonable to conclude that over the recent period, price transmission from international markets to domestic producers indeed improved globally. This result might be due to better market integration and reduction in price support for producers. In order to interpret these results, one should bear in mind the general liberalization momentum that started in the 1990s. After the collapse of the Soviet Union and of its central-planning tradition, many countries had to turn to the market economy model. The Washington consensus (World Bank, IMF) insisted on domestic structural reforms as a condition to provide development assistance, and consequently many countries undertook liberalization reforms. Eventually, the Uruguay Round’s negotiations, which gave birth to the modern World Trade Organization (WTO) in 1995, also significantly contributed to reduce barriers to free trade around the globe and to contribute to better integration. The evolution is particularly marked and significant in the European Union, where strong reforms of the Common Agricultural Policy were implemented.

VII — A CROSS-SECTIONAL INVESTIGATION OF PASS-THROUGH HETEROGENEITY

In their broad investigation of consumer food price pass-through worldwide (147 countries, monthly data between 2000 and 2012) Bekkers et al (2017) used cross-sectional regressions to examine the potential drivers of the heterogeneity observed in their long-run estimates. They found a negative elasticity of pass-through to per-capita income (−0.3), thus concluding that consumer prices in poorer countries tended to be less insulated from the world commodity markets than high income countries. This result can be explained by the fact that the share of primary food in food consumption (and thus in the domestic food price index) is expected to be lower in richer countries. They also found significant negative impacts of some trade policies indicators.¹⁹ To the best of our knowledge, no similar analysis has been conducted on commodity-specific producer price pass-through estimates.

This section thus aims at identifying explanatory variables for the heterogeneity observed in price transmission from international markets to domestic producers. To increase the number of data-points and extend the analysis to more countries, we pooled the estimates from the two sub-periods and for the three grains, including period and cereal dummies in the regression.

$$\widehat{PT} = \mu_0 + \sum_{k=1}^K \varphi_k \cdot X_k \tag{10}$$

¹⁹ Specifically, the “National Rate of Assistance” (NRA) to the agricultural sector (see Anderson et al, 2008) does not significantly affect their cross section of long-run pass-through estimates, while the measure of “uniform tariff equivalent of tariff and non-tariff measures based on Most Favored Nation (MFN) tariffs” (the “Trade Restrictiveness Index”) has a significant negative impact on the long-run price transmission (see Kee et al, 2009). Eventually, the “Import Dependency Ratio” (IDR), which measures imports relative to food consumption, happens positively correlated with the long-term pass-through. Countries that depend more on imports have higher pass-through.

Among the right-hand side variables, we include GDP per capita (in log). For estimates relating to the first sub-period, the per-capita income is taken as the value for year 1980 (in constant USD) while the corresponding value for the second sub-period relates to year 2005.²⁰

We also add more original variables to the regression:

1. The first (*Prod/Supply*) is the ratio of domestic production relative to the “total domestic supply” in the country (in year 1980 for the first sub-period and in 2005 for the second). This variable is generated from the Food Balance Sheets (FBS) indicators of the FAO, for each country and each crop. Let’s emphasize that the name of the variable to the denominator is in fact misleading: in the FAO dataset, total domestic supply corresponds to the domestic production, to which they add imports, subtract exports and add the quantity released by the domestic inventories. As such, this total domestic supply represents the quantity consumed over the year by the country, and the ratio measures the quantity produced domestically relative to the equilibrium quantity consumed. This ratio can take all positive values. When it is below one, it means that the country either had to import or to use its inventories. The lower the value the higher the dependence on these sources of supply. If the ratio is above one, then this implies that the country is a net producer that can either export or build inventories. Aside from this variable, we generate a dummy variable (*Excess*) taking the value of 1 should *Prod/Supply* be larger than one, which we can interact with *Prod/Supply*. This way, we allow for a differential impact of the production gap depending on whether the country is an excess or deficit producer.²¹ We expect producers in exporting countries to be more integrated to world markets (and even to contribute to setting the equilibrium market price). Conversely, we anticipate that producers in deficit countries are more responsive to local market conditions than to world commodity prices.
2. The second variable accounts for the importance of the specific crop in the cereals consumption mix of the country. There again we use FAO’s Food Balance Sheets, and divide the average daily calorie intake from either wheat, maize or rice over the total average daily calorie intake. Depending on the reference period for the pass-through estimate, this variable corresponds either to 1980 or to 2005.²²
3. A third variable is taken from the *Political Regime Characteristics and Transitions* dataset compiled by Marshall, Gurr and Jagers as part of the Polity IV project (Center for Systemic Peace), in order to account for the situation of the country along the autocracy-democracy dimension (Polity2 index). We could indeed hypothesize that autocratic or dictatorial regimes are more autarchic and thus more insulated from

²⁰ Note that similar regression results are obtained when taking averages over each of the sub-periods.

²¹ There again, using averages over the sub-periods rather than values for 2005 and 1980 yields similar regression results. An alternative measure of trade integration was tested, which consisted in the ratio of imports to production or of exports to production (see Appendix 12).

²² Averages over the sub-periods yield very similar results.

world market prices. On the opposite, one could consider that these countries care less about their poor, and thus do not intervene much to stabilize market prices.

4. A fourth variable is built from the Tariff Download Facility of the World Trade Organization (WTO). This database reports by country and product the level of the tariffs that were applied on imports. Three years (at most) are available for each country, but they are not necessarily the same for all countries (ranging from 2000 to 2017). Our variable is the average, over available years, of the average ad valorem duties imposed respectively on wheat, maize and rice imports for the most favored nation (MFN). Alternatively, the measure of bounds ad valorem tariffs could be used. Given that the data is only available for recent years, these variables were considered only when analyzing the most recent sub-period. It is expected that countries implementing higher tariffs should be less integrated to world markets, and that their producers should be more insulated from international market price swings. Yet this relationship is far from straightforward: indeed, should a country only levy constant ad valorem tariffs on imports, the estimated pass-through coefficients should not be affected (in the log form, the tariffs would fall in the constant). Two reasons might explain why tariffs could be correlated with pass-through, though: on the one hand, it could very well be the case that the level of tariffs be positively correlated with other (non-tariff) barriers. On the other hand, as it is not possible to follow tariffs through time, high tariffs in our database may signal the ability of a given government to use tariffs in a discretionary fashion to stabilize domestic prices.
5. Eventually, the trade restrictiveness indices (TRI) computed by Kee et al (2009) building on the work by Anderson and Neary (1994) were also tested in the regression. These indices measure the loss in domestic welfare implied by the domestic trade regimes (we used the TRI considering tariffs alone as well as that corresponding to tariffs and non-tariff barriers taken together). Contrary to the WTO tariff variables, this data aggregates all economic sectors for a given country (it is therefore not specific to the three crops considered in this article and rather reflects the overall degree of trade policy interventions).

Summary statistics for the variables of interests are provided in Table 8.

Table 8: Summary statistics of the variables

variable	Both sub-periods					Sub-period 1 only (1970-1990)					Sub-period 2 only (1990-2013)				
	N. obs.	Mean	Std. Dev.	Min.	Max.	N. obs.	Mean	Std. Dev.	Min.	Max.	N. obs.	Mean	Std. Dev.	Min.	Max.
ST-PT (ECM-nominal-noER)	281	0.29	0.33	-0.63	1.24	175	0.17	0.31	-0.63	1.24	106	0.49	0.27	-0.42	1.04
LT-PT (ECM-nominal-noER)	276	0.52	0.93	-4.48	4.06	170	0.34	1.06	-4.48	3.34	106	0.80	0.56	-2.17	4.06
ST-PT (ECM-nominal-ER)	281	0.32	0.34	-0.66	1.74	175	0.23	0.33	-0.66	1.74	106	0.48	0.30	-0.59	1.05
LT-PT (ECM-nominal-ER)	277	0.64	0.80	-3.69	4.06	174	0.61	0.83	-3.39	3.37	103	0.70	0.75	-3.69	4.06
LN (GDP per capita)	768	14.73	1.60	11.34	18.18	345	14.56	1.59	11.34	18.18	423	14.86	1.60	11.98	18.02
Production / Supply	633	0.74	0.76	0.00	11.74	289	0.75	0.66	0.00	6.00	344	0.74	0.83	0.00	11.74
Weight in food consumption	778	0.13	0.15	0.00	0.76	353	0.13	0.16	0.00	0.76	425	0.13	0.14	0.00	0.71
Polity 2 index	768	1.63	7.46	-10.00	10.00	348	-1.22	7.70	-10.00	10.00	420	3.99	6.37	-10.00	10.00
Bounds tax rate											162	36.83	44.73	0.00	200.00
MFN tax rate											165	9.38	15.16	0.00	65.00
Tariff TRI											150	0.13	0.07	0.05	0.42
Tariff and NTB TRI											150	0.36	0.12	0.09	0.66

Note: Long-term pass-through larger than 5 in absolute value were taken away from the sample

The results presented in Table 9 below use the pass-through estimates (both long- and short-term) obtained with the error correction model. Note that similar regressions were run with the other models (first difference with up to three lags) with comparable results.

Table 9: Cross-section regression of pass-through estimates

Entire sample of sub-period PT Error-correction model	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.034*** (0.012)	0.031*** (0.011)	0.031*** (0.011)	0.027** (0.012)	0.022 (0.015)	0.013 (0.014)	0.125 (0.182)	-0.086*** (0.032)	-0.085** (0.033)	-0.084** (0.033)	-0.091*** (0.034)	-0.122*** (0.040)	-0.117*** (0.043)	0.370 (0.427)
Wheat dummy	0.021 (0.043)	0.045 (0.041)	0.051 (0.042)	0.039 (0.044)	0.019 (0.043)	0.078* (0.043)	0.035 (0.038)	0.065 (0.141)	0.078 (0.144)	0.078 (0.143)	0.080 (0.146)	0.043 (0.140)	0.060 (0.145)	0.163 (0.134)
Maize dummy	0.069 (0.042)	0.096** (0.041)	0.100** (0.041)	0.046 (0.041)	0.064 (0.042)	0.067* (0.040)	0.064* (0.039)	-0.054 (0.149)	-0.031 (0.152)	-0.035 (0.152)	-0.063 (0.152)	-0.096 (0.148)	-0.067 (0.156)	-0.086 (0.140)
Period dummy (1991-2013)	0.278*** (0.036)	0.266*** (0.035)	0.266*** (0.035)	0.282*** (0.036)	0.263*** (0.037)	0.260*** (0.035)	0.231** (0.093)	0.525*** (0.100)	0.511*** (0.100)	0.507*** (0.102)	0.526*** (0.100)	0.497*** (0.110)	0.482*** (0.110)	0.399* (0.223)
Production / Supply		0.071** (0.030)	0.093* (0.055)			0.130** (0.059)			0.043 (0.042)	0.101 (0.205)			0.092 (0.219)	
(Production / Supply) x Excess			-0.046 (0.063)			-0.092 (0.067)				-0.050 (0.210)			-0.052 (0.225)	
Excess production dummy			0.102 (0.069)			0.155** (0.071)				-0.020 (0.180)			0.027 (0.191)	
Weight in food consumption				-0.267** (0.108)		-0.334*** (0.121)					-0.222 (0.379)		-0.040 (0.380)	
Polity 2 index					0.004 (0.003)	0.003 (0.003)						0.010 (0.011)	0.009 (0.011)	
Country dummies							YES							YES
Constant	-0.359** (0.169)	-0.378** (0.162)	-0.420** (0.168)	-0.213 (0.171)	-0.176 (0.213)	-0.120 (0.212)	-1.887 (2.678)	1.618*** (0.488)	1.565*** (0.488)	1.529*** (0.491)	1.725*** (0.542)	2.173*** (0.619)	2.041*** (0.673)	-5.272 (6.305)
R ²	0.242	0.286	0.295	0.252	0.242	0.312		0.079	0.077	0.078	0.078	0.089	0.085	
N of observations	276	275	275	274	273	270	276	276	275	275	274	273	270	276
Number of countries							75							75
Observations per country							3.680							3.680

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

To make sure that the results are not driven by the changing composition of the panel over the two sub-periods, the regressions were run also over the restricted sample of country-commodity pairs that are present in both sub-periods, with very close output (see Appendix 12, which also displays the results obtained with averaged values of GDP per capita, Production / Supply and Weight in food consumption over the sub-periods rather than values for years 1980 and 2005). Other robustness checks included pure cross-section regression (i.e. for the first sub-period and for the second sub-period separately – see below).

Looking at the estimates displayed above, several important results emerge.

First and foremost, the coefficients on the “period dummy” confirm the results from the previous section: pass-through estimates obtained in the second period are significantly larger than those of the first period. In our sample, the increase in producer price pass-through lays between 23 and 29 percentage points for the short-term coefficient, and between 40 and 52 percentage points for the long-term coefficient (but recall that the latter is much less precisely estimated). Overall, the world producers thus appear more integrated with the international commodity markets. Turning to the relationship between pass-through and income, one notes that GDP per capita seems to be positively correlated with the short-term coefficient, and negatively correlated to the long-term one. A one percent increase in GDP per capita is associated with a 3 percentage point increase in short term pass-through, and with a 10 percentage point decrease in long-term pass-through. Prices in wealthier countries therefore tend to react significantly more to international commodity markets in the short-run (greater direct

price transmission), while the long-term effect is lower. Working on long-run consumer price pass-through (using food price indices), Bekkers et al (2017)'s, had also highlighted a negative elasticity to income. Our results on commodity-specific producer price pass-through for the long-term seem to go in the same direction. Yet again, the significant standard errors associated with our long-run point estimates should lead us to interpret these latter results with care (all the more so as this result no longer holds true when using the first-difference models, see Appendix 14).

We now focus on the left panel of the table (regressions on short-term pass-through estimates). The ratio of domestic production over supply consistently turns out to be positively correlated to pass-through: the higher this ratio, the larger the pass-through. To consider separately excess producers and deficit producers, let's focus on columns (3) and (6) which include the excess production dummy as well as the interaction term.

The main takeaways are the following:

1. The pass-through for excess producers is significantly larger than the pass-through for deficit producers. This can be seen when observing the coefficient on the "excess production dummy variable". Unsurprisingly, countries that produce more than they actually need are more integrated to world markets through their exports. The price they receive is more quickly indexed on the international commodity market prices.
2. The coefficient on the straight "Production / Supply" variable indicates that deficit countries that are closer to being self-sufficient are more integrated to world markets. Conversely, producers in countries with large production deficit tend to be more insulated from world price fluctuations. These producers do not intervene in global markets and the price they receive is rather determined by local market conditions. Over the marketing year, local production and imports might not occur at the same period, explaining a further disconnect between world markets and domestic prices
3. When summing the coefficients on the straight and interacted variables, one finds a positive, yet not always significant parameter. Larger excess producers are not necessarily more integrated than smaller excess producers. Being an excess producer is more relevant to pass-through than being a large excess producer.

These results are robust to selecting only the subset of country-commodity pairs that are observed in both sub-periods, as well as when looking only at pass-through estimates from the latter period. Overall, the higher the ratio of production over consumption, the larger the pass through. However the relationship is not linear: one finds a discretionary jump around the point where the quantity produced domestically matches the quantity consumed, and the slope is smaller for excess producers.

The importance of the cereal in the food consumption basket is negatively (and most of the time significantly) correlated with the level of pass-through. This result indicates that more

insulation is provided to domestic cereal producers when the country's population is heavily dependent on a cereal for its food intake.

On the right panel, only do income and the period dummy seem have significant coefficients. The other explanatory variables do not seem to be correlated with the long-term pass-through estimates. Yet one needs to remember that long-term pass-through estimates are rather concentrated around 1 (and generally not statistically significantly different from this value). The lower dispersion of the point estimates in each cross-section might therefore explain this output.

Running the regressions over each sub-period taken separately also yields interesting conclusions (see Table 10 and Table 11). Strikingly, the GDP elasticity parameters appear insignificant in the former period, and much larger (and significant) in the second. In the 70s and 80s, domestic price insulation was much less dependent on the country's position along the income ladder. Indeed, wealthy countries such as those belonging to the European Union did implement price support to their producers. Similarly, being an excess producer had insignificant impact on short-run pass-through in the former period and turned out a relevant covariate in the latter (see also the relevance of the size of the production deficit). Conversely though, the importance of the crop in the food basket was more relevant in the earlier period than it was more recently. This result can be interpreted as a larger emphasis put on insulating domestic consumer prices through the stabilization of farm-gate prices.

Last, considering bounds tax rate (available only for the latter period) is included as a potential covariate in Table 11 (column (5b)). Unsurprisingly, the regression output confirms that higher average bounds tax rates are associated with lower pass-through, thus confirming the insulating role of tariff barriers for domestic producers. Interestingly, the tariffs seem to affect both long- and short-term pass-through. The results obtained with the "most favored nation" tariff yielded coefficients of the same order of magnitude as the bounds variable, yet they were not significantly different from 0 and are not reported. Looking at trade policies from a broader perspective, the trade restrictiveness indices (TRI) also proved to be negatively correlated with pass-through (there again, both for long- and short-term coefficients). The effects are large and significant for the Tariff TRI, while they are smaller and not statistically significant when considering the TRI variable accounting for both tariffs and non-tariff barriers. As already pointed out, a constant proportion of tariff on imports should not have any impact on pass-through, just because the relative variations of prices from one period to the other are preserved. Yet this results, that holds both for bounds tax rates on cereals and for general tariff TRI goes against the expectations. This probably means that high average tariff countries use import levies in a more active and discretionary way in order to stabilize their domestic markets. Indeed, the higher the average tax rate, the more leeway there is to reduce it when prices surge and to increase it when they fall.

Table 10: Cross-section regression of pass-through estimates – 1970-1990

FIRST SUB-PERIOD Error-correction model	1970-1990 pass-through estimates											
	Short-term Pass-through						Long-term Pass-through					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
LN(GDP per capita)	0.019 (0.016)	0.015 (0.014)	0.011 (0.015)	0.011 (0.015)	0.000 (0.019)	-0.013 (0.019)	-0.108** (0.048)	-0.105** (0.049)	-0.116** (0.050)	-0.118** (0.050)	-0.152** (0.060)	-0.155** (0.064)
Wheat dummy	-0.007 (0.057)	0.015 (0.054)	0.006 (0.054)	0.012 (0.056)	-0.014 (0.057)	0.025 (0.055)	0.015 (0.202)	0.022 (0.204)	-0.024 (0.202)	0.037 (0.203)	-0.029 (0.202)	-0.052 (0.202)
Maize dummy	0.061 (0.055)	0.091* (0.053)	0.089 (0.054)	0.031 (0.053)	0.054 (0.055)	0.055 (0.052)	-0.047 (0.215)	-0.022 (0.219)	-0.051 (0.218)	-0.074 (0.222)	-0.107 (0.214)	-0.096 (0.226)
Production / Supply		0.109*** (0.033)	0.063 (0.070)			0.105 (0.075)		0.055 (0.073)	0.115 (0.295)			0.104 (0.312)
(Production / Supply) x Excess			0.090 (0.098)			0.033 (0.101)			0.091 (0.318)			0.085 (0.339)
Excess production dummy			-0.127 (0.114)			-0.061 (0.113)			-0.416 (0.300)			-0.350 (0.317)
Weight in food consumption				-0.349*** (0.130)		-0.344** (0.146)				-0.433 (0.478)		-0.096 (0.471)
Polity 2 index					0.005 (0.004)	0.005 (0.004)					0.010 (0.014)	0.008 (0.014)
Constant	-0.127 (0.228)	-0.174 (0.215)	-0.064 (0.232)	0.062 (0.225)	0.163 (0.279)	0.310 (0.282)	1.954*** (0.707)	1.864*** (0.712)	2.086*** (0.751)	2.172*** (0.772)	2.640*** (0.911)	2.693*** (1.011)
R ²	0.020	0.097	0.107	0.053	0.027	0.143	0.027	0.025	0.040	0.030	0.039	0.046
N of observations	170	169	169	169	167	165	170	169	169	169	167	165

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 11: Cross-section regression of pass-through estimates – 1991-2013

SECOND SUB-PERIOD Error-correction model	1991-2013 pass-through estimates															
	Short-term Pass-through							Long-term Pass-through								
	(1)	(2)	(3)	(4)	(5)	(5b)	(5d)	(6)	(1)	(2)	(3)	(4)	(5)	(5b)	(5d)	(6)
LN(GDP per capita)	0.062*** (0.015)	0.057*** (0.015)	0.049*** (0.015)	0.061*** (0.016)	0.052** (0.022)	0.064*** (0.015)	0.043** (0.017)	0.035 (0.022)	-0.047* (0.027)	-0.051* (0.028)	-0.063** (0.030)	-0.035 (0.027)	-0.094*** (0.034)	-0.008 (0.025)	-0.118*** (0.042)	-0.105*** (0.033)
Wheat dummy	0.066 (0.067)	0.094 (0.065)	0.100 (0.065)	0.069 (0.073)	0.071 (0.068)	0.093 (0.065)	0.067 (0.060)	0.122* (0.068)	0.142 (0.173)	0.164 (0.179)	0.158 (0.166)	0.101 (0.198)	0.165 (0.166)	0.179 (0.173)	0.273*** (0.094)	0.131 (0.189)
Maize dummy	0.099 (0.065)	0.124* (0.065)	0.122* (0.067)	0.095 (0.064)	0.098 (0.065)	0.092 (0.066)	0.064 (0.063)	0.104 (0.069)	-0.041 (0.157)	-0.023 (0.164)	-0.028 (0.163)	-0.004 (0.143)	-0.047 (0.158)	-0.060 (0.169)	-0.045 (0.087)	-0.005 (0.149)
Production / Supply		0.048* (0.028)	0.143 (0.087)					0.155* (0.092)		0.036 (0.045)	0.082 (0.220)					0.005 (0.222)
(Production / Supply) x Excess			-0.134 (0.087)					-0.150 (0.093)			-0.095 (0.223)					-0.022 (0.223)
Excess production dummy			0.255*** (0.082)					0.277*** (0.085)			0.303 (0.188)					0.264 (0.192)
Weight in food consumption				-0.022 (0.186)				-0.185 (0.192)			0.436 (0.443)					0.419 (0.442)
Polity 2 index					0.004 (0.005)			0.004 (0.006)					0.020** (0.010)			0.024** (0.011)
Bounds tax rate						-0.001* (0.001)								0.001 (0.001)		
Tariff TRI							-1.548*** (0.403)									-3.413** (1.477)
Constant	-0.537*** (0.233)	-0.527** (0.229)	-0.499** (0.228)	-0.521** (0.244)	-0.411 (0.314)	-0.531** (0.232)	-0.021 (0.303)	-0.287 (0.309)	1.504*** (0.447)	1.512*** (0.445)	1.609*** (0.419)	1.247*** (0.416)	2.090*** (0.558)	0.867** (0.392)	2.986*** (0.826)	2.090*** (0.468)
R ²	0.140	0.187	0.265	0.139	0.144	0.240	0.291	0.272	0.030	0.036	0.069	0.036	0.050	0.056	0.360	0.097
N of observations	106	106	106	105	106	98	93	105	106	106	106	105	106	98	93	105

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Further robustness checks were run and are reported in Appendix 13, Appendix 14, and Appendix 15. In Appendix 13 regressions were run on each cereal taken separately, to account for the possible heterogeneity between crop insulation behaviors beyond the mere dummies of the previous tables. These tables generally confirm the results commented above, although the smaller number of observations makes the coefficients less precise. In particular, the significant impact of the time dummy is found in the case of all three cereals (the only exception being long-term pass-through for rice). Positive income elasticities for the short-term pass-through are observed in the case of wheat and rice. Negative estimates are found for the coefficient corresponding to the weight of the cereal in the food consumption basket (although not always significant). Eventually, the ratio of production over supply is positively correlated with the short-term pass-through (but the coefficients for the excess supply dummy and the interacted term are not significant).

Alternative definitions of the dependent variable were also tested. Appendix 14 displays the regression results using pass-through estimates obtained with first-difference specifications and up to three lags. The outputs are again very similar to Table 9. Eventually the results displayed in Appendix 15 consider pass-through estimated with ECMs accounting for exchange rate variations, or measured with real instead of nominal prices (the international dollar price is deflated by the US CPI while the domestic dollar producer price is deflated by the domestic CPI). Similar conclusions are drawn from these robustness checks.

VIII — CONCLUSION

Economies across the world are not affected similarly by international grain market price fluctuations. Full and immediate price transmission from dominant world commodity markets to domestic producers and consumers is more of an exception than a rule. This can stem from various features, including dispersion of harvest seasons over the calendar year, management of national inventories, import or export restrictions, production subsidies, etc. International commodity price series only crudely proxy the domestic situations.

This article examines in detail the question of price transmission from international grains markets to domestic producer prices over the 44 years between 1970 and 2013 for three major grain products that are central to the question of feeding the world's growing population: wheat, maize and rice.

Building on data from the World Bank and the FAO, we conduct a thorough econometric investigation of the co-integration properties linking the international market price series and the annual domestic producer prices. We find that although the series generally evolve together, some exceptions can be found, thus signaling efficient price insulation from several countries and for some commodities. Interestingly, when dividing the time line into two sub-periods, we observed that co-integration was more difficult to exhibit in the earlier period (1970-1990) than in the latter (1991-2013).

Going further, we applied various estimation techniques (from first-difference to error correction models) to provide robust producer price pass-through estimates that would not be at risk of spurious correlation. On top of reporting more robust producer price pass-through estimates for cereals, over a longer time horizon and for a larger number of countries than the scarce previous studies, this analysis usefully complements the extant literature on consumer price transmission. We emphasize that commodity-specific producer prices are more straightforwardly related to international commodity market prices than are consumer prices indices, due to their higher position in the food processing chain and to the potential for substitution within the consumption basket. We also stress that consumer prices encompass a varying degree of “commodity content”, with raw cereals representing an insignificant portion of the price paid by consumers in developed countries (due to processing or marketing costs) while accounting for most of the cost of feeding oneself in the poorest countries.

In order to confirm the intuition that arose from the co-integration analysis, we adapted the error correction model framework to account for the possibility of a change in pass-through between the earlier and the latter sub-periods. We demonstrated that many countries, especially in the European Union exhibited a significant increase in their short- and long-run pass-through over time, a result that is in line with the strong reforms of the CAP enforced from 1992 onward.

Eventually, we conducted a cross-sectional analysis of the drivers of producer price pass-through. Pooling the estimates obtained for each of the three cereals, and for the two sub-periods, we provide additional proof to the general increase in short- and long-term pass-through in the most recent period. We exhibit a positive and significant correlation between price transmission in the short run and the country's income level which corroborates that richer countries are more integrated into world commodity markets. We also demonstrate that countries that are excess producers tend to be characterized by higher short term pass-through, thus signaling a better integration in world trade for large suppliers. Conversely, we show that countries with a large production deficit tend to have lower producer price pass-through, indicating that they probably implement trade policies to insulate their producers from large international price swings (such as selling out all of the local production before importing what is needed to meet consumption needs). The weight of the cereal in the consumer food basket also proves being significantly linked to producer price pass-through. When a commodity represents a large proportion of the average national calorie intake, countries appear to implement better price insulation at farm-gate. This interesting result highlights significant production side policies to achieve consumer price stability.

CHAPTER 2: AIR TRAFFIC AND ECONOMIC GROWTH – THE CASE OF DEVELOPING COUNTRIES

This chapter corresponds to an article written together with François Bourguignon (PSE)

Abstract

This paper investigates the relationship between air traffic and economic growth in various developing regions and compares it with an “enduring industry fact” of an elasticity around 2 for the developed world. The analysis is conducted from two distinct databases, both with regional aggregates and with country-level ECM estimations. We conclude that there does not seem to be substantial differences in elasticities across the various regions and we show that the introduction of autonomous country-specific time trends leads to a substantial reduction of elasticity estimates.

Keywords: air transportation, panel cointegration, error correction model, GDP-elasticities, development.

JEL Classification: F14, F23, F43, F63, L93

I — INTRODUCTION

Air transportation is both a factor and an indicator of development. On the one hand, it is a factor of progress as it facilitates transportation within extended countries or countries without good land transportation infrastructure and it connects the country with the rest of the world. On the other hand, it is an indicator of development as its volume clearly depends on the level of economic activity as well as on the affluence of the population. Additionally, it may also be an indicator of the structure of economic development as a more outward oriented economy may be associated, other things equal, with more intense passenger or freight air traffic.

As often in economics, it is difficult to disentangle these two roles of air transportation – i.e. a development adjuvant or a service whose demand increases with development – as they most likely are both intimately linked (development and air transportation are clearly endogenous magnitudes). Yet, the observation of the way the volume of air transportation changes with the level and, possibly, the structure of the economic activity might give some useful information on its role in development.

This paper is a simple exploration of the relationship between the development of air transportation and economic growth across different regions and countries in the world. It aims at determining whether developing regions share common patterns despite their different degree of economic development. The methodology thus essentially builds on a systematic comparison of the relationship between air transportation, GDP and some other variables in different parts of the world, both at the region and at the country levels.

The paper relies on two sets of data. The first source is the International Civil Aviation Organization (ICAO) database, which reports annual data on passenger and freight traffic on domestically registered airlines at the country level. The second source is the Airport Council International (ACI) database (proprietary), which reports, over a shorter period, passenger and freight traffic for a number of airports in the world. Those databases and their reliability are discussed in Section II.

The rest of the paper is organized as follows. Section III focuses on the relationship between GDP and air transportation at the aggregate regional level with the two databases. It investigates in particular the homogeneity of that relationship over time and across regions. In Section IV, the analysis is conducted at the country level based on the ACI data. This data source has been preferred to the ICAO database because air traffic is defined there in a less restrictive way, even though it covers less countries and for a shorter period. The estimation of the GDP/air transportation relationship is made under the assumption of the same GDP-elasticity of air traffic across countries within a given region, but possibly some heterogeneity across regions. Robust estimates are obtained using panel co-integration techniques including an error correction specification that allows distinguishing between short-run and long-run effects of GDP growth. A complementary analysis in terms of GDP per capita is conducted to address the development aspect of the issue. The general lessons to be drawn from this exploratory statistical analysis are summarized in a concluding section.

Oddly enough, the literature on air transportation and development is rather limited. Possibly because of market size and data availability, existing economic studies on air transportation tend to concentrate on developed countries, see for instance Smyth and Pearce (2008). Relatively little work seems to have been devoted to developing and emerging countries, and these analyses tend to consider either the industrial organization of the sector, as Goldstein (2001) in the African context, or the business multiplier effects of air transport in the domestic economies – see for instance ATAG (2003). A substantial amount of work has been done to estimate demand models – see in particular the meta-analysis in InterVistas (2007) – but this is generally done at a micro level, i.e. route by route. Ishutkina and Hansman (2009) use the ICAO data to analyze the co-evolution of the total number of air passengers by country and developing region but they stop short of producing GDP elasticities.

Estimates of the aggregate relationship between total air transportation and GDP are generally done on the basis of the ratio between the growth rates of the two magnitudes. This elasticity is generally found to be rather high, typically greater than unity. For instance, Fu et al. (2010) survey the literature and come up with the following key benchmark estimates: 1.75 in the US, according to the US Department of Transport, 1.5 in the UK, and a median elasticity of 1.4 in a set of 12 studies bearing mostly on developed countries, reviewed by Gillen et al. (2008). At the world and regional levels, Swan (2008) reports that per-GDP air travel, which corresponds to the ratio of the volume of air traveling measured in passenger-kilometer divided by the GDP, has increased by 42 per cent²³ in the world between 1990 and 2014. This suggests an elasticity of 1.8, an order of magnitude in line with what the dominant view seems to be among operators. Indeed an IATA economic briefing issued in December 2008, which tried to forecast what could be the impact of the crisis upon air traffic worldwide, stated that “*One enduring industry ‘fact’ (their emphasis) is that traffic grows twice as fast as GDP*”.²⁴ How to interpret this ‘fact’ is unclear, however. As a GDP-elasticity, it is tempting to interpret it as a 1% increase in GDP causes a 2% increase in air transport. But it may also simply convey the view that the autonomous trends of air transport and GDP happen to be in ratio 2:1. This paper intends to distinguish these two points of view and calls for taking this 2:1 ratio with extreme care.

The problem with estimates based on the ratio of growth rates is that they implicitly assume that GDP is the sole determinant of the growth of air traffic. However, one may think of many other determinants, including airfares, the market regulation or the construction of new airports. A methodology that would be more elaborate than taking growth rate ratios or merely regressing the log of air traffic on the log of GDP is clearly called for. For lack of data, the present paper stops short of such an objective. Instead, it relies on a more elaborate specification of the possible relationship between air transportation and GDP that tries to disentangle that relationship from autonomous time trend.

²³ Calculation based on Table 2 in that paper.

²⁴ See also O’Connell (2012). Both the IATA document and O’Connell also suggest that the elasticity is higher in times of recession.

II — AIR TRAFFIC DATA

This paper uses two databases on air traffic. The first source is the International Civil Aviation Organization (ICAO)²⁵ as reported in the free access World Development Indicators database on the World Bank site.²⁶ A big advantage of this source is the period it covers: 1970-2014. Apparently, no other data source covers such a long period in a homogeneous way. Yet this advantage comes with some major restrictions. The most severe one is that only the total (international and domestic) scheduled traffic by the air carriers registered in a given country is reported. In other words, the database only accounts for the traffic handled by 'national' air carriers (or possibly 'domestically' registered subsidiaries of foreign companies), whatever the destination-origin pair serviced by those carriers. For instance, Uganda traffic statistics include Air Uganda passengers, the only airline licensed by the Ugandan Civil Aviation Authority (it ceased operations in 2014). However, it would not include passengers boarding a British Airways flight from Kampala, Uganda to London, UK. On the other hand, it would have included passengers boarding an Air Uganda flight in Bujumbura, Burundi to fly to Nairobi, Kenya, if there had been such a route.

The condition that the air carrier must be registered in a country is important. It means that ICAO statistics on passengers and flights are practically restricted to national companies (or again possibly foreign companies if they have a subsidiary registered in the country). This is not necessarily a problem for countries large enough for at least one national company to be operating at all times, provided it is safe to assume that the market share of national companies in international traffic is approximately constant. This is more of a problem for smaller countries with few air carriers or even only one. There, the addition or discontinuation of a home-based air carrier may cause significant changes in reported air traffic.

In the case of small developing countries, the latter issue is clearly problematic. For instance, Air Uganda was created in 2007 as a substitute to Uganda Airlines, a public company that went bankrupt in 2000. Such events necessarily have a strong impact on the passenger traffic data collected by ICAO: indeed, the reported number of passengers carried for Uganda went down from 179,400 in 1999 to 39,379 in 2000.²⁷ The 2002 failure of the regional company Air Afrique in West Africa is another example of the imperfect coverage of ICAO data. There clearly is no reason to expect that the traffic would become null because of these companies leaving the market. Their market share simply went to foreign companies.

A second restriction of ICAO data is that the public data set only provides the total number of passengers on any flight operated by any airline registered in the country, even though data are probably available by routes and by stages. This simply means that it will only be possible to conduct an analysis on the aggregate traffic (merging together the traffic between a country and

²⁵ Civil Aviation Statistics of the World and ICAO staff estimates.

²⁶ <http://databank.worldbank.org/data/reports.aspx?source=World-Development-Indicators>

²⁷ In July 2014 Air Uganda suspended operations indefinitely. Indeed, the issuer of its license, the Uganda Civil Aviation Authority (CAA), ran into problems after failing a safety audit by the International Civil Aviation Organization. Air Uganda was the only domestic airline licensed by the CAA. Yet, oddly enough, and unlike in 2000, the ICAO database shows only a slight decrease of traffic in 2014.

the rest of the world and the domestic traffic within the country). This is a big difference with other data sources. IATA²⁸ data, for instance, comes by airlines and routes. Yet, those alternative sources also have limitations. IATA data only partially cover low-cost and charter companies. Additionally they are not freely accessible.

The Airport Council International (ACI) source is comparatively less problematic. The data is collected by ACI member airports and gives the count of enplaning and deplaning passengers (with connecting passengers being collected only once). It is possible to distinguish between domestic and international traffic, yet, the data purchased from ACI only corresponds to the total number of passengers and therefore to a very direct measure of air passenger traffic. The difficulty of that database is that the sample of reporting airports varies over time, as more and more airports join the ACI, and new airports are built. Others cease operations or are converted into military airports and are therefore dropped from the sample at some point. Another restriction is that the data covers a much shorter period than ICAO data. To illustrate those two limitations, note that for the period between 1994 and 2013, there are 517 airports with a complete series (spread over 93 countries), while if one restricts the period of observation to 2000-2013, the complete series amounts to 757 airports in 124 countries (see Table 12 below).

Table 12: Description of the three databases provided by the ACI

	Full Database 1994-2013	Balanced Panel 1994-2013	Balanced Panel 2000-2013
Number of years	20	20	14
Number of datapoints (airport x year)	22 702	10 340	10 598
Number of airports in the database	2 190	517	757
<i>of which in Africa (AFR)</i>	241	37	72
<i>of which in W.Asia-Pacific (ASP)</i>	581	47	95
<i>of which in Europe (EUR)</i>	697	243	291
<i>of which in Latin America (LAC)</i>	315	45	105
<i>of which in Middle East/ E.Asia (MEA)</i>	113	13	39
<i>of which in North America (NAM)</i>	243	132	155
Average number of observation per airport	10.4	20.0	14.0
Number of countries in the database	186	93	124
<i>of which in Africa (AFR)</i>	50	20	32
<i>of which in W.Asia-Pacific (ASP)</i>	40	16	21
<i>of which in Europe (EUR)</i>	46	35	39
<i>of which in Latin America (LAC)</i>	36	12	22
<i>of which in Middle East/ E.Asia (MEA)</i>	12	8	8
<i>of which in North America (NAM)</i>	2	2	2

Assuming that for all countries, reporting airports are the most important ones, the ACI statistics should be better at characterizing the actual evolution of national traffic than the ICAO data for small countries where national companies have been operating irregularly. The problem is the representativeness of the sample of airports in the database, especially the sample that corresponds to the 1994-2013 period. For bigger countries, and under the assumption of a somewhat constant market share for domestic airlines, the two databases should show a comparable evolution of traffic. This is less likely to be the case for developing countries.

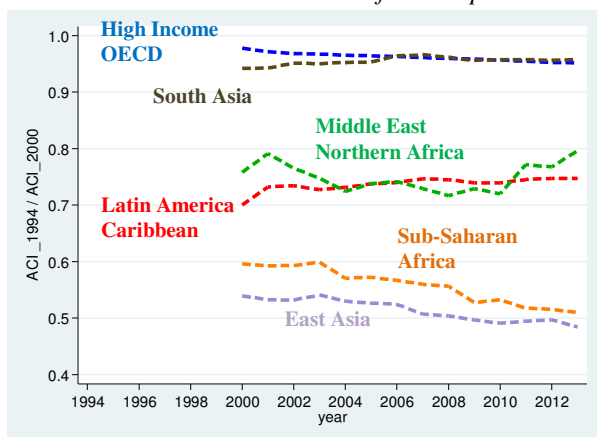
²⁸ IATA is the International Air Transport Association, i.e. the industry's professional association..

Graph 9 graphically compares the results obtained when computing regional aggregates from each of the three balanced dataset (“ACI_2000”, the ACI base of 757 airports over 2000-2013; “ACI_1994”, the ACI base of 517 airports over 1994-2013; and “ICAO_1994”, a balanced version of the ICAO base over 1994-2013).²⁹ The graph on the left (a) plots the ratio of the regional aggregates between the two ACI sets (ACI_1994 divided by ACI_2000). The right graph (b) plots the ratio of the aggregates obtained with ACI_1994 divided by those from ICAO_1994.

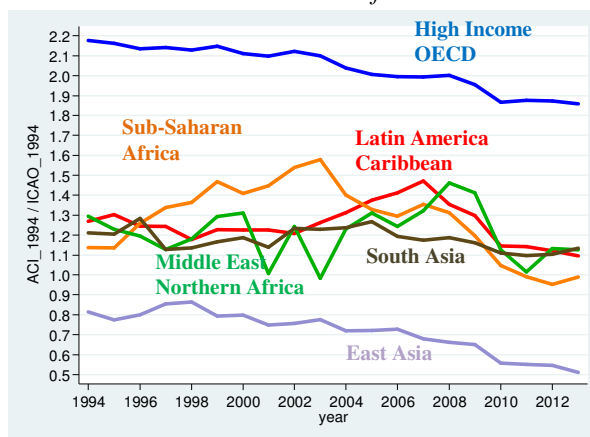
The groupings that are displayed in Graph 9 follow the World Bank definitions.

Graph 9: Comparison of the regional traffic estimates between the three balanced datasets

(a) Regional aggregates: Comparison between the 1994-2013 balanced ACI set of 517 airports and the 2000-2013 balanced ACI set of 757 airports



(b) Regional aggregates: Comparison between the 1994-2013 balanced ACI set of 517 airports and the balanced ICAO set of countries.



Graph 9(a) shows that the relationship between the two ACI sets is rather stable. As more airports are included in ACI_2000 than in ACI_1994, it is not surprising that the ratio be lower than one. Only for Middle-East/Northern Africa do we find a pretty erratic behavior over the period. The slightly declining trend that is observed for East Asia and for Sub-Saharan Africa indicates that some airports which reported over a shorter period did have a stronger growth than others.

Graph 9(b) compares ACI and ICAO aggregates over 1994-2013. It can be seen that the traffic estimates from the two sources are more or less proportional. Graph 9(b) is consistent with the difference of definitions between the two data bases. Because the ICAO data refers to domestically registered airlines, the corresponding volume of traffic in a country is expected to be lower than the traffic reported by the main airports of the country, at least if the coverage of airports is comprehensive enough. This turns out to generally be the case (with the noticeable exception of East Asia). Also the fact that the lines are generally downward sloping would mean that the market share of domestically registered companies tends to increase over time, which seems to make sense. Another explanation could be that the traffic of large newly built airports is not accounted for in the ACI balanced panel data.

²⁹ The only country that is added with a balanced version of the ICAO base over 2000-2013 is Armenia, which does not enter in the composition of the country-groupings under scrutiny. This therefore explains why we only refer to the ICAO set when balanced over 1994-2013.

Another subset of the ACI data will be used in the section of this paper dealing with panels of countries. It consists of the main airports of a country – most often the capital and/or the largest cities' airport. The difference with the data sets reported in Graph 9 is that the resulting panel is unbalanced. A detailed presentation of the construction of this set can be found in Appendix 16, but the main idea is to pick for each country an airport (or a group of airports) with the longest possible time depth and being as representative (in terms of size) as possible. If one is to select one representative airport by country, this selection must be handled with much care as some cities have multiple airports, the traffic of which need to be added to account for the capacity limits. For example, if one focuses on the United Kingdom, the larger traffic is observed in London Heathrow, but other airports help support the traffic growth for the city (Luton, Gatwick, London City Airport...). Secondary airports (which later become primary) are often created to cope with the traffic limitations of the main airport (see for instance the case of Paris: in 1994, both Charles-de-Gaulle and Orly airports were fairly close in terms of traffic – respectively 28.7 and 26.6 million passengers. Yet in 2013, Charles-de-Gaulle represented more than twice the traffic reported by Orly – 62.1 vs. 28.3 million passengers). Additionally with the development of the low-cost industry, some peripheral airports contributed actively to the growth of air traffic.

More expensive databases might give better information on aggregate air traffic than the two just described. As mentioned above, the IATA database is constructed from airline information so that national and regional traffic data is that reported by the companies registered in the country or the region, which may be very different from the actual traffic.³⁰ Other databases collect detailed information on origin-destination flows but they also are incomplete – e.g. low-cost carriers are not recorded – and/or cover only a few recent years, and/or are not freely accessible.³¹

III — AIR TRANSPORTATION AND GDP: AN ANALYSIS BY REGION

This section analyzes the regional aggregates obtained from the three balanced databases. Given the differences in the evolution of the estimates of total regional traffic seen in *Figure 1*, we expect that the ACI and ICAO databases might lead to different conclusions, but the magnitude of the difference still needs to be assessed.

We start with the ICAO database, which offers the advantage of covering a longer time period. Graph 10 shows the evolution of passenger traffic since 1970 by developing region and for developed countries as a whole. The ordinate scale is set in natural logarithms so that the slope of the various curves corresponds to the growth rate of passenger air traffic in the various groups of countries. Three distinct patterns are readily observable. First, the traffic in developed countries is much larger than in any other region – almost three times the traffic in East Asia by

³⁰ See <http://www.iata.org/publications/Documents/monthly-traffic-statistics-specs.pdf>

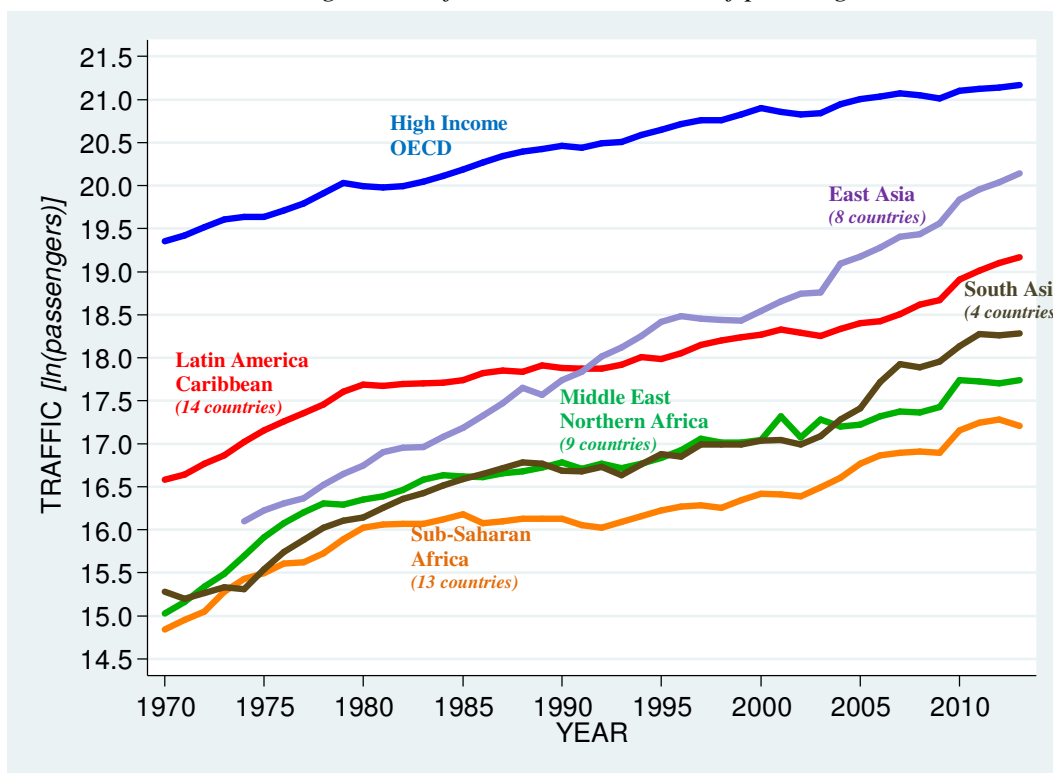
³¹ This is the case of the MIDT (Market Information Data Transfer) database which records all fares going through travel agencies, including airlines' agencies with proprietary data available since 2001. For a list of available data sources and a short critical review of them see Devriendt, L, B. Derudder and F. Witlox, *Introducing a New and Exciting Global Airline Database: 'MIDT', Airlines, e-zine, issue 32, (2013).*

2013 – but its rate of growth is smaller and declining. Second, East Asia appears as the most dynamic region of the world with a practically constant growth rate close to 10% per annum. The evolution of air transportation in the other three regions is similar: a fast increase in the 1970s, followed by a long slowing down – even a stagnation in Sub-Saharan Africa – during the following two decades, and a new acceleration over the past 10 years or so.

Air traffic in a region logically depends on the degree of economic affluence and on the economic activity of that particular region. Quite remarkably, very much of the heterogeneity in the previous figure mimics differences in the time profile of economic growth rates over the last 40 years across regions. In particular, the slowing down of growth in the developing world (leave aside East Asia) during the 1980s and part of the 1990s seems to have directly affected the evolution of passenger air traffic.

Graph 10: Air traffic evolution by regional aggregate (1970-2013)

*ICAO database (balanced for the “passenger” variable over 1970-2013),
Natural logarithm of the annual number of passengers*



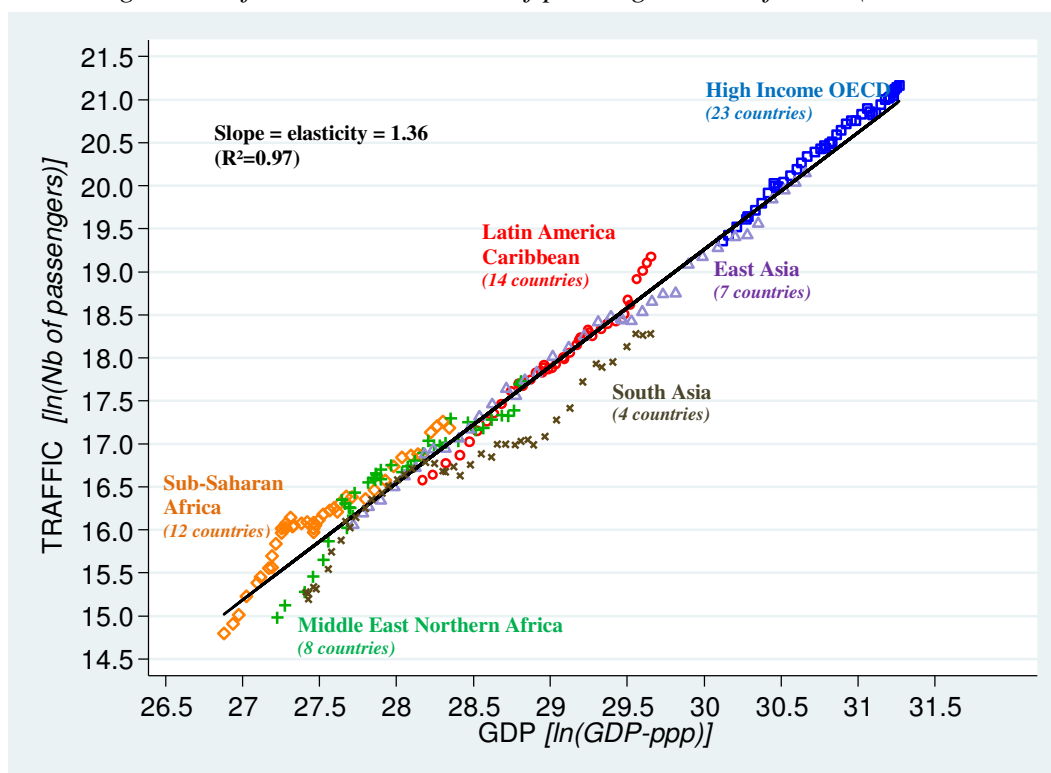
Graph 11 plots the logarithm of air traffic against the logarithm of GDP for the five regional groups of countries considered in the previous figures. The shape of the resulting plots appears much more similar across regions than what could be observed in the preceding chart, even though a clear slowing down of air transportation relative to GDP is still noticeable in the case of South Asia and Sub-Saharan Africa. For the three other groups of countries, Graph 11 exhibits two remarkable features. First, the three scatter plots are quite clearly linear, with a slope that is comparable across regions. Taken at face value, this would mean that the elasticity of air transportation with respect to GDP has been approximately constant over the last 40 years in these three groups of countries. The elasticity may be a bit higher in the case of high income

countries, but, overall it seems to oscillate around a value of 1.35. The second remarkable feature is that the three scatter plots lie approximately on the same line, with clear overlaps between them. In other words, not only does it seem to be the case that the elasticity of air transportation is similar for the East Asian region and high income countries, but the levels of traffic look similar across regions for given levels of GDP. East Asia in 2006 had the same volume of GDP as high income countries in 1970, 36 years earlier, around 12,000 billion ppp-corrected 2011 USD (for roughly 2.5 times more population for East Asia). For this common level of total GDP, air traffic was the same in 2006 East Asia as in high income countries in 1970, around 270 million passengers. Seven years later, in 2013, East Asia has the same total GDP as high income countries in 1984 and, again, the same volume of passenger air traffic. The same may be observed when comparing Latin America and East Asia. The overlap of the two scatter plots in Graph 11 is even much longer.

The GDP-air traffic relationship is much less regular for Sub-Saharan Africa and South Asia. Yet, it is remarkable that, in both cases, there seems to be a tendency for the scatter plots not to diverge permanently from the kind of common path that other regions seem to have followed. Sub-Saharan Africa was close to the common path in the 1970s, then diverged for two decades, but seems to be getting close to it again over the recent years. Likewise, South Asia was for some times on the same path as East Asia (with some lag), then diverged, but is eventually getting back to it.

Graph 11: The relationship between passenger air traffic and GDP by region (1970-2013)

*ICAO database, (balanced for the “passenger” and “GDP” variables over 1970-2013),
Natural logarithm of the annual number of passengers and of GDP (USD-PPP-2011)*

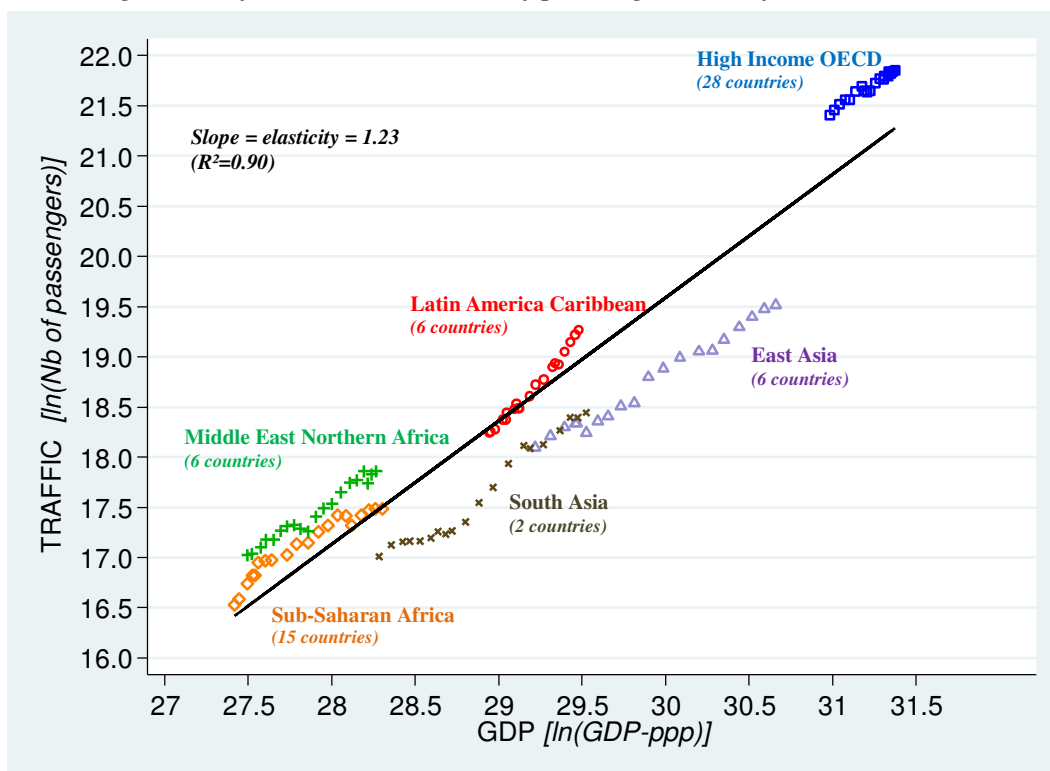


Given what has been said above about the quality of the ICAO data, the idea that all regions follow more or less the same path in terms of the relationship between GDP and air traffic is to be taken with extreme care. On the one hand, it was seen that ICAO data were weak, or at least strongly divergent from ACI data for a region like Sub-Saharan Africa. On the other hand the apparent strong common correlation between passenger air traffic and GDP in *Figure 3* may be very much affected by the strong autonomous time trends behind the evolution of both variables. Yet, the idea of a common path across regions remains an interesting hypothesis that will be formally tested below. It must also be emphasized that what might be true at the regional level might prove wrong at the level of sub-regions and, a fortiori, for individual countries within regions.

A proof that the apparent similarity across regions in Graph 11 may be due to the data, the length of the period and the country composition of regions is provided by Graph 12 which shows the same relationship on the basis of the ACI database (balanced set of 517 airports) on a shorter period and for a different set of countries for each region. Regions appear more heterogeneous in this figure than in the previous one.

Graph 12: The relationship between passenger air traffic and GDP by region (1994-2013)

*ACI database (balanced for the “passenger” and “GDP” variables over 1994-2013),
Natural logarithm of the annual number of passengers and of GDP (USD-PPP-2011)*



The top of Table 13 reports the GDP elasticity of air transportation in the various regions obtained from a linear regression in growth rates when using the complete ICAO database. Such a specification is preferable to a regression in level or in logarithms because of the spurious correlation that may come from the increasing time profile of the two series, even though the consequence is a somewhat imprecise estimation of the GDP elasticity. The average elasticity across regions is around 1.4, roughly the estimate reported in Graph 11. In agreement with the

comments made on that figure, and quite remarkably, the GDP elasticity of passenger air traffic does not appear to be significantly different across regions. This can be easily guessed from the wide overlap of the 95% confidence intervals that can be computed from the standard errors of estimates reported in Table 13 and this is confirmed by a standard Chow test (not reported here). On average, the confidence interval of the elasticity estimate extends from around .5 to 2.3, which includes the 'enduring industry fact' recalled above of an elasticity equal to 2. A second remarkable result in the top of Table 13 is that the autonomous time trend of regional air traffic – i.e. the constant of a regression specified in time variation – is not significantly different from zero. Here, too, however, the interval of confidence of the estimate is quite broad. If it cannot be excluded that the annual trend is zero, it cannot be excluded that it is above 1 percent or even more.

The very bottom of Table 13 is based on the ACI data, the traffic in each country being approximated by the traffic in those airports with complete series over 1994-2013. Because of a shorter time period, and possibly a different data source, the precision of the elasticity estimates is much lower than in the preceding case. Orders of magnitude are generally comparable, but estimates are not significant for Sub-Saharan Africa and the Middle East/North Africa region. The estimated GDP elasticity for South Asia is abnormally high and is compensated for by an abnormally high and quite suspicious negative time trend.

Table 13: Econometric estimates of regional GDP-elasticities and autonomous trend for passenger air traffic in the ICAO and the ACI databases.

ICAO Balanced panel of countries over 1970-2013 - Regional aggregates							
$\Delta(\ln.\text{Passenger})$	World <i>(78 countries)</i>	OECD <i>(23 countries)</i>	Latin America Caribbean <i>(14 countries)</i>	Sub-Saharan Africa <i>(12 countries)</i>	Middle East North Africa <i>(8 countries)</i>	East Asia <i>(7 countries)</i>	South Asia <i>(4 countries)</i>
$\Delta(\ln.\text{GDP})$ <i>(i.e. GDP-elasticity)</i>	1.915*** <i>(0.420)</i>	1.928*** <i>(0.266)</i>	1.440*** <i>(0.285)</i>	1.369** <i>(0.575)</i>	0.769*** <i>(0.245)</i>	1.549*** <i>(0.424)</i>	1.483** <i>(0.636)</i>
Constant <i>(i.e. annual trend)</i>	-0.020 <i>(0.015)</i>	-0.009 <i>(0.009)</i>	0.011 <i>(0.012)</i>	0.009 <i>(0.020)</i>	0.036** <i>(0.014)</i>	-0.012 <i>(0.033)</i>	-0.007 <i>(0.037)</i>
Nobs	43	43	43	43	43	39	43
Adjusted R ²	0.43	0.57	0.39	0.14	0.05	0.12	0.15

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

ICAO Balanced panel of countries over 1994-2013 - Regional aggregates							
$\Delta(\ln.\text{Passenger})$	World <i>(118 countries)</i>	OECD <i>(28 countries)</i>	Latin America Caribbean <i>(15 countries)</i>	Sub-Saharan Africa <i>(21 countries)</i>	Middle East North Africa <i>(8 countries)</i>	East Asia <i>(12 countries)</i>	South Asia <i>(6 countries)</i>
$\Delta(\ln.\text{GDP})$ <i>(i.e. GDP-elasticity)</i>	2.214*** <i>(0.709)</i>	1.788*** <i>(0.472)</i>	1.532** <i>(0.726)</i>	1.544 <i>(1.080)</i>	0.879 <i>(0.963)</i>	1.959*** <i>(0.559)</i>	3.900*** <i>(0.910)</i>
Constant <i>(i.e. annual trend)</i>	-0.033 <i>(0.026)</i>	-0.005 <i>(0.013)</i>	0.015 <i>(0.023)</i>	-0.016 <i>(0.046)</i>	0.019 <i>(0.028)</i>	-0.049 <i>(0.037)</i>	-0.160** <i>(0.058)</i>
Nobs	19	19	19	19	19	19	19
Adjusted R ²	0.45	0.46	0.24	0.09	-0.04	0.16	0.47

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

ACI Balanced panel of airports over 1994-2013 - Regional aggregates							
$\Delta(\ln.\text{Passenger})$	World <i>(83 countries)</i>	OECD <i>(28 countries)</i>	Latin America Caribbean <i>(6 countries)</i>	Sub-Saharan Africa <i>(15 countries)</i>	Middle East North Africa <i>(6 countries)</i>	East Asia <i>(6 countries)</i>	South Asia <i>(2 countries)</i>
$\Delta(\ln.\text{GDP})$ <i>(i.e. GDP-elasticity)</i>	2.008*** <i>(0.325)</i>	1.821*** <i>(0.305)</i>	1.449*** <i>(0.407)</i>	0.606 <i>(0.756)</i>	2.585 <i>(1.565)</i>	1.414** <i>(0.540)</i>	2.927*** <i>(0.569)</i>
Constant <i>(i.e. annual trend)</i>	-0.039*** <i>(0.013)</i>	-0.014 <i>(0.008)</i>	0.013 <i>(0.016)</i>	0.022 <i>(0.043)</i>	-0.061 <i>(0.070)</i>	-0.032 <i>(0.043)</i>	-0.116*** <i>(0.036)</i>
Nobs	19	19	19	19	19	19	19
Adjusted R ²	0.57	0.59	0.37	-0.02	0.14	0.15	0.54

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Note: elasticity estimates are the regression coefficients of the rate of growth of air traffic over the rate of growth of GDP, the constant in that regression being an estimate of the autonomous time trend. NB: to compute the elasticity estimates at the regional level, it was necessary to balance the data accounting for missing observations both in the GDP series and in the traffic series at the country level. The number of countries in each group is thus again different. Standard error in brackets and italics.

A possible reason for these rather aberrant results is the brevity of the period of observation. The effect of brevity is well illustrated in the middle of Table 13, which reports results of regressions run on the ICAO database but over the same period as ACI Data – i.e. 1994-2013. Again, rather aberrant results are obtained for South Asia with a huge GDP elasticity compensated by an equally huge negative time trend. As before the elasticity estimates are not significantly different from zero for Sub-Saharan Africa and the Middle East/North Africa region.

Overall, there is a considerable imprecision in these regional estimates of the GDP elasticity of air traffic to GDP, mostly due to some uncertainty about the coverage of the data – in particular ICAO data when compared to ACI data on the 1994-2013 period – and, for ACI data, the paucity of observations. These constraints make it difficult to test other specifications of the dynamics of the relationship between economic activity and air traffic and to test other possible explanatory variables. With both data bases, it is also the case that regional GDP-elasticity estimates are likely to be very much influenced by the largest countries in regional samples. It is thus sufficient that the data be of dubious quality for one or two large countries for the regional estimates to be severely biased.

A way out of these difficulties, i.e. the paucity of observations and the dominance of large countries in regional samples, is to shift the analysis from the region to the country level, assuming that air traffic in given subsets of countries, and primarily in geographic regions, follows some common pattern. This is the approach adopted in the next section.

IV — ECONOMIC DETERMINANTS OF PASSENGER AIR TRAFFIC: A COUNTRY PANEL ANALYSIS

If they offer the advantage of smoothing measurement error at the country level, aggregate regional data used in the preceding section ignore a huge mass of information at the country level. Analyzing in more detail the way in which air traffic may depend on GDP and other domestic variables requires working with the country as the unit of analysis. When working with ACI data, however, the period of observation is too short to analyze in any detail the full dynamics of the GDP-air traffic dynamics at the country level. Hence the focus of this section on panel data models, which essentially assume that some key coefficients are common to all countries in a regional subset, or possibly worldwide. Being available on longer time periods, ICAO data would theoretically permit a less restrictive specification. Yet, as seen above there are doubts about the time consistency of this database in the case of some countries, in particular in Africa. It will be seen later in this section that these doubts are well grounded.

The standard dynamic panel data model has the following autoregressive form:

$$A_{i,t} = \theta.A_{i,t-1} + \alpha.Y_{i,t} + {}^t\beta.X_{i,t} + v_i + \varepsilon_{i,t}; t \in \llbracket 1; T \rrbracket, i \in I \quad (11)$$

where $A_{i,t}$ stands for the volume of passenger air traffic in country i at time t (in logarithm), $Y_{i,t}$ for the logarithm of GDP, whereas $\mathbf{X}_{i,t}$ represents a vector of additional potential economic determinants of air traffic and $\varepsilon_{i,t}$ the effect of unobservables as well as measurement errors, assumed to be independent of the other variables on the right-hand side of *eq. 11*. The parameters of interest are the GDP-elasticity α , and the β -coefficients that describe the impact of non-GDP determinants. The constant v_i somehow represents the scale/size of passenger air traffic in country i . It is a 'fixed effect' specific to country i , standing for the constant effect of that country's specific characteristics, unlike the coefficients α and β , which are assumed to be common to all countries in the specific grouping I , that defines the panel. Finally the autoregressive term in *eq. 11* allows describing in a simple way the time structure of the effects of the variables on the right-hand side.

It is well-known since Nickell (1981) that the standard fixed effects (FE) approach using OLS with country dummy-variables to account for the fixed effects v_i leads to biased estimates when the number of time observations is limited. This is due to the demeaning of the dependent and independent variables in *eq. 11* through the fixed effects procedure. In a balanced panel and in presence of a large number of panel observations – i.e. countries – the bias in the estimation of θ is negative and, as both $Y_{i,t}$ and $\mathbf{X}_{i,t}$ are likely to be correlated with $A_{i,t-1}$, the estimates of α and β are also biased.

A well-known unbiased alternative to this standard procedure is the Arellano-Bond approach to *eq. 11*, which consists in estimating *eq. 11* in differenced form using a Generalized Method of Moment (GMM) or the system-GMM, which jointly estimates the level and the difference equations. In the present case, however, these methods face a major difficulty, which is that the dependent variable, air traffic, as well as some independent variable, GDP in particular, are most likely to be non-stationary variables, i.e. random walks, stochastic trend processes or so-called I(1) variables. Under these conditions, the Arellano-Bond approach which consists of using level variables to instrument time variations is severely biased. Indeed, this is equivalent to instrumenting stationary variables (time variations) with non-stationary variables (levels). Binder et al. (2005) show that this is also the case with system GMM, even with additional moment conditions. The alternative proposed by these authors is rather heavy to implement, however.

Applying the formal unit-root test to the two main variables of our analysis, the log of air traffic and that of GDP, reveals that indeed for almost all countries the hypothesis of a unit root – i.e. the autocorrelation coefficient being equal to unity – cannot be rejected. This is true using the standard Dickey-Fuller test, but also when it is assumed that the variable contains a deterministic trend and when the lag structure of the underlying stochastic process is assumed to be more complicated – Augmented Dickey Fuller test. The results of the test for each country are displayed in Appendix 17. In the ACI database (130 countries with at least 10 contiguous observations between 1994 and 2013) the ADF tests leads to the dropping of only 12 countries.

1. Co-integration test with panel data

It is easily seen that *eq. 11* above is compatible for I(1) variables only if these variables are co-integrated. To see this, subtract $A_{i,t-1}$ from each side to get:

$$\Delta A_{i,t} = (\theta - 1).A_{i,t-1} + \alpha.Y_{i,t} + {}^t\boldsymbol{\beta}.X_{i,t} + v_i + \varepsilon_{i,t}; t \in \llbracket 1; T \rrbracket, i \in I$$

The LHS of that equation is stationary, which implies that the linear combination of I(1) variables on the RHS must be stationary. This means that $A_{i,t}$, $Y_{i,t}$ and those variables in $X_{i,t}$ which are I(1) must be co-integrated.

In view of this property of the data, a natural approach to estimating the relationship between air traffic and economic variables is to rely on co-integration techniques for panel data. Several co-integration tests for panel data are available in the literature – see for instance the survey by Hurlin and Mignon (2007). In the present case, however, note that the test is not whether non-stationary air traffic and GDP variables are co-integrated within each country but whether they are co-integrated with the same co-integrating coefficients. A simple way of testing the latter hypothesis has been proposed by Kao in the case of two I(1) variables. It consists of regressing one over the other using panel OLS with fixed effects and then testing whether the autocorrelation coefficient of the residuals across countries is low enough to reject the hypothesis of a unit root – see Kao (1999, p.8) or Hurlin and Mignon (2007, p.255).

In fact, Kao (1999, p. 21) proposes a co-integration test that applies to more than two I(1) variables with a deterministic trend, but we present here the argument for two variables. Kao's theorem 4 (p. 22) can be summarized as follows. Let the co-integration equation be in the present case:

$$A_{i,t} = \alpha^*.Y_{i,t} + v_i + \varepsilon_{i,t} \quad (12)$$

Let A and Y be two I(1) variables with deterministic trends, $\delta_i^A.t$ and $\delta_i^Y.t$ respectively. Finally, let $\hat{\varepsilon}_{it}$ be the residual of *eq. 12* when applying OLS with fixed effects. Then, it can be shown that the co-integration unit-root test for $\hat{\varepsilon}_{it}$ has the same asymptotic distribution as the unit root test for testing $\rho = 1$ in the following regression:

$$m_{i,t} = \rho.m_{i,t-1} + \gamma_i.t + v_i + u_{i,t} \quad \text{with} \quad m_{i,t} = A_{i,t} - \left(\frac{\delta_i^A}{\delta_i^Y} \right).Y_{i,t} \quad (13)$$

The intuition here is derived from the property that, in an I(1) series with a deterministic trend, the trend asymptotically dominates the stochastic part. The switch from $A_{i,t}$ to $m_{i,t}$ in *eq. 13* is equivalent to de-trending $A_{i,t}$. Then regressing $m_{i,t}$ on $Y_{i,t}$ and a trend is asymptotically equivalent to regressing the $m_{i,t}$ on a (country specific) trend only. This is because $Y_{i,t}$ is asymptotically equivalent to a trend. The first part of *eq. 13* is thus equivalent to testing the stationarity of the residual of the co-integration equation (*eq. 12*).

Under some general assumptions, Kao (1999, p. 22) gives the asymptotic distribution of $(\hat{\rho} - 1)$. Namely, under the null of no-homogeneous co-integration,

$$K = \frac{\sqrt{N} \left[T(\hat{\rho} - 1) - \frac{\mu}{\pi} \right]}{\sqrt{\frac{2895}{112}}} \Rightarrow \mathcal{N}(0; 1) \quad (14)$$

where:

$$\begin{cases} \mu = \mathbb{E} \left[\frac{1}{T} \sum_{t=1}^T \tilde{m}_{i,t-1} \times u_{it} \right] \\ \pi = \mathbb{E} \left[\frac{1}{T^2} \sum_{t=1}^T (\tilde{m}_{i,t-1})^2 \right] \end{cases}$$

and:

$$\begin{cases} \tilde{m}_{i,t} = m_{i,t} - \bar{m}_i - d_i & ; \quad \bar{m}_i = \frac{1}{T} \cdot \sum_{t=1}^T m_{i,t} \\ d_i = \frac{\sum_{t=1}^T (t - \bar{t}) \cdot m_{i,t}}{\sum_{t=1}^T (t - \bar{t})^2} & ; \quad \bar{t} = \frac{T + 1}{2} \end{cases}$$

Other tests are proposed by Kao (1999) which apply to the t-statistic associated with the estimation of ρ or extend the Augmented Dickey Fuller test. They proved less restrictive than the test above in all the applications developed in the present paper.

2. Applying Kao's test to ACI data

The results obtained with the ACI and ICAO data are summarized in Table 14. This table shows for various regional or economic – i.e. OECD – groupings of countries the number of countries (N) the average number of observation per country (T), the ρ coefficient in *eq.* 13 and the Kao statistic, K in *eq.* 14.

Although covering the same geographical area, the exact composition of the country groupings cannot be constrained to be the same as in the preceding section. Indeed, on the one hand, the panelization that was necessary to aggregate the data regionally in the preceding section is no longer required. On the other hand, the ADF tests on PIB and traffic series lead to the dropping of some countries in this new approach. Another difference with the aggregate regional results lies in the gathering of South Asia and East Asia into a single region. The reason for this is that the tests developed by Kao are asymptotic with respect to the number of countries in a group, and there were too few countries in South Asia for this condition to be approximately satisfied. In this respect, it must be noted that it would have been possible to design other country groupings than those used in this paper, distinguishing for instance between various parts of Africa or between South and Central America. Alternatively, possibly different results might also have been obtained by using various combinations of countries from a geographic region. Some attempts were made in this direction, but no conclusive results came out of the analysis. All countries for which both the log of air traffic and the log of GDP were found to be I(1) were included in their respective region or grouping.

Table 14 shows that the hypothesis of no homogeneous co-integration of the log of air traffic and the log of GDP across countries can be rather safely rejected for the various developing regions, for the OECD countries and even for the whole set of more than 100 countries which passed the ADF test on air traffic and GDP. This is true for both the ACI and the ICAO data over the 1994-2013 period, and also over the whole period 1970-2013 period for the latter. It can be

observed that in all cases, the estimated auto-correlation coefficient ρ is very significantly below unity, which is equivalent to the condition for the stationarity of the residual in *eq.12* and therefore for co-integration.

The panel co-integration test is so uniformly positive in Table 14 that one may worry that it is not discriminatory enough. Although results are not reported here, however, it turns out that some sub-regional groupings do not pass the test. This is the case for instance of the East-Africa region with ICAO data over 1994-2013, despite the fact that the database for that region includes 9 countries. Similarly, Central Asia (4 countries) does not pass the test. As for ACI data, the OECD (22 countries) fails the test, as well as West Europe (16 countries).

It should be noted that the co-integration tests reported in Table 14 refer to two variables only, the log of air traffic and the log of GDP. Kao tests may easily be extended to more than two variables when variables are I(1) with deterministic trends. It turned out that the other variables that could have been taken into account into the analysis were either very close to trends, as it would be the case for population for instance, or themselves stationary as it is the case with the openness of the economy or the terms of trade – see below. Of course, there are also many country characteristics that may explain a different relationship between air traffic and GDP like the size of a country, whether it is an island or whether it exerts touristic attraction. But these characteristics are all included in the country fixed effect present in the co-integration tests.

Now that the panel homogeneous co-integration tests have been satisfactorily passed, it is time to return to our original goal to estimate the dynamics of the relationship between passenger air traffic and GDP on the basis of regional country panels. A convenient way of representing the short-run and long-run dynamics of that relationship, and a way consistent with the co-integration property, is provided by the Error Correction Model (ECM) specification. Formally, this specification writes:

$$\Delta A_{it} = -\phi \cdot [A_{it-1} - \chi \cdot Y_{it-1} - v_i] + \sum_{s=1}^{+V} (\psi_{As} \cdot \Delta A_{it-s}) + \sum_{s=-U}^{+U} (\psi_{Ys} \cdot \Delta Y_{it-s}) + {}^t \boldsymbol{\omega} \cdot \boldsymbol{X}_{it} + \varepsilon'_{it} \quad (15)$$

The term in square bracket corresponds to the co-integration or long-run relationship so that, at any point in time, the growth rate of air traffic compensates part of the observed gap in that relationship, with an 'error correction' coefficient ϕ , which is assumed to be the same across countries. The second term on the RHS stands for the dynamics of that correction, as it introduces some dependency between the current and past growth of air traffic. The following term describes the direct effect of past, present and possibly future changes in the independent variables on the current growth of air traffic. For the co-integration logics to go through, however, it is important that these variables be stationary. The last term before the white noise allows considering variables the levels of which might directly affect the evolution of air traffic on the short run, as well as a deterministic trend. Overall, the dynamics that can be represented by this specification thus seems rather complete.

Table 14: Test of the absence of homogeneous co-integration in regional country panels

ACI 'MainAirports' database 1994-2013

Country groupings	All	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Nb. of countries	118	30	19	27	11	16
Average Nb. of obs.	17.0	18.5	15.4	16.9	17.5	15.8
Rho (ρ)	0.634***	0.804***	0.474***	0.543***	0.617***	0.588***
<i>Standard Error</i>	<i>-0.037</i>	<i>(0.058)</i>	<i>(0.037)</i>	<i>(0.091)</i>	<i>(0.062)</i>	<i>(0.073)</i>
Kao DF ρ -statistic	-12.748***	-3.927***	-6.871***	-7.613***	-4.378***	-4.668***
p-value (2 tails-test)	0.000	0.038	0.000	0.000	0.000	0.000

ICAO database (1994-2013)

Country groupings	All	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Nb of countries	126	29	16	22	14	25
Average Nb of obs.	18.0	18.8	18.5	17.5	16.4	17.7
Rho (ρ)	0.692***	0.750***	0.532***	0.739***	0.509***	0.560***
<i>Standard Error</i>	<i>(0.034)</i>	<i>(0.021)</i>	<i>(0.114)</i>	<i>(0.067)</i>	<i>(0.102)</i>	<i>(0.067)</i>
Kao DF ρ -statistic	-12.049***	-4.868***	-6.853***	-4.006***	-5.971***	-7.558***
p-value (2 tails-test)	0.000	0.000	0.000	0.000	0.000	0.000

ICAO database (1970-2013)

Country groupings	All	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Nb of countries	142	28	21	36	11	25
Average Nb of obs.	34.0	38.2	38.3	32.6	37.8	33.7
Rho (ρ)	0.781***	0.795***	0.865***	0.808***	0.805***	0.758***
<i>Standard Error</i>	<i>(0.025)</i>	<i>(0.021)</i>	<i>(0.040)</i>	<i>(0.031)</i>	<i>(0.003)</i>	<i>(0.025)</i>
Kao DF ρ -statistic	-17.222***	-7.953***	-4.793***	-6.844***	-4.813***	-7.550***
p-value (2 tails-test)	0.000	0.000	0.000	0.000	0.000	0.000

Note: standard errors in brackets and italics, * $p > .1$, ** $p > .05$, *** $p > .01$

The databases are restricted to those countries with at least 10 continuous years of observation, and with $I(1)$ GDP and traffic variables (cf. ADF procedure above).

The main results of the ECM estimation are shown in Table 15 for the ACI database. Two specifications of eq. 15 are reported on that table (with and without time trend). Given the already limited time depth of the series, the regressions only include one lag of the dependent variable ($\forall s > 1, \psi_{As} = 0$). For the same reason, only are contemporary and first lag values of the differentiated explanatory variable (GDP) considered ($\forall s \neq 0 \text{ or } 1, \psi_{Ys} = 0$). The models include two auxiliary variable X: the terms of trade (TOT) as well as the presence and magnitude of political disorders, taken from the Cross-National Time-Series Data Archive, a political science database that was initially launched by A. Banks.³² The variable used in this paper

³² Banks, Arthur S., Wilson, Kenneth A. 2015. Cross-National Time-Series Data Archive. Databanks International. Jerusalem, Israel; see <http://www.databanksinternational.com>

aggregates various dimensions of political disorders, from major protests to political assassinations and civil conflicts.³³ In the present case, it has been normalized to lay between zero and one by dividing it by the largest value in the whole sample.

Other variables describing the countries' economic structures have been tried without success. This has been the case for instance with variables representing the sectoral structure of the GDP or the degree of openness of the economy, assuming that a more open economy would use air transportation more intensively. None of them came out significantly. Note however that, on average over the observation period, this does not mean that they do not play some role in the relationship between air traffic and GDP. Their effect may simply be hidden in the fixed effect coefficients v_i of the panel ECM (eq. 15). For example, the fact that the GDP-export share does not come out significantly in the estimation of eq. 15 simply means that variations in openness during the observation period did not lead to significant changes in the volume of air traffic. This does not necessarily contradict the view that a more open economy may be more intensive in air traffic. Yet, this pure cross-sectional property is not investigated in the present paper.

The second specification in Table 15 simply adds a time trend to the auxiliary variables X. It is expected that such an autonomous source of growth reduces the estimated GDP elasticity of passenger air traffic.

As can be seen from eq. 15 the long-run GDP elasticity of air traffic is given by the ratio of the coefficient of lagged $\ln(GDP)$ and that of $\ln(air\ traffic)$. The corresponding estimates and their standard errors appear at the bottom of the first block – i.e. no time trend specification – of Table 15. Overall, these figures are comparable if not rigorously identical to those obtained in the preceding section on the basis of regional aggregates. The main difference is that they are more precise, even though their standard error is still high in the Middle East/North Africa. In general across regions, the 95% confidence interval lies between 1 and 2. More precisely, the smallest lower bound is reached with Latin America (0.86) and the largest upper bound is for the OECD (2.30). As before, it is worth stressing that, on the basis of these confidence intervals, the long-run GDP elasticity of air traffic does not appear to be different across regions. The ECM specification enables to investigate in more detail the true dynamics of the air traffic/GDP relationship and in particular to distinguish between the short-run elasticity (that is the immediate reaction of air traffic to a variation of GDP) and the long-run elasticity (or in other words, the increase in air traffic when this variation is permanent). Interestingly enough, the figures reported in the “Growth of GDP” row of Table 15 show that the short-run elasticity is quite substantial, as a matter of fact of the same order of magnitude as the long-run elasticity. This holds for all regions, except perhaps in the Middle East and Africa, where the short term elasticity estimate is smaller and less precise. We tested whether the short-term and long term elasticity coefficients were different (cf the “Testing $(\chi - \psi_{Y0}) = 0$ ” row of Table 15), and only for the whole set of 118 countries does the difference come up as statistically significant.

³³ We consider the variable labelled “Domestic09” in the database.

**Table 15: Estimates of the dynamics of the air traffic/GDP relationship
(ECM specification) ACI data 1994- 2013**

Country groupings	All	High Income OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Dependant variable = growth of traffic (Δ Log Traffic)						
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic ($-\phi$)	-0.194*** (0.029)	-0.137*** (0.034)	-0.329** (0.111)	-0.359*** (0.052)	-0.134 (0.080)	-0.197** (0.053)
Lagged Log GDP ($\phi\chi$)	0.324*** (0.042)	0.265*** (0.063)	0.391** (0.134)	0.519*** (0.078)	0.140 (0.095)	0.373** (0.111)
Political Disorder (ω_1)	-0.188 (0.180)	0.186 (0.323)	-0.073 (0.397)	-0.495** (0.147)	0.489 (0.441)	-0.375 (0.272)
Terms of Trade (ω_2)	0.020 (0.025)	0.024 (0.034)	0.050 (0.089)	0.063 (0.053)	0.043 (0.047)	-0.110 (0.091)
Growth of GDP (ψ_{y0})	1.056*** (0.216)	1.708*** (0.128)	1.018*** (0.230)	0.855 (0.491)	0.370 (0.276)	1.707*** (0.284)
Long-run GDP-elasticity of air traffic (χ)	1.668*** (0.118)	1.942*** (0.179)	1.188*** (0.163)	1.444*** (0.117)	1.044** (0.389)	1.893*** (0.151)
Testing ($\chi - \psi_{y0}$)=0	0.613** (0.213)	0.233 (0.201)	0.170 (0.163)	0.589 (0.517)	0.674 (0.466)	0.186 (0.238)
R ² (within)	0.173	0.369	0.249	0.198	0.074	0.308
Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic ($-\phi$)	-0.525*** (0.037)	-0.343*** (0.033)	-0.639*** (0.061)	-0.663*** (0.059)	-0.566*** (0.101)	-0.482*** (0.067)
Lagged Log GDP ($\phi\chi$)	0.459*** (0.073)	0.171 (0.135)	0.470* (0.191)	0.372 (0.236)	0.339* (0.135)	0.650* (0.298)
Political Disorder (ω_1)	-0.145 (0.175)	-0.144 (0.260)	0.811 (0.539)	-0.320 (0.278)	0.208 (0.480)	-0.414 (0.222)
Terms of Trade (ω_2)	0.067* (0.032)	0.215* (0.091)	0.040 (0.081)	0.114* (0.052)	0.043 (0.080)	-0.209 (0.197)
Growth of GDP (ψ_{y0})	0.978*** (0.224)	1.605*** (0.162)	0.807** (0.267)	0.745 (0.561)	0.232 (0.288)	1.611*** (0.314)
Average time trend	1.56%*** (0.37%)	1.39%*** (0.34%)	1.47%* (0.76%)	2.73%*** (0.98%)	1.85%* (0.97%)	0.94% (1.30%)
#neg. Trend // #pos. Trend	13 <0 // 27 ~ // 78 >0	0 <0 // 6 ~ // 24 >0	2 <0 // 11 ~ // 6 >0	2 <0 // 10 ~ // 15 >0	0 <0 // 6 ~ // 5 >0	1 <0 // 14 ~ // 1 >0
Long-run GDP-elasticity of air traffic (χ)	0.874*** (0.157)	0.498 (0.379)	0.736* (0.309)	0.562 (0.347)	0.599* (0.278)	1.348* (0.599)
Testing ($\chi - \psi_{y0}$)=0	-0.103 (0.193)	-1.107** (0.417)	-0.071 (0.141)	-0.183 (0.465)	0.367 (0.253)	-0.263 (0.440)
R ² (within)	0.376	0.488	0.447	0.397	0.338	0.445
Nb of obs.	1887	524	274	428	182	237
Nb of countries	118	30	19	27	11	16
Average Nb of obs.	15.99	17.47	14.42	15.85	16.55	14.81

Standard errors in brackets and italics, * $p > .1$, ** $p > .05$, *** $p > .01$

The ACI database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP and traffic variables (cf. ADF procedure above). In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).

The political disorder and terms of trade variables turned out to be the only variables that had some significant impact on air traffic among the set of additional variables that were tried. Not surprisingly, when significant, political disorders reduce air traffic for a given GDP. Not surprisingly either, over the 1994-2013 period, this variable is significant only in Sub-Saharan Africa, the region most affected by political conflicts. Without time trends, the terms of trade variable is never significant.

The bottom part of Table 15 shows the results of introducing an autonomous and country-specific time trend in the specification of the model. As could be expected, the country-level time trends contribute to reducing the long-term GDP elasticity of air traffic. It is indeed more

than halved when all countries are considered together, as well as in the case of High-Income OECD countries and Sub-Saharan Africa. The drop in the long-run GDP elasticity estimate is accompanied by a sizable increase in its standard error, so that the long-run elasticity is not significantly different from zero anymore for two groups. Although still negative, the impact of the political disorders is no longer significantly different from zero in Africa. The variable does not come out as significant in any of the groupings when a country-specific time trend is accounted for. However, the terms of trade variable is now significant at the 10% level in the OECD and Sub-Saharan Africa, as well as for the set of all available countries. In all three cases, the coefficient is positive, indicating that better terms of trade tend to increase air traffic.

We looked more closely at the content of the country-specific time trends. We report in the table their simple average for each group of countries, and we also provide an indication on their distribution. Indeed, we report the number of countries with a significantly negative trend (“<0”), with a trend non-significantly different from zero (“~”), and with a significantly positive trend (“>0”)³⁴. Except from Asia, the average trends are significantly positive. If one focuses on the country specific trends obtained with the full sample, one can see that they lie between a significant -2.25% for Tonga and a significant 7.10% for Latvia. The BRICs are all associated with a significantly positive trend (point estimates between 3.48% for India and 5.39% for China).

Estimation results obtained with the ICAO database over the period 1994-2013 are shown in Table 16.³⁵ If the long-run GDP elasticity estimates in the top of Table 16 do not appear to be significantly different from those obtained with the ACI data, except perhaps for Latin America, some major differences appear. The first one is the lower level of explanatory power of the ECM in comparison with the preceding table (the only exception being the Middle East/North Africa region). Indeed, the R² statistic, which corresponds to the percentage of the variance within countries explained by the ECM variables, is rather low: it even represents less than 10% for the set of all countries or for Sub-Saharan Africa. Second, some variables lose all significance in some regions, despite their obvious relevance: GDP has no significant immediate impact on air traffic in the case of Sub-Saharan Africa and the Middle East/North Africa; political disorder is no longer significant in the case of Sub-Saharan Africa, although this is probably where it is expected to be have a major negative impact, yet it now plays a significantly negative role in Asia.

The effect of introducing a country-specific time trend in the co-integration equation is also somewhat different from what was observed with the ACI data. Except for Asia, no long-term elasticity is statistically different from zero. Even the short term elasticities lose all significance for Latin America, Sub-Saharan Africa and the Middle East. The time trends themselves are much less often significant.

³⁴ For a given country, the trend estimated with the whole set and that obtained with the regional set needs not be the same. The trend coefficients are deemed statistically significant if their p-value is smaller than 0.05.

³⁵ The model was also tested on the ICAO data over the 1970-2013 period, and the results are presented in *Appendix 3*.

**Table 16: Estimates of the dynamics of the air traffic/GDP relationship
(ECM specification) ICAO data, 1994-2013**

ICAO database starting 1994 (1994-2013)

Country groupings	All	High Income OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Dependant variable = growth of traffic (Δ Log Traffic)						
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic ($-\phi$)	-0.171*** (0.040)	-0.278*** (0.062)	-0.208*** (0.044)	-0.120 (0.070)	-0.324*** (0.070)	-0.209*** (0.032)
Lagged Log GDP ($\phi\chi$)	0.254*** (0.074)	0.421*** (0.111)	0.416*** (0.070)	0.206 (0.162)	0.487*** (0.078)	0.387*** (0.068)
Political Disorder (ω_1)	-0.141 (0.177)	1.100 (0.835)	-0.312 (0.586)	-0.197 (0.374)	0.253 (0.193)	-0.527*** (0.071)
Terms of Trade (ω_2)	0.025 (0.041)	0.078 (0.065)	0.080 (0.096)	0.035 (0.099)	-0.090 (0.048)	-0.030 (0.032)
Growth of GDP (ψ_{y0})	0.697*** (0.144)	1.299* (0.494)	0.953** (0.314)	0.246 (0.211)	0.201 (0.255)	1.055*** (0.195)
Long-run GDP-elasticity of air traffic (χ)	1.486*** (0.245)	1.516*** (0.202)	1.995*** (0.507)	1.711** (0.630)	1.505*** (0.113)	1.851*** (0.208)
Testing ($\chi - \psi_{y0}$)=0	0.789*** (0.236)	0.217 (0.618)	1.042 (0.605)	1.465* (0.694)	1.305*** (0.311)	0.795** (0.307)
R ² (within)	0.073	0.163	0.194	0.036	0.200	0.173
Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic ($-\phi$)	-0.326*** (0.044)	-0.368*** (0.016)	-0.398*** (0.038)	-0.237* (0.086)	-0.556*** (0.098)	-0.506*** (0.050)
Lagged Log GDP ($\phi\chi$)	0.244 (0.233)	0.136 (0.331)	0.272 (0.306)	0.072 (0.440)	0.305 (0.305)	1.050*** (0.179)
Political Disorder (ω_1)	-0.212 (0.173)	0.524 (0.481)	-0.139 (0.649)	-0.787 (0.471)	0.562* (0.230)	-0.309* (0.128)
Terms of Trade (ω_2)	0.063 (0.070)	0.211 (0.226)	0.287* (0.116)	0.119 (0.117)	-0.087 (0.095)	-0.005 (0.074)
Growth of GDP (ψ_{y0})	0.578*** (0.159)	1.534*** (0.403)	0.541 (0.458)	0.185 (0.267)	-0.080 (0.268)	1.073*** (0.220)
Average time trend	0.58% (0.81%)	1.20% (1.14%)	0.91% (1.15%)	0.02% (0.17%)	2.78% (1.59%)	-1.56%* (0.80%)
#neg. Trend // #pos. Trend	14 <0 // 71 ~ // 41 >0	1 <0 // 21 ~ // 7 >0	1 <0 // 14 ~ // 1 >0	4 <0 // 16 ~ // 2 >0	0 <0 // 10 ~ // 4 >0	9 <0 // 13 ~ // 3 >0
Long-run GDP-elasticity of air traffic (χ)	0.748 (0.644)	0.370 (0.890)	0.684 (0.799)	0.302 (1.782)	0.549 (0.596)	2.074*** (0.331)
Testing ($\chi - \psi_{y0}$)=0	0.169 (0.557)	-1.164 (0.652)	0.143 (0.551)	0.117 (1.641)	0.629 (0.440)	1.001** (0.352)
R ² (within)	0.221	0.247	0.307	0.204	0.312	0.318
Nb of obs.	2137	515	280	362	216	418
Nb of countries	126	29	16	22	14	25
Average Nb of obs.	16.96	17.76	17.50	16.45	15.43	16.72

Standard errors in brackets and italics, * $p > .1$, ** $p > .05$, *** $p > .01$

The ICAO database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP and traffic variables (cf. ADF procedure above). In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).

Based on that comparison of ECM estimates and in agreement with our initial intuition of a lesser quality of the ICAO data due to its focus on nationally registered companies only, we tend to have more confidence in the results obtained with the ACI data. The results obtained with this data and an estimation procedure based on country panels by region confirm the role of economic activity as a determinant of the volume of passenger air traffic. For the various regions considered in this paper, the hypothesis cannot be rejected that GDP and air traffic are

cointegrated variables, each with a powerful trend. When not controlling for this trend, the long-run elasticities of air traffic to GDP are of the same order of magnitude as the aggregate regional estimates reported in the previous section of this paper, but thanks to the panel specification they are more precisely estimated, even though the 95 percent interval remains rather large in several instances. Interestingly enough, the short-run elasticities most often are of the same order of magnitude as the long-run elasticities, so that the impact of GDP on air traffic seems close to being instantaneous. However, things are different when autonomous trends are taken into account, which the aggregate regional analysis failed to identify. In general, allowing for such trends substantially reduces the GDP-elasticity.

The preceding analyses on the relationship between air traffic and GDP are complemented with an investigation of the link between the development level and air transportation. We merely substitute per-capita GDP to the GDP variable in *eq. 15*, assuming that the population variable would be represented by a time trend. The ADF procedure mentioned in the beginning of Section IV (and the results of which are reported in Appendix 17) applied to the per-capita variable leads to the rejection of the same countries plus Guinea. The Kao tests of panel cointegration (for traffic and per-capita GDP) are passed for each sub-region (although only at the 10% confidence level for the Middle-East). The estimation results are displayed in Table 17.

Using Per-capita GDP does not significantly alter the results. One can notice a slight increase in the long-term elasticity coefficients (when no trend is added) or in the trend coefficients (when they are present). This is probably due to the need to account for the population growth trend in the new specification). Another noticeable fact is that the long term elasticity coefficient is no longer significantly different from zero for the Middle-East (with and without trend). The proximity of these results to those obtained with GDP is not really surprising. The population size in most countries is close to a time trend, especially on a less than 20 year period. As GDP per capita also includes a time trend, it can hardly be distinguished from GDP in the preceding regressions.

Table 17: Estimates of the dynamics of the air traffic/GDP per capita relationship (ECM specification) ACI data 1994- 2013

Country groupings	All	High Income OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Kao DF ρ -statistic	-13.669	-2.073	-5.449	-4.998	-1.700	-5.853
p-value (2 tails-test)	0.000	0,038	0.000	0.000	0,089	0.000
Dependant variable = growth of traffic (Δ Log Traffic)						
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic ($-\phi$)	-0.138*** (0.039)	-0.151** (0.042)	-0.271** (0.089)	-0.217** (0.060)	-0.067 (0.041)	-0.155*** (0.036)
Lagged Log GDP <i>per capita</i> ($\phi\chi$)	0.280** (0.092)	0.353*** (0.092)	0.384* (0.137)	0.446** (0.157)	-0.000 (0.063)	0.373*** (0.084)
Political Disorder (ω_1)	-0.173 (0.172)	0.267 (0.333)	-0.183 (0.364)	-0.475** (0.130)	0.662 (0.458)	-0.445 (0.313)
Terms of Trade (ω_2)	0.061* (0.027)	0.055 (0.044)	0.077 (0.071)	0.054 (0.058)	0.076 (0.045)	-0.093 (0.100)
Growth of GDP <i>per capita</i> (ψ_{ν_0})	1.041*** (0.225)	1.706*** (0.131)	1.061*** (0.236)	0.873 (0.574)	0.079 (0.220)	1.656*** (0.291)
Long-run GDP <i>pc</i> -elasticity of air traffic (χ)	2.039*** (0.204)	2.342*** (0.172)	1.416*** (0.235)	2.056*** (0.329)	-0.001 (0.948)	2.412*** (0.270)
Testing ($\chi - \psi_{\nu_0}$)=0	0.998*** (0.219)	0.636** (0.210)	0.355 (0.200)	1.183* (0.592)	-0.080 (0.944)	0.756* (0.316)
R ² (within)	0.142	0.365	0.223	0.114	0.042	0.272
Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic ($-\phi$)	-0.513*** (0.037)	-0.337*** (0.032)	-0.641*** (0.063)	-0.675*** (0.065)	-0.549*** (0.098)	-0.482*** (0.062)
Lagged Log GDP <i>per capita</i> ($\phi\chi$)	0.425*** (0.079)	0.210 (0.132)	0.483* (0.220)	0.488 (0.285)	0.034 (0.133)	0.650* (0.291)
Political Disorder (ω_1)	-0.180 (0.176)	-0.128 (0.261)	0.807 (0.535)	-0.346 (0.286)	0.090 (0.459)	-0.449 (0.237)
Terms of Trade (ω_2)	0.074* (0.032)	0.228* (0.095)	0.038 (0.084)	0.101 (0.055)	0.080 (0.075)	-0.213 (0.200)
Growth of GDP <i>per capita</i> (ψ_{ν_0})	0.920*** (0.218)	1.595*** (0.166)	0.813* (0.285)	0.787 (0.556)	-0.045 (0.214)	1.529*** (0.319)
Average time trend	2.26%*** (0.29%)	1.40%*** (0.27%)	2.02%*** (0.58%)	3.75%*** (0.50%)	3.17%*** (0.63%)	1.84%* (0.91%)
#neg. Trend // #pos. Trend	4 <0 // 15 ~ // 99 >0	0 <0 // 2 ~ // 28 >0	2 <0 // 8 ~ // 9 >0	0 <0 // 4 ~ // 22 >0	0 <0 // 2 ~ // 10 >0	1 <0 // 9 ~ // 6 >0
Long-run GDP <i>pc</i> -elasticity of air traffic (χ)	0.828*** (0.167)	0.623 (0.380)	0.754* (0.342)	0.723 (0.395)	0.063 (0.246)	1.350* (0.593)
Testing ($\chi - \psi_{\nu_0}$)=0	-0.091 (0.182)	-0.972* (0.401)	-0.059 (0.134)	-0.064 (0.474)	0.108 (0.230)	-0.179 (0.442)
R ² (within)	0.371	0.483	0.447	0.404	0.315	0.437
Nb of obs.	1886	524	274	410	199	237
Nb of countries	118	30	19	26	12	16
Average Nb of obs.	15.98	17.47	14.42	15.77	16.58	14.81

Standard errors in brackets and italics, * $p > .1$, ** $p > .05$, *** $p > .01$

The ACI database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP per capita and traffic variables (cf. ADF procedure above). In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).

V — CONCLUSION

This paper tried to estimate the GDP-elasticity of air traffic in developing countries, with the idea of testing whether that relationship is different from what is observed and what is known in developed countries, and in particular this common view of an elasticity around 2.

Two types of analyses were conducted. Looking at regional aggregates, it would indeed seem that the GDP-elasticity of air traffic is rather high – with an average point estimate around 1.4 – and not significantly different across regions of the world. With one data base, it is not even sure that the whole relationship between air traffic and GDP differs across regions. In other words, it cannot be excluded that air traffic in East Asia or Latin America will be the same as in the whole set of developed countries when GDP will be of the same order of magnitude. A limitation of this analysis, however, is the imprecision of all estimates. When point estimates are around 1.4 on average, it cannot really be excluded that actual elasticities are close to 2 or close to 1!

To gain in precision, the analysis was then led at the country level assuming that the relationship between GDP and air traffic would be the same across countries, up to some fixed effect, in the same geographical region. Using panel co-integration techniques and an Error Correction Model specification to estimate the dynamics of the GDP-air traffic relationship, results were found to be consistent with the aggregate regional analysis when excluding the possibility that the relationship could include powerful country-specific autonomous trends. Yet, quite different results were obtained when allowing for such trends. GDP-elasticities of air traffic were much lower, and in several instances not statistically different from zero – but not significantly different from unity either! Substituting GDP with per-capita-GDP does not significantly alter the conclusions.

Based on the data used in this paper, three important conclusions seem to come out. a) There does not seem to be significant differences between developing regions, nor between them and developed countries, in the way economic activity affects air traffic. This is even true for the least advanced countries in Sub-Saharan Africa. b) But, the GDP-elasticity of air traffic seems to be significantly much lower than the commonly held view that it should be around 2, as soon as country specific autonomous time trends are taken into account. A unit elasticity, which would correspond to a rather intuitive economic argument, can certainly not be ruled out. c) The estimates of the present paper are rather imprecise possibly because of the rather imperfect coverage of the data and/or the brevity of the observation period.

The latter conclusion points to the need to improve the kind of analysis pursued in this paper with better data. It is indeed rather surprising that no fully reliable data set on national air traffic for most countries in the world is presently freely available.

CHAPTER 3: MAIN DETERMINANTS OF PROFIT SHARING POLICY IN THE FRENCH LIFE INSURANCE INDUSTRY³⁶

This chapter draws upon: Borel-Mathurin, Fabrice, Pierre-Emmanuel Darpeix, Quentin Guibert Stéphane Loisel (2018). Main Determinants of Profit Sharing Policy in the French Life Insurance Industry. The Geneva Papers on Risk and Insurance - Issues and Practice, 43: 420. <https://doi.org/10.1057/s41288-018-0080-9>.

Abstract

The current low interest rate environment and the entry into force of Solvency II raise question about the stability of the life insurance industry in Europe and the sustainability of traditional insurance products. We use a data-set built from French supervisory reports to investigate the drivers of the participation rates (equivalent to annual yields) served on euro-denominated life-insurance contracts over the period 1999-2013. Our analysis confirms practitioners' intuition on the alignment with the 10-year French government bond; we later analyze the deviation of participation rates from this reference. Our data indicate that financial margins are more strictly targeted than participation. We find evidence that surrenders are fairly uncorrelated with participation, suggesting that other levers are used to monitor them. While higher asset returns can imply better yield for policyholders, riskier portfolios do not necessarily translate into better participation.

Keywords: participation rate, profit sharing policy, life insurance, panel data, regulatory database.

JEL Classification: G22, G11, E21, E49.

³⁶ The opinions expressed in this paper do not necessarily reflect the views of the ACPR. The usual disclaimers apply. The authors are very thankful to An Chen for her thorough reading and discussion of an earlier version of this paper. They wish to thank participants to an internal ACPR seminar, to the 2015 IAA colloquium, and to two anonymous referees for their helpful comments and suggestions. They are also grateful to their colleagues at ACPR for their help in improving the paper. Eventually, the paper benefited from the excellent research assistance of Farida Azzi, and thrilling discussions with Pierre Valade. The remaining mistakes are the responsibility of the authors.

Many life insurance products around the world entail guaranteed rates combined with a profit sharing policy. The guaranteed rates can potentially be of prudential concern depending on their level and length. These features are extremely country-dependent, as they are the result of a combination of legal obligations and competition. In German-speaking countries as well as in Norway or Sweden, the guarantees are similar to a long-term cliquet-type option and create a heavy financial risk on insurers in a low yield environment. Many savings contracts in Asia (e.g. Japan, Taiwan or South Korea) and non-traditional life insurance products in US, such as variables annuities, offer guaranteed rates which may be highly risky. Numerous recent studies draw the attention of the public to the potential threat that a long lasting low interest rate environment could pose to financial stability (Swiss Re, 2012; Hieber *et al.*, 2014; Berdin and Gründl, 2015; Moody's, 2015). Overall, the current context calls for a thorough investigation of the sustainability and regulation of traditional life insurance contracts (see e.g. Schmeiser and Wagner, 2015).

France is characterized by relatively short-term, low guaranteed rates in comparison to other European countries, which makes the participation strategy all the more important and the insurers more resilient. In addition, this policy is often quite flexible for insurers as bonus participation (beyond the technical rate guarantee) is decided at the end of the considered period, after observing the realized risk factors and in some cases the prior decisions of some competitors. This contrasts with certain European countries, like Germany, where insurers are required by law to declare part of the amount of the smoothing reserve depleted at the beginning of the year, in addition to the participation bonus defined in arrears that will be given at the end of the year.

Contrary to interest rate guarantees, the participation strategies used by European life insurers for their euro-denominated savings contracts with profit participation has seldom been studied, partly because life insurance markets are not standardized. Indeed, the legal, fiscal, accounting and regulatory environments do vary from one country to the other: even though Solvency II is supposed to bring more standardization, there will still remain large differences, in particular regarding the way to build the legal reserves used to smooth the financial results. Legally binding minimum profit-sharing rules will also remain asymmetric across countries. Most authors interested in this matter (see Section II) point out that participation strategies depend not only on the present and past performance of the insurers' assets portfolios, but also on policyholders' expectations in terms of performance and regularity, on the characteristics of the insurance portfolio, on the insurer's ability to smooth its financial results, on other insurers' behavior and on the set of substitute products available in the market. However, almost all authors address these issues with simple and *a priori* assumptions on the profit sharing management rules, mainly for valuation purposes. There is a clear lack of empirical literature studying these behaviors both in France and in other countries.

In a context of low interest rates, it is essential for a supervision authority to understand the participation strategies in order to be able to pin down potential vulnerabilities for insurers which would face too stringent a constraint and subsequently struggle to honor their liabilities. In France, given the weight of life insurance in households' total savings, getting a clear picture of the empirical factors explaining the participation rates is all the more important.³⁷

In the present paper, we attempt to bridge this gap by carrying out the first empirical study of participation strategies in the French market with a panel data-set built from the supervisory reports collected by the French insurance and banking supervisor, namely the *Autorité de Contrôle Prudentiel et de Résolution* (ACPR). To the best of our knowledge, no similar study has been conducted in France so far. We follow a classical empirical strategy with econometric regressions. Because participation rates (in French, *taux de revalorisation*) seem to be influenced by economic variables that are common to all insurers, and because stability over time and policyholders' expectations seem to be important, we study the participation rate offered by each insurer compared to a common reference rate for that year. Thanks to various robustness and time-stability checks, this paper is able to produce an objective empirical assessment of the main drivers that impact the participation rates offered by French insurers on their euro-denominated participating contracts. This study provides econometric insight to back or question assumptions that have been made so far after expert judgment, and is pertinent to the consumer protection objectives of the French supervisor.

We further provide empirical evidence of the relative importance of government bond rates, firm's asset return, as well as some other soundness and reserving variables to explain participation rates. As expected, we show that insurers clearly adjust participation rates to the current government bond rates and to the previous participation rates, but they interestingly do so even when the financial performance is above these benchmarks or when investments in equity are more sizeable. Additionally, we identify different steering strategies implemented by different groups of insurers, especially the priority given to stabilizing the financial margin. Our approach also provides counterintuitive results on the relation between surrenders³⁸ and participation rates and enables us to challenge the classical reaction function specified by practitioners to model dynamic surrenders for the overall portfolio. Our final contribution is to analyze the regulatory framework of the French life insurance market by comparing it with other European countries (see e.g. Eling and Holder, 2013).

³⁷ In France in 2013, the mathematical reserves (MRs) for life insurance with participation added up to more than EUR 1.4 trillion, that is about 70% of the French gross domestic product (<http://acpr.banque-france.fr/publications/rapports-annuels/chiffres-du-marche-francais-de-la-banque-et-de-lassurance.html>).

³⁸ An official general definition of *surrenders* is provided in the delegated acts of the Solvency II Directive (see Commission européenne (2015), p.21), yet a proper definition of *lapse* could not be found. In the academic literature on life insurance, both terms are broadly used as synonyms (see Eling and Kochanski, 2013). In the context of this article, for clarity reasons, we choose to use exclusively the word *surrender*, which we define as the policyholder's decision to fully or partially terminate his policy and withdraw the corresponding surrender value.

The chapter is organized as follows. Section II provides a synthetic review of the related literature in insurance, and extends it to other fields of research with potentially useful models. We briefly describe the French regulatory context in Section III. In Section IV, we introduce the database, define and characterize the most relevant variables, and provide a first attempt to graphically analyze the information contained in the data. In Section V, we develop the econometric models that are tested in Section VI. Section VII concludes.

II — LITERATURE REVIEW

Some authors, like Grosen and Jørgensen (2000), Hansen and Miltersen (2002) or Ballotta *et al.* (2006) address the fair value of savings contracts. Other authors like Planchet and Thérond (2007), Bauer *et al.* (2006) and Hainaut (2009) consider risk management or asset-liability management and make assumptions on participation strategies.

Participation rates are expected to be strongly related to three interconnected insurer's objectives: its own profits, return stability and customer loyalty.

Asset returns and average term interest rates naturally remain very important explanatory variables for participation strategies in empirical studies (see Gandolphe, 2014), in theoretical approaches directly linked to asset returns (see Bacinello, 2001), or when one monitors a kind of stability reserve like in Grosen and Jørgensen (2000) because the evolution of this reserve is strongly influenced by present and past asset returns and interest rate levels.

Regularity often becomes an optimization objective in the literature: Planchet and Thérond (2007) show that participation rates are less volatile in the presence of a dynamic strategic asset allocation than with a static one. In Grosen and Jørgensen (2000), Bauer *et al.* (2006) and Gerstner *et al.* (2008), one or several reserves are used to meet this smoothing objective.

The way customers may react to irregular participation rates or to a decreasing trend is very important for the insurer. Due to the lack of available data, most French authors like Planchet and Thérond (2007) assume that surrender rates depend on a static and a dynamic component. The dynamic part either follows the specifications given by experts or depends in a simple manner on the difference between the offered rate and the “market rate”. Of course, it is very challenging to define this “market rate” or the policyholders' expected rate. Policyholders' behavior in life insurance and mass surrender risk have been analyzed by Milhaud *et al.* (2010), Loisel and Milhaud (2011) and in numerous actuarial dissertations (see e.g. Eling and Kochanski, 2013).

These approaches do not adequately take into account the specificity of the French market, namely the discretionary feature of the participation strategy. We shall present French regulatory framework specificities in Section III to better explain and motivate our empirical strategy and results.

Given the importance of the regulatory environment for the life insurance industry, as well as its national specificities, we provide in this section some stylized facts about the legal and contractual rules that apply to life insurers operating in France.

1. Contracts and their specificities

The French market is mainly segmented into euro-denominated and unit-linked contracts. In our investigation, we focus on individual euro-denominated contracts. This section briefly describes the main characteristics of French euro-denominated contracts.

Euro-denominated contracts in their purest form are savings products with guaranteed capital. The money collected by the insurer is invested in the financial markets, and the French law imposes that at least 85% of the net financial income and 90% of the net technical income be redistributed to policyholders (see article A.331-4 of the *Code des Assurances*). This legal profit-sharing mechanism applies globally at the fund level. However, much leeway is given to the insurer with respect to the timing of the distribution: it can either be distributed immediately (more precisely at the end of the year during which the benefits were recorded), or endowed in a smoothing reserve (*Provision pour participation aux bénéfices*, see 2), with the obligation to distribute it within eight years (see article A.132-7 of the *Code des Assurances*).

The mathematical provisions are computed using a technical interest rate (*taux technique*) which is bounded by the *Code des Assurances* (see article A.132-1) to a maximum of 75% of the semi-annual average of French sovereign bonds at the date of subscription for the first eight years, and a maximum of 60% of this rate afterwards.³⁹ The interest paid to policyholders cannot be less than this technical rate, which can therefore be considered as a guaranteed rate of return over the coverage period of the contract. Over the past decade, in a context of decreasing yields, most contracts were set or renegotiated with a technical rate of zero (see Darpeix, 2016).⁴⁰ This guarantee thus became synonymous with the capital guarantee, although old contracts still in the portfolio remain a matter of concern. What we call “participation rate” in this article is the sum of the technical interest and the “pure” participation distributed (thus equivalent to a yield on life insurance products).

On top of this regulatory minimum, the insurer can contractually guarantee a given level of profit-sharing (*taux minimum garanti*) as a commercial argument (see articles A.132-2 and A.132-3 of the *Code des Assurances*).⁴¹ Until the *Arrêté du 7 juillet 2010*, the Code read that these minimal guaranteed rates could be fixed for several years, or revised annually, with an

³⁹ Note that we indicated the current binding constraint, but the *Code des Assurances* stipulates that after eight years, the technical rate is also subject to an upper limit of 3.5%. These limits were set in their current form in 1995.

⁴⁰ As of 2014, 75% of mathematical provisions for individual euro-denominated life insurance products were associated with a 0% technical rate, and 84% had technical rates lower than 1%.

⁴¹ Other contractual mechanisms exist (e.g. promotional rates) but the *taux minimum garanti* is clearly the most common.

upper bound equal to 85%⁴² of the insurer's average return on assets over the previous two years. The guarantee could also vary according to a financial reference, but for no more than eight years. Since 2010, the guaranteed rates can only be offered on an annual basis (*Taux minimum annuel garanti*) and are limited to 80% of the insurer's average return on assets over the previous two years.⁴³ Note that the prudential reports do not provide standardized information on the contractual guarantees, which prevents us from investigating the impact of this optional constraint on the participation strategy.⁴⁴

In the end, it may seem that the rates served to the policyholders are fairly constrained, with minimal profit-participation to be given, and multiple limitations in terms of the guarantees that can be provided. However, the inter-temporal smoothing through the dedicated reserves and the legislative limitations to the guarantees offered to the policyholders makes the profit-sharing mechanism rather discretionary in the French market.

Importantly, the legal minimal profit-sharing rules are in no way applied on a contract by contract basis. In addition to the discretion in the timing of the distribution, there is indeed significant regulatory leeway in the allocation of the profit participation across the contracts in the portfolio. Some groups of contracts can be particularly favored (as they include contractual profit-sharing clauses, for instance), while others might receive relatively limited participation (e.g. because the policyholders are deemed very unlikely to surrender). These features could not be captured with the prudential data we used as they are not granular enough.

2. Reserves

Two types of legal reserves can significantly impact the financial returns used to determine the legally binding minimum amount of profit sharing in the French context.

Provision pour participation aux bénéfices (PPB, the French profit sharing reserve). The relationship between the PPB and the participation rate is fairly mechanical since the PPB is depleted in order to increase the participation rate and *vice versa*, following the ideas of Grosen and Jørgensen (2000). The primary goal of the PPB is to smooth the variations of the participation rate. It thus acts as a buffer stock, and its variations should theoretically be uncorrelated with the variable it smooths. However, the stock gives a good indication of the insurer's ability to face bad years in the future.⁴⁵

In France, **asset reserves** usefully complement the historical value accounting. This overall system pushes firms to buy interest rate products and hold them to maturity. In addition to the PPB, three asset reserves are used to steer the aggregate financial results: the *provision pour risque d'éligibilité* (PRE), the *provision pour dépréciation durable* (PDD) and the *réserve de*

⁴² Before 1995, this limit was 90% [Arrêté du 28 mars 1995, JORF n 83 du 7 avril 1995, entrée en application au 1^{er} juin 1995].

⁴³ Other limitations were included in 2010, with references to the maximal technical rate and the average rate served to the policyholders over the previous two years.

⁴⁴ The C21 tabs of the prudential reports are used by controllers to investigate each firm's guarantees, but this information is not standardized and therefore not necessarily comparable between firms at the macro-level.

⁴⁵ Article A.132-7 of the *Code des Assurances* imposes that the amounts stored in the PPB be released within eight years.

capitalisation (RC). The PRE is an overall provision that is endowed when the amount of unrealized capital losses over the entire portfolio exceeds a given threshold. The mechanism is quite similar for the PDD, but at the individual asset level and without offsetting (netting). The *réserve de capitalisation* stores the capital gains and losses made on various bond selling.

Over the past 35 years, the fiscal advantages for this type of instrument have eroded substantially. While it would have been interesting to account for the evolution in the taxation regime of life insurance in France, most major changes occurred before the beginning of the period under survey, i.e. 1999.⁴⁶

IV — DATA AND EXPLANATORY VARIABLES

Our objective is to model the participation rate, defined as the average annual yield offered to policyholders on their euro-denominated life insurance contract. The data used in this paper comes from the ACPR. This section explains the different steps taken to build the database, describes the variables of interest and provides a first graphical analysis of the data.

1. Data

This paper is based on a new data set that we build from the regulatory data reported by each French insurance undertaking⁴⁷ to the French supervisor on an annual basis.⁴⁸ This regulatory database mainly contains aggregated accounting data and prudential information gathered for the purpose of the permanent monitoring of the French insurance market. It is used to ensure compliance with the law and to check the undertakings' solvency positions under the Solvency I framework. We use this source to construct indicators at the entity level, since more granular primary data is not directly available. We consider only the undertakings' branches that correspond to individual savings contracts with profit participation.⁴⁹ The source of data, as well

⁴⁶ For instance, the *Contributions sociales* were established in 1990 and did not apply to the life insurance interests before 1997. The tax rate on the accrued interests then came up from 0% before 1996 to 15.5% in 2014, but the largest part of the increase occurred between 1996 and 1998, when the tax rate was already 10%. Similarly, since 1983, contracts that were more than 6 years old benefited from a full income tax exemption. Yet in 1990 this exemption was only granted after 8 years, and in 1998, the full exemption became a reduced taxation at a rate of 7.5%. Since then, the tax brackets have not changed. Consequently, with our database covering the period 1999-2013, we are not able to assess the impact of these major fiscal changes.

⁴⁷ The expression "insurance undertaking" should be understood in its broadest sense, as it includes all the undertakings in the insurance sector that are under ACPR supervision. For the life insurance market, there exist three main French insurance legislation regimes, namely the Insurance Code (*Code des Assurances*), the Mutual Insurance Code (*Code de la Mutualité*) and the Social Security Code (*Code de la Sécurité Sociale*), all regimes falling under ACPR supervision.

⁴⁸ See <http://acpr.banque-france.fr/documents-a-remettre-en-assurance.html> for a description (in French) of the reporting templates. In short, undertakings must submit an annual report including general information, accounting documents (balance sheet, P&L ...) and data for prudential needs i.e. credit, reinsurance, solvency, reserves reports.

⁴⁹ Technically speaking, we consider contracts classified in categories 1 (*Contrats de capitalisation à prime unique*), 2 (*Contrats de capitalisation à prime périodique*), 4 (*Autres contrats individuels d'assurance vie à prime unique*) and 5 (*Autres contrats individuels d'assurance vie à prime périodique*) according to article A.344-2 of the *Code des Assurances*. Note that these categories are only variations on the French individual saving contracts. In the categories 1 and 4, contracts with a single premium are considered, whereas the categories 2 and 5 are dedicated to regular premiums.

as its limitations and the procedure used to build the variables of interest, are precisely described in Appendix 19. The mathematical reserves and the corresponding market coverage both increased steadily to respectively 1,051 billion euros, i.e. 96% of the total market in 2013.

After cleaning the data, we have a sample of 89 entities over a period of 15 years (1999 to 2013). Due to missing data and mergers, we actually observe between 51 (in 1999) and 71 (in 2005) undertakings each year. In total, this corresponds to 936 company-years. The set of entities left aside – either because of size or due to lack of proper data – only represents a small portion of the overall mathematical reserves over the period. Depending on the year, it corresponds to between 1% and 25% of the total mathematical reserves for the scope of interest.

Our data is thus limited to the largest French life insurance undertakings (mathematical reserves larger than EUR 50 million).⁵⁰

The initial data-set is not balanced, for obvious reasons of mergers and acquisitions between firms; neither is the final data-set. To illustrate this point, only 31 undertakings are followed over the entire 15–years period, i.e. they are fully observed over the whole period 1999–2013, have no missing data, no atypical points and undergo no significant mergers or acquisitions.

2. Variables of interest

Our variables of interest are calculated from the entity-level information contained in the annual supervisory reports, i.e. detailed balance-sheet data, P&L data, and other specific complementary information requested by the supervisor for micro-prudential purposes. The vast majority of the insurers in the panel are not listed and we therefore cannot use market data as a supplementary source of information. Table 18 lists the variables, their definitions, their sources and provides summary statistics.

The main dependent variable is the *participation rate* which is calculated from the accounting data. We use a transformed version of this variable, namely the *participation spread* (noted ρ) which corresponds to the departure of the participation rate away from the OAT-10Y yield. The following explanatory variables and controls are tested:

- Policyholders' behaviour is summarised by the surrender rate. Following Milhaud *et al.* (2011) or Eling and Kiesenbauer (2011), one would hypothesize that participation and surrender rate would move in the opposite direction: the higher the participation rate, the lower the incentive to surrender in a given year.
- Soundness variables are used to assess the insurers' robustness. We consider the solvency position (capital ratio), an indication of unrealized capital gains and losses (UCGL) and the amount stocked in the profit sharing reserve (the *Provision pour participation aux bénéficiaires* or PPB). Acting as a buffer stock to smooth participation over time, the PPB is good indicator for the insurer's resilience.

The categories 1 and 4 have different fiscal features. In practice, category 4 is clearly the most important in terms of mathematical reserves and drives the results.

⁵⁰ Note that the final scope excludes the undertakings specialized in providing pension, disability or healthcare insurance (*Institutions de prévoyance*) which are ruled by the *Code de la Sécurité Sociale*.

- The log of the mathematical reserves is used to control for a size effect. Following Lorson and Wagner (2014) and their analysis of the German life insurance market, we expect size to have a direct impact on profitability and repercussions on the amount of profit sharing.
- ALM variables aim to capture the effect of asset management policy. Indeed, the more profitable the assets, the more generous should the participation policy be (see Bacinello (2001) for details). To check this, the gap between asset returns and the OAT-10Y rate, the amount of capital gains use as proxies for assets' management rules, the share of equity (indicator of the investment risk profile) and the financial margin⁵¹ are tracked.
- Aside from the supervisory data, variables capturing the general evolution of the financial and macroeconomic environment are included: according to Planchet and Thérond (2007) and Gandolphe (2014), the OAT rate is expected to have a great impact on the participation rate. Similarly, the 10-year OAT rate is expected to be the main indicator for both the temporal drift and the macroeconomic context. Other economic and financial covariates are considered (e.g. the annual return on the CAC40 index and its annual realized volatility, French GDP growth, French inflation and unemployment rate) but prove less conclusive.

Some descriptive analysis and graphical evidence of the main potential drivers of the observable trend are displayed below. This graphical depiction is motivated by the lack of empirical studies on profit sharing strategies in France, as well as the large differences compared with other European systems. Graph 13 displays the joint evolutions of participation rates, asset returns and OAT-10Y rates. The mean and median participation rates are characterized by a smooth downward trend. They seem to follow the French 10-year bond yield with a lag of several years. This is particularly visible when the government bond rate breaks its trend, as is the case in 2005 for instance. The participation rates are characterized by a low variability around the median. A main aim of ours is therefore to understand how the government bond rates cycles could drive the insurer's profit sharing policy as the series seem to follow parallel trends. Several interpretations of this fact can be proposed. The first one is that insurers use the 10-year government bond as a short term target and consider that, given the duration of their liabilities,⁵² they should serve about the same yield. The second explanation is that the OAT-10Y actually captures the first order financial environment effect, which affects the asset returns, in turn affecting the profits to be shared with policyholders.

On the asset side, both the average and median returns are larger than the OAT-10Y rates, except for year 2002. From Graph 13c, we infer that the asset mix of the insurers allows them to smooth their profits when the government bond rates decrease, as is the case over the period 2008-2013. This can explain the stabilization in the downward drift of the participation rates in 2012 and 2013. For this variable, the causality relationship seems pretty straightforward – it is

⁵¹ Defined here as the ratio of the financial profits not distributed to policyholders relative to the mathematical reserves since the financial products generated by the company can either be stored in the PPB for future use or distributed to the policyholders *via* the participation rate, or be included in the company's financial income (with potential distribution to the shareholders), in analogy with the optimal dividend strategies surveyed in Avanzi (2009).

⁵² This duration is largely driven by the fiscal advantage to policyholders after eight years.

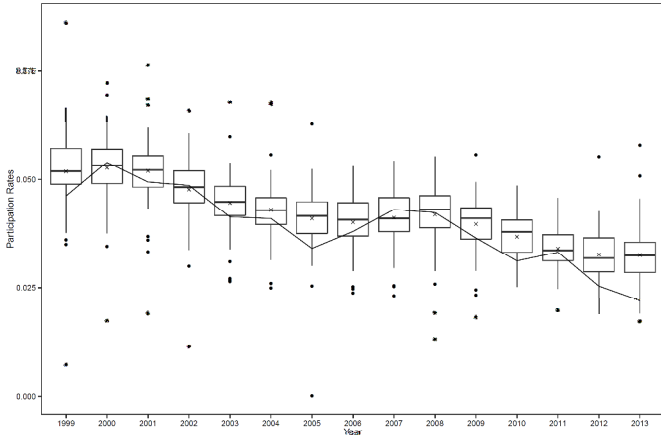
hard to consider that the participation rate, decided at the end of the year, would have an impact on the financial income accumulated over the year.

Forgetting about the trends, if the PPB played its role perfectly, it should vary widely in order to keep the participation rate constant. Indeed, we observe in Graph 13d that the amount of PPB decreases when financial stresses occur in 2001, 2008 and 2011, which is in line with a dampener instrument hypothesis.

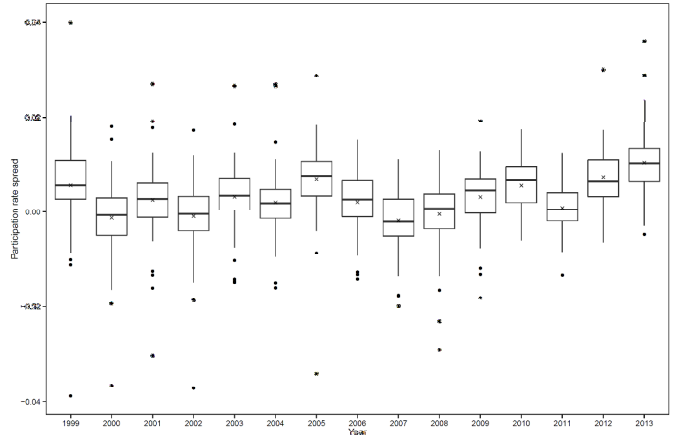
Table 18: Variable definitions and summary statistics.

Variable	Definition	Source	Mean	Std. Dev.	Min. - Max.
<i>Dependent Variable</i>					
Participation Rate (<i>Taux de revalorisation</i>)	Sum of all technical interests and direct participation served on both mathematical reserves and outflows. The rate is computed assuming 1) iso-allotment of premiums and outflows over the year 2) simple interest (not compounded), and 3) 24 fifteen-days periods each year (interests calculated twice a month).	French supervisory reports C1-tabs (P&L)	4.18%	0.95%	0.02% ; 8.61%
Participation Rate Spread ρ	Departure of the firm's participation rate from the corresponding year's French government bond rate (OAT-10Y). A positive value means that the profit-sharing distributed exceeds the safe asset's return.	French supervisory reports C1-tabs (P&L)	+30bps	79bps	-387bps ; 399bps
<i>Soundness variables</i>					
Capital Ratio	Solvency position under Solvency I including subordinated notes.	French supervisory reports C6-tab	2.89	1.60	0 ; 12.04
UCGL Ratio	Amount of unrealized capital gains and losses (UCGL), i.e. the differences between the market values and the net accounting values for all asset classes (real estate, equity, equity mutual funds, bonds, fixed-income mutual funds, loans and deposits) coming from the statement of investments, relative to the investments' net accounting value at the end of the year.	French supervisory reports Balance sheet and N3BJ-tab	5.43%	5.50%	-18.18% ; 38.54%
PPB Ratio (BoY)	Amount of profit-sharing reserve (<i>Provision pour participation aux benefices</i> - PPB) divided by the mathematical reserves, both quantities taken at the beginning of the year.	French supervisory reports C1-tab (P&L)	2.48%	2.44%	0% ; 21.29%
<i>Size variable</i>					
Log. of MRs (BoY)	Natural logarithm of the mathematical reserves (MRs) at the beginning of the year (amounts in million euros).	French supervisory reports C1-tab (P&L)	7.85	1.80	-0.48 ; 12.25
<i>Asset reserves</i>					
PRE Ratio	Amount of PRE (<i>Provision pour risque d'exigibilite</i>) relative to the net book value of all investments at the end of the year.	French supervisory reports C5-tab	0.14%	0.39%	0% ; 3.27%
PDD Ratio	Amount of PDD (<i>Provision pour depreciation durable</i>) relative to the net book value of all investments at the end of the year.	French supervisory reports N101-tab	0.70%	1.00%	0% ; 7.72%
RC Ratio	Amount of RC (<i>Reserve de capitalisation</i>) relative to the net book value of all investments at the end of the year.	French supervisory reports C5-tab	1.62%	1.49%	0% ; 9.72%
<i>ALM variables</i>					
Asset Return	Ratio of the investments' net earnings, i.e. the fixed incomes plus realized capital gains and losses minus the financial management fees, in the life perimeter over the investments' total net accounting value averaged over the year.	French supervisory reports C1-tab (P&L)	4.65%	1.46%	-3.17% ; 11.23%
Asset Returns Spread θ	Departure of the firm's asset return from the corresponding year's French government bond rate (OAT-10Y). A positive value means that the firm's asset portfolio outperforms the safe asset.	French supervisory reports C1-tabs (P&L)	77bps	135bps	-803bps ; 748bps
Capital Gain Ratio	Capital gains relative to the investments' total net accounting value over the year.	French supervisory reports C1-tab (P&L)	1.36%	1.17%	0% ; 9.40%
Equity (perc. of Asset)	Market value of both equities and equity mutual funds at the end of the year relative to the total market value of all classes of assets.	French supervisory reports N3BJ-tab	12.7%	8.40%	0% ; 57.85%
Financial Margin	Investments' net earnings minus the total amount of both the net technical interest and the net profit sharing (distributed and stored). This amount is considered relative to the mean mathematical reserves over the year.	French supervisory reports C1-tab (P&L)	0.49%	1.10%	-4.19% ; 11.85%
<i>Other variables</i>					
Surrender Rate (<i>Taux de rachat</i>) OAT-10Y	Sum of surrender amounts divided by the the mean mathematical reserves over the year. Yearly average of the 10-year French government bond rate (<i>Obligation assimilable du Tresor a 10 ans</i>).	French supervisory reports C1-tab (P&L) Banque de France	5.66% 3.88%	3.02% 0.84%	0.06% ; 32.55% 2.20% ; 5.39%

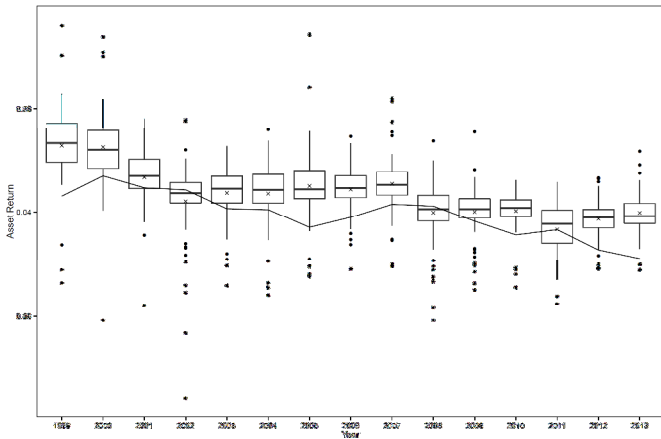
Graph 13: Graphical description of specific variables



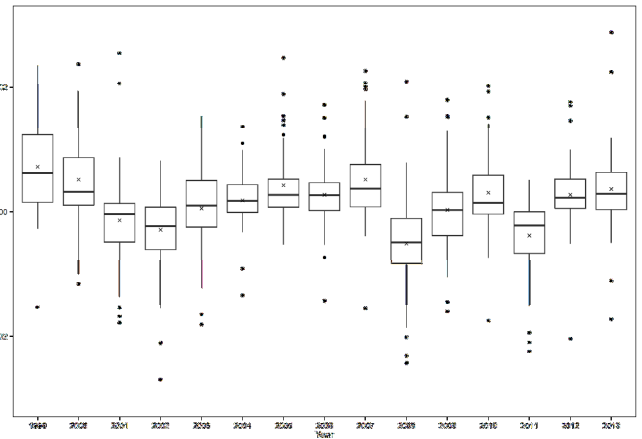
(a) Participation rates.



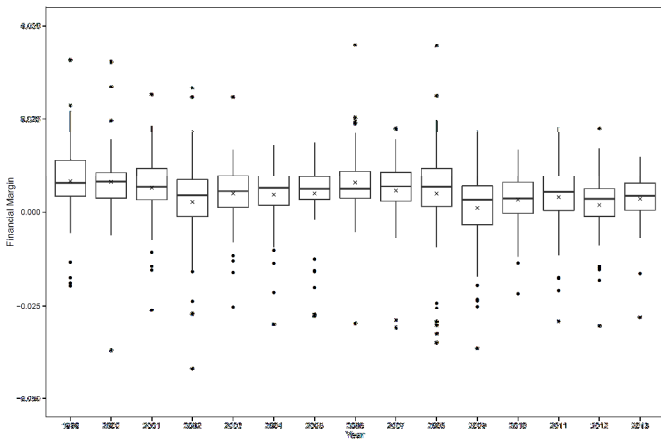
(b) Participation rate spreads: ρ .



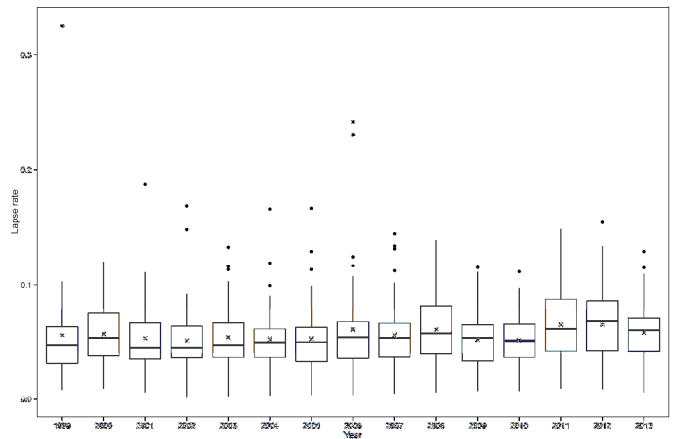
(c) Asset returns.



(d) Changes in PPB ratio.



(e) Financial margins.



(f) Surrender rates.

Note: Boxplots of the (a) participation rates, (b) participation spreads, (c) asset returns, (d) changes in PPB ratio, (e) financial margins, and (f) surrender rates over the period. The two whiskers give roughly a 95% confidence interval. The bottom and top of the box indicate the first and third quartiles, with the black band within the box representing the median, and the cross the arithmetic mean. The black solid line displays the OAT-10Y rates on sub-graphs (a) and (c).

Strikingly, Graph 13e reveals that the average and median financial margins are constant over the period with a small downward adjustment in 2009. Graph 13f plots the distribution of surrender rates over time for our sample of insurers. The average surrender rate is included in the interval [5%; 7%] over the period, with an upward variation in 2006-2008 and in 2011-2012. However, a direct link with the participation rate is difficult to observe at the aggregated level. The rises in surrender rates do not seem to be strongly correlated with participation rates and one can even spot years in which a good participation rate (relative to the OAT-10Y) is associated with a high surrender rate, demonstrating its inability to be neatly forecasted.

Finally, this analysis provides some insights about the main drivers of the participation strategy which we will test in the next sections with deeper econometric analysis.

V — EMPIRICAL STRATEGY

Given the strong relationship between participation rates and the decreasing yield on the 10-year French government bonds, we model ρ – the deviation of the participation rates from the OAT-10Y. Similarly, we consider asset returns relative to the OAT-10Y with the variable θ . In this section, we introduce the different models we estimate, both static and dynamic.

1. The baseline model

Profit sharing policy is quite complex to model as insurers develop multi-criteria strategies across time (Hainaut (2009)). It is clear that various types of strategies can emerge, but it seems reasonable to consider that insurers aim to maximize and/or stabilize their future profits over a specific time-horizon, under solvency and regulatory constraints. Life insurers can use the PPB reserves to smooth future incomes and are encouraged to retain the more profitable contracts within the portfolio (i.e. avoid their surrender). Thus, in a very stylized way, it seems reasonable to consider that insurers may want to maintain a target participation rate as an aggregated control variable. Since the French life insurance market is characterized by low guaranteed rates, one lever for an insurer to control surrenders (and thus reach their target) is to serve competitive participation rates. Another lever may involve certain commercial practices, such as temporary promotional rates on new contracts. A similar specification has been recently proposed by Bonnin *et al.* (2014) in a stylized model for saving contracts as part of the ORSA.⁵³ This participation target can be reached either with financial income (fixed incomes or capital gains) or through adjustments in the level of PPB. In good times, there consequently exists a trade-off between raising the contracts' participation rates immediately and endowing the PPB to release it in the bad years that could follow.

⁵³ Consistently with the Article 45 of the Solvency II Directive, the *Own Risk Solvency Assessment* is a fundamental part of the internal risk management system for an insurer, taking into account its specific risk profile, its risk tolerance and its strategy. This system allows to comply continuously with the Solvency II requirements and to monitor the relevance of the capital calculation model. See also Guibert *et al.* (2014).

To account for this, we specified a baseline model with a latent target participation rate. This latent rate aims at satisfying policyholders' expectations in order to avoid the negative consequences of an increase in surrenders. At a given time t , we assume that the participation rate follows the OAT-10Y plus a target rate spread, and that deviations from this target depend on specific idiosyncratic variables. As this target is not observable, we try to approximate it using the previous analysis and the specifications used by practitioners for valuation purposes which we outline below.

Let $r_{i,t}$ and $r_{i,t}^{ROA}$ represent respectively the participation rate and the return on assets over year t for insurer i . We denote by r_t^{OAT} the average OAT-10Y rate over the same period. We consider $\rho_{i,t} = r_{i,t} - r_t^{OAT}$ the participation rate spread (the excess performance over the OAT yield), as well as $\theta_{i,t} = r_{i,t}^{ROA} - r_t^{OAT}$ the financial performance relative to the OAT. Lastly, let $\rho_{i,t}^*$ be the specific target spread of insurer i .

We introduce the baseline linear model to assess the participation rate spread

$$\rho_{i,t} = \alpha \rho_{i,t}^* + \boldsymbol{\beta}^\top \mathbf{x}_{i,t} + \mu_i + \varepsilon_{i,t} \quad (16)$$

where $\mathbf{x}_{i,t}$ represents a vector of specific control variables (including $\theta_{i,t}$) which can be either known at time $(t - 1)$ or observed during year t . The coefficient μ_i corresponds to the insurer fixed effect and $\varepsilon_{i,t}$ is a random disturbance term of mean 0.

Our intuition is that insurers aim to be as close as possible to their target and the actual deviation is merely explained by unexpected changes in specific indicators. This choice of variable (taking the participation rate's deviation from r_t^{OAT} rather than its absolute value) enables us to somewhat de-trend our data in a way that is natural to asset managers in the insurance industry, knowing the implicit benchmark role of the OAT-10Y. We also include in our regressions the absolute rate of the OAT-10Y as a control variable to make sure we account for the evolution of the macroeconomic and financial context, and to anchor our model in absolute terms. Other observable covariates that could be potential drivers of participation were described in IV.2.

As the target rate references used by practitioners are very close to and highly correlated with the OAT-10Y rate, we first assume a common target rate spread equal to 0, i.e. $\rho_{i,t}^* = 0$. The model we eventually estimate can thus be written

$$\rho_{i,t} = \boldsymbol{\beta}^\top \mathbf{x}_{i,t} + \mu_i + \varepsilon_{i,t} \quad (17)$$

where the vector $\mathbf{x}_{i,t}$ contains $\theta_{i,t}$, r_t^{OAT} and other controls.

We consider different sets of explanatory variables and test both pooled OLS and insurer fixed effect estimators in order to exhibit the main drivers for participation rates.⁵⁴

⁵⁴ See e.g. Baltagi (2013) for a description of classic techniques used for panel data.

2. Dynamic model

In the previous subsection, we assume that the target rate spread is common, and that the level of the participation rate only depends on the OAT-10Y rate. We now want to test a more flexible model where the target at time t also depends on the observed rate spread at time $(t - 1)$. With this specification, our rationale is that policyholders expect participation rates to be smoothed over time and consider the previous rate as an implicit reference. With this assumption, the participation rate at time t depends on the participation rate at time $(t - 1)$. (eq. 16) then takes the form

$$\rho_{i,t} = \gamma\rho_{i,t-1} + \boldsymbol{\delta}^\top \mathbf{x}_{i,t} + \nu_i + \epsilon_{i,t} \quad (18)$$

The model defined by (eq. 18) is a dynamic panel model, which raises some questions about the estimation procedure. As noted by Bond (2002), for dynamic models, the OLS estimator is biased upwards while the fixed effects estimator is biased downwards. A suitable technique with dynamic panel data consists in using a generalized method of moments (GMM) estimator based on the fact that the number of valid instruments grows with t . On top of the pooled OLS and fixed effects estimations, we therefore estimated (eq. 18) via two-steps system GMM.

VI — EMPIRICAL RESULTS

This section presents the main results obtained.⁵⁵ The first subsection focuses on a static model while the second analyzes the econometric results of the more advanced model with a dynamic target rate. We conclude this section with a cluster analysis of profit sharing behaviors. Several robustness and stability checks are proposed in Appendix 20 and in Appendix 21.

1. Econometric analysis with static target rate

Table 19 displays the estimates for the static model (eq. 17) both with pooled-OLS and fixed effects specifications adding the major potential explanatory variables of the participation spread one at a time.

For each model specification, the first column corresponds to the pooled-OLS estimates, and the second one to the fixed effects. We juxtapose both specifications in order to better visualize the fixed effects component. We also examine whether the coefficients of the baseline model are affected by the introduction of additional variables. The estimations appear to be relatively stable in terms of sign and significance.

Unsurprisingly, the assets' excess performance over the year has a positive impact on the participation served end of year. This effect however remains somewhat moderate, as a return on assets one percentage point (100bps) higher than the OAT-10Y implies a participation rate only 15 to 20bps above the French government bonds. Of course, this relates to the insurers' objective

⁵⁵ Computations are carried out with Stata.

to smooth participation over time, and good performance is partially stored in the PPB reserve for future release. Nevertheless, one can question the low level of pass-through for the financial performance.

Table 19: Estimates for the static model.

		<i>Participation Rate Spread $\rho_{i,t}$</i>							
		Model 1		Model 2		Model 3		Model 4	
		OLS	FE	OLS	FE	OLS	FE	OLS	FE
Asset Return	OAT-10Y	0.230*** (0.027)	0.208*** (0.027)	0.202*** (0.026)	0.153*** (0.025)	0.213*** (0.026)	0.151*** (0.025)	0.212*** (0.026)	0.148*** (0.025)
	OAT-10Y			-0.248*** (0.027)	-0.293*** (0.028)	-0.251*** (0.027)	-0.306*** (0.028)	-0.259*** (0.027)	-0.341*** (0.027)
	Surrender Rate					-0.031*** (0.008)	-0.046*** (0.010)	-0.030*** (0.007)	-0.053*** (0.010)
	PPB Ratio (BoY)							0.016* (0.009)	0.067*** (0.022)
	Constant	0.001*** (0.000)	0.001*** (0.000)	0.011*** (0.001)	0.013*** (0.001)	0.013*** (0.001)	0.016*** (0.001)	0.013*** (0.001)	0.016*** (0.001)
	Nobs	936	936	936	936	936	936	936	936
	F statistic	72	58	77	100	56	73	42	69
	R^2	0.16	0.45	0.22	0.52	0.24	0.53	0.24	0.54
	Adjusted R^2	0.15	0.39	0.22	0.47	0.23	0.48	0.24	0.49

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the static models, with both pooled-OLS and fixed effects (FE) specifications. The constants correspond to the mean of fixed effects for FE models. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

The level of the OAT-10Y and the average participation spread move in the opposite direction. This relationship is largely significant, and can be interpreted as a smaller leeway to distribute below the OAT-10Y when the OAT-10Y is itself closer to zero, as participation cannot be negative due to the capital guarantee. The surrender rate consistently comes out as negatively and statistically significantly associated with the participation spread under different specifications. This coefficient is *prima facie* counter-intuitive: it seems to indicate that a higher occurrence of surrenders for a given firm over the year is associated, at the end of the year, with a smaller departure of the participation from the OAT-10Y. In other words, more surrenders would lead to lower participation. While we had hypothesized that insurance executives would have tried to contain the increase in surrenders through a higher participation rate, this appears not to be the case at the aggregate level. As already mentioned, the link between participation and surrenders is not straightforward, although disaggregated contract-level data would be very helpful to empirically explore this issue further.

This result might mean that insurers are not so concerned by surrenders, but it more likely indicates that they manage surrenders at a more granular level than the one we can observe with our data. They indeed have the possibility to increase the participation on contracts they really want to keep in their portfolio while lowering the average participation they serve in aggregate. Commercial strategies can be more efficient than participation policies in containing undesired surrenders and encouraging exit from the contract, or amendment acceptance, for policies that are no longer profitable to the insurer. Yet another explanation would be that surrenders and participation are both linked to the general macroeconomic context, which, when deteriorating,

induces simultaneously more surrenders (emergency funds theory) and lower financial results on the insurers' assets and thus lower participation. Lastly, one could potentially explain the sign of this coefficient with an argument on policyholders' rationality. They could indeed anticipate that given specific constraints, the insurer will not be able to serve a competitive participation, and decide to surrender. However, this does not seem very plausible given what it would imply in terms of financial literacy and knowledge of the insurer's portfolio of assets (see e.g. Arrondel *et al.*, 2013).

Last we consider the level of the profit sharing reserve at the beginning of the period. A higher stock of PPB enables the insurer to serve higher rates. Indeed, this variable is positively and significantly correlated with the participation spread under the fixed effects specification. Good past performances help boost participation. The magnitude however is extremely small, as a higher ratio of PPB relative to Mathematical Reserves by one percentage point is only associated with seven additional basis points on the participation rate.

Additional variables are considered and the results are reported in Appendix 20. In a nutshell, our Model 4 seems fairly robust to the introduction of additional variables (limited omitted variable bias), and might be usefully complemented with the UCGL, RC and asset structure variables. These variables do not add much explanatory power to the model, however.

It is lastly worth emphasizing that the definition of the covariates greatly limits the potentiality for reverse causality. Indeed, the participation rate is decided at the end of year. The annual financial performance, the average OAT-10Y rate over the year, and the surrenders are thus perfectly known at the time of decision. Additionally, we considered the PPB stock at the beginning of the year to avoid the potential endogeneity that stems from the trade-off at the end of the year between distributing the net financial income and endowing the PPB. The four explanatory variables are thus not influenced by the participation rate. This does not preclude the possibility that some variables could be driven by another latent factor, although the OAT-10Y variable seems to properly capture the general effect of the macroeconomic and financial environment.

2. Econometric analysis with dynamic target rate

Table 20 proposes an alternative model to account for the auto-correlation of the participation rate. Unsurprisingly, the lagged participation rate comes out positive and statistically significant in every specification, although the magnitude of the coefficient is slightly eroded as we add more control variables. The coefficients on the common covariates of Model 4 and Model 12 are extremely close. This alternative specification preserves the signs, magnitude and significance of the earlier estimates.

Table 20: Estimates for the dynamic model.

	Participation Rate Spread ρ_{it}																			
	Autocorrelation				Model 9				Model 10				Model 11				Model 12			
	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM		
Lag [Participation - OAT-10Y]	0.547*** (0.046)	0.300*** (0.058)	0.334*** (0.072)	0.457*** (0.043)	0.212*** (0.055)	0.220*** (0.055)	0.451*** (0.041)	0.182*** (0.052)	0.198*** (0.05)	0.442*** (0.041)	0.176*** (0.052)	0.188*** (0.049)	0.444*** (0.041)	0.182*** (0.050)	0.444*** (0.041)	0.182*** (0.050)	0.444*** (0.041)	0.182*** (0.048)		
Asset return - OAT-10Y				0.161*** (0.021)	0.211*** (0.029)	0.191*** (0.028)	0.119*** (0.020)	0.133*** (0.027)	0.135*** (0.027)	0.130*** (0.021)	0.132*** (0.027)	0.143*** (0.028)	0.129*** (0.021)	0.125*** (0.027)	0.129*** (0.021)	0.125*** (0.027)	0.129*** (0.021)	0.146*** (0.028)		
OAT-10Y							-0.241*** (0.023)	-0.282*** (0.024)	-0.285*** (0.029)	-0.242*** (0.023)	-0.292*** (0.025)	-0.283*** (0.029)	-0.254*** (0.023)	-0.331*** (0.025)	-0.254*** (0.023)	-0.331*** (0.025)	-0.254*** (0.023)	-0.300*** (0.030)		
Surrender rate																				
PPB Ratio (BoY)																				
Constant	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001** (0.000)	0.010*** (0.001)	0.012*** (0.001)	0.012*** (0.001)	0.011*** (0.001)	0.015*** (0.001)	0.014*** (0.001)	0.011*** (0.001)	0.015*** (0.001)	0.011*** (0.001)	0.015*** (0.001)	0.011*** (0.001)	0.013*** (0.001)		
Nobs	842	842	842	842	842	842	842	842	842	842	842	842	842	842	842	842	842	842		
F statistic	143	27	.	109	37	.	112	75	.	88	57	.	73	65	.	73	65	.		
R ²	0.31	0.44	.	0.37	0.51	.	0.44	0.58	.	0.45	0.58	.	0.45	0.6	.	0.45	0.6	.		
Adjusted R ²	0.31	0.37	.	0.37	0.45	.	0.44	0.53	.	0.45	0.53	.	0.45	0.55	.	0.45	0.55	.		
Arellano-Bond AR(1) p-value			0.00			0.00			0.00			0.00			0.00			0.00		
Wald-Chi ² p-value			0.00			0.00			0.00			0.00			0.00			0.00		
Sargan test p-value			0.00			0.00			0.00			0.00			0.00			0.00		
Hansen test p-value			0.84			0.85			0.84			0.91			0.84			0.89		

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the dynamic models, with pooled-OLS, fixed effects (FE) and two steps system-GMM specifications. Model 9 captures the participation rate spread dynamic and Models 10-12 consider the effect of additional variables. The results obtained with Model 4 are displayed for comparison purpose. The constants correspond to the mean of fixed effects for FE models.

*p<0.1; **p<0.05; ***p<0.01.

3. Clustering of insurers

As we observe the individual data, several participation patterns seem to emerge. Of course, with only 15 years at hand at most, we cannot be certain to observe a firm line of conduct for the considered undertaking: for many companies, we do not have enough variability to extrapolate an empirical behavioral rule, yet for some of them, it becomes clear that a constant financial margin is targeted, with priority over a smooth participation rate.⁵⁶

We now consider a simple grouping of the companies according to their average financial performance over the period of observation. The idea is to pinpoint those companies which are consistently showing poor asset returns, and see whether their behavior is significantly different from the rest. In line with our previous approach, we consider that poor performances can be characterized by a return on assets lower than the OAT-10Y. We consider a statistic corresponding to the average spread between the assets' returns and the OAT-10Y over the period, $\bar{\theta}_i$, corrected by the standard deviation σ_i^θ . As already mentioned, the number of observations per companies is small and varies from one firm to the other. We therefore need to correct the standard error, and divide it by the square root of the number of observations N_i . In the end, the indicator we use to order the company i according to their financial performances is Γ_i , defined as

$$\Gamma_i = \bar{\theta}_i - \frac{\sigma_i^\theta}{\sqrt{N_i}}$$

We group the firms into four categories:

- In category *A*, we gather all companies for which the statistic Γ is negative (19 insurers and 160 observations). Broadly speaking, those are the firms which, over the period of observation, have performed below the OAT-10Y;
- Category *B* encompasses the companies with a Γ between 0 and 0.5 (28 undertakings for 285 observations);
- The insurers in category *C* have a Γ between 0.5 and 1 (22 companies and 252 observations);
- Category *D* corresponds to the firms that outperform the rest of the market, with a Γ larger than 1 (20 firms and 239 observations). Leaving aside the correcting factor, this means that these companies outperformed the OAT-10Y by more than 100bps on average over the period.

The thresholds are set arbitrarily (except for the zero bound), but it appears that the four groups are rather balanced and enable us to conduct estimations on the sub-samples. Table 21 provides the average participation spread for each group.

⁵⁶ A tentative categorization of strategic “patterns” is explained in Appendix 22.

Table 21: Average participation rate spread over the performance subgroups.

	Panel A	Panel B	Panel C	Panel D
$\bar{\rho}_i$	-0.00101 (0.00078)	0.00328*** (0.00042)	0.00307*** (0.00048)	0.00537*** (0.00041)

Note: This table contains the estimated average participation rate spread for each performance subgroup (Panels A-D) with their robust standard errors in parentheses (White). *p<0.1; **p<0.05; *** p<0.01.

We first look at averages, as we want to see whether the performances on the financial markets translated into heterogeneous participation strategies. The first feature is that all four groups served a participation rate extremely close to the OAT-10Y rate on average over the period, as $\bar{\rho}_i$ lies between 0 and 54bps. Looking more carefully at the two extreme groups, A and D, we see that, on average, those which performed poorly had an aggregated mean performance 65bps below the OAT-10Y and served a participation roughly at the OAT-10Y. On average then, those undertakings gave more to their policyholders than they made on the markets. As for the out-performers, whose aggregated average performance was 160bps above the OAT-10Y over the period, they served 54bps above the OAT-10Y rate to their policyholders. This is particularly peculiar, as the legal framework is not meant to allow for such a gap between financial performances and profit-sharing; even accounting for the option to defer the participation through the PPB, this disconnect should not appear on a 15-year period, given the obligation to release the PPB within 8 years.

Second, we estimate Model 4 for each sub-group. The results of these estimations are displayed in Table 22. Although the signs and significance levels are broadly preserved, the magnitude of the coefficients varies across categories. Indeed, the better performing an insurer, the less important the OAT-10Y in the determination of the participation rate. Still more surprisingly, the performance itself becomes less relevant. Another interesting result concerns the surrender rates, which become insignificant for the poor performers. A similar analysis was conducted with the dynamic model, with similar results.

Table 22: Estimation of Model 4 by performance subgroups.

	<i>Participation Rate Spread $\rho_{i,t}$</i>									
	Model 4 - Entire set		Model 4 - Panel A		Model 4 - Panel B		Model 4 - Panel C		Model 4 - Panel D	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Asset Return – OAT-10Y	0.212*** (0.026)	0.148*** (0.025)	0.239*** (0.061)	0.165*** (0.059)	0.262*** (0.059)	0.233*** (0.053)	0.083* (0.043)	0.072* (0.037)	0.088* (0.052)	0.114** (0.049)
OAT-10Y	-0.259*** (0.027)	-0.341*** (0.027)	-0.248*** (0.083)	-0.471*** (0.082)	-0.261*** (0.052)	-0.296*** (0.051)	-0.369*** (0.052)	-0.360*** (0.048)	-0.182*** (0.049)	-0.253*** (0.055)
Surrender Rate	-0.030*** (0.007)	-0.053*** (0.010)	-0.000 (0.035)	-0.001 (0.046)	-0.054*** (0.015)	-0.103*** (0.019)	-0.043*** (0.013)	-0.003 (0.023)	-0.038*** (0.012)	-0.055*** (0.014)
PPB Ratio (BoY)	0.016* (0.009)	0.067*** (0.022)	0.025 (0.015)	0.078 (0.047)	0.015 (0.015)	0.056* (0.033)	0.037* (0.021)	0.047 (0.047)	0.003 (0.017)	0.055 (0.042)
Constant	0.013*** (0.001)	0.016*** (0.001)	0.009*** (0.003)	0.016*** (0.004)	0.015*** (0.002)	0.018*** (0.003)	0.018*** (0.002)	0.015*** (0.002)	0.013*** (0.002)	0.015*** (0.002)
Nobs	936	936	160	160	285	285	252	252	239	239
F statistic	42	69	8	18	27	39	18	20	7	11
R^2	0.24	0.54	0.27	0.65	0.29	0.56	0.18	0.40	0.13	0.48
Adjusted R^2	0.24	0.49	0.25	0.59	0.28	0.50	0.17	0.34	0.11	0.43

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for Model 4, with both pooled-OLS and fixed effects (FE) specifications over the performance subgroups. The constant correspond to the mean of fixed effects for FE models. *p<0.1; **p<0.05; ***p<0.01.

VII — CONCLUSION

This paper aims at better understanding the main drivers of participation strategies in the French life insurance market. We build a new data-set from confidential regulatory data at the firm level. Our econometric analyses show that the average participation rate is largely determined by the government bond rate as well as by the firm's asset return, and its level of PPB. To the best of our knowledge, we are the first to provide empirical evidence of these phenomena.

In France, profit sharing is essentially discretionary, as most contracts are associated with a 0% technical interest rate. Other guarantees can be contractually offered by insurers as a promotional consideration, but these guarantees are more and more constrained by law, and in any event, the information on these rates cannot be found in the supervisory reports. Unlike other countries,⁵⁷ the minimal yield on life insurance policies is not an absolute legal rate (leaving aside the capital guarantee that corresponds to a 0% guaranteed return). Rather, the law imposes that a fraction of the technical and financial incomes be given back to the policyholders, either directly through the participation rate, or indirectly via a profit-sharing reserve (with 8 years to transfer it to customers). Two limits of the French legislation merit emphasis. First, it is extremely tricky for insurance supervisors to actually ensure that the PPB is indeed released on schedule since money is fungible, and earmarking the profits stored in any given year is not possible. Second, the regulatory framework does not impose an equality of treatment in terms of profit sharing level across groups of policyholders within the same fund, as participation is defined globally at the fund level. The insurer can therefore decide to favor one contract over another. As our database is elaborated at the undertaking level, our results apply to the average participation served by an insurer. Further works based on contract-by-contract investigations might usefully complement this analysis and provide a clearer view on the distribution of participation within an insurer's portfolio.

Our investigations help us highlight different kinds of results, some being counter-intuitive with respect to the usual business modeling for profit-sharing insurance. First we show that, surprisingly, surrenders are not a first order driver of the participation strategies. While our data does not provide a clear illustration, we are led to believe that surrender is monitored by insurer at a much more disaggregated level. Several explanations are proposed and could be explored in further empirical research, which would require individual data. Second, our estimations provide the striking observation that riskier insurers' portfolio allocations (larger shares of equity) lead to less participation.

To check the consistency of our results, we run the model over two sub-periods (time stability) as well as on sub-samples (obtained by splitting the data according to the firms' average financial performance over the period). The results show little variation, yet a graphical

⁵⁷ For example in Germany, life insurance products have high fixed guaranteed throughout the duration of the contract. The main part of the guarantees is attached to this fixed guarantee level set when the contract was underwritten. Indeed, this upper guaranteed level is regulated and is fixed at 60% of the average returns of the 10Y government bonds. From January 1st, the German parliament has decreased the upper bound level from 1.75% to 1.25% for the new business and the future premiums on the ongoing contracts.

analysis enables us to pinpoint heterogeneous strategies: while we know that insurance firms can use their financial margins to manage their participation strategy, we illustrate that some undertakings give priority to smooth margins over smooth participation. Others smooth the rate they serve to policyholders, and others again distribute all out-performances but never serve less than the government bonds (i.e. they absorb the bad performances). Finally, we illustrate that firms also differ in their use of the PPB: some manage it very actively while others do not. A finer typology could be used by supervisors to spot potential misbehavior in the effective profit sharing process.

Some interesting and difficult questions could not be tackled because of the low data granularity. Causality between surrenders and participation rates could not be tested with our data-set, despite the considerable relevance of this question under the Solvency II regime. Lastly, the competitive aspects of the participation strategy appear to be crucial: some additional information on the pacing of the announcements by the undertakings could help enhance this analysis.

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APPENDICES

APPENDIX 1: LITERATURE REVIEW ON THE CONSEQUENCES OF FOOD PRICE SPIKES AND PRICE VOLATILITY

Abstract

Food price volatility has drawn much attention from the international community in the beginning of the 21st century, in the aftermath of the 2008 and 2010 food riots. One strand of the literature aimed at identifying the economic origins of the increased variability of prices (supply shocks, underinvestment in the agricultural sector, financial speculation and increased demand from the emerging markets), while several articles were trying to assess whether there had actually been a change in the volatility regime in the first place.

Yet another strand of the literature focused on the consequences of food price shocks and volatility. This paper provides a comprehensive review of this extensive literature on the impacts of food price shocks and food commodity volatility. The consequences are assessed both in micro- and macroeconomic terms, from the consumer's and producer's sides, as well as from the theoretical and empirical points of view. If the vast majority of studies points to a detrimental impact of food price shocks on the livelihood of many in the developing world, and on potentially dire consequences on production, growth and political stability, this literature review reveals, above all, the lack of proper investigation about the consequences of food price volatility in itself. The hype around the excessive volatility of the food markets did not translate into an academic focus on the consequences of this price instability.

Keywords: Food price volatility, investment, development, human capital, conflicts.

JEL Classification: E20, I15, I25, O24, O40, Q11, Q18, Q34.

Introduction

The primary goal of this paper was to propose an analytical review of the academic literature on the economic consequences of food price volatility: We aimed at understanding why food price volatility was at the root of unprecedented political and humanitarian stakes, and at identifying the mechanisms through which it could transpire in the real economy, especially in developing countries.

One might think that such a broadly defined subject might be confronted with far too large a corpus of academic papers to provide an efficient synthesis, especially given the intense lights that have been shed on the issue over the past decade in the media. Yet it so happens that it did not turn out to be the case, and only did a handful of papers precisely address the consequences of food price volatility. In order to get some more insights on the issue at stake, we were forced to even enlarge our topic so that to include individual food price shocks on the one hand, and macroeconomic volatility broadly defined on the other hand. As such, our paper deals more

broadly about the consequences of food price movements, and do not constrain itself to food price volatility strictly speaking.

Even if price volatility and price shock are theoretically two distinct concepts, it nevertheless makes sense to survey their consequences jointly. Some high volatility episodes actually stem from a succession of price shocks, and getting insights on the way people react to a given price shock can help better understand the impact of price instability.

Price movements are an issue on both the production and consumption sides: The risk that is associated with sudden and unexpected variations of prices (volatility) puts many farmers into difficulty, since they cannot manage to estimate their revenues on the long run in a reliable way, which leads them to limit investment in productive capital, all the more so as credit and insurance are often not available to them. Simultaneously, price shocks, even when predictable, threaten the survival of the poorest, for which food expenditure amounts for an extremely important fraction of their current budget and who often lack access to credit markets.⁵⁸ The survival mechanisms implemented in crisis situations are most likely to involve women and children labor, the interruption of schooling and medical care, as well as a dramatic reduction of the food intake. In economic terms, price shocks often induce a suspension of investment in human capital.

The difficulties that most inhabitants of developing countries face to access international markets (may they be physical, financial or insurance-related), as well as the low level of initial resources are additional factors that magnify their vulnerability. Whether volatility translates into predictable variability or into uncertainty, it presumably induces a strong liquidity risk that limits investment in physical capital, as well as in human capital. It is therefore reasonable to think that food price volatility damages long-run economic growth since it reduces the constitution of productive capital stock, and limits the productivity gains that are traditionally associated with the population's health and education.

Our analysis builds on a very large collection of scientific articles addressing the link between food prices and the economy at large. We believe that limiting ourselves to the rare articles investigating the consequences of food price volatility would have been far too restrictive. We are perfectly aware that volatility and shocks are not overlapping concepts, yet we believe that, in the absence of thorough investigation on the consequences of volatility *per se*, analyses of shocks are the most relevant information available. Put it simply, the response of an economy to a given shock is often the best proxy we have to assess the impact of highly variable prices. Although it is necessary to distinguish between volatility and price levels, it is important to understand that the analysis of a given price shock provides valuable indications of what happens at each positive jump of a price series that is characterized by its great variability.

⁵⁸ See, e.g. FAO (2011): "Furthermore, even perfectly predictable changes in prices can cause problems for poor households that are unable to borrow when prices are high and thus are unable to 'smooth' their consumption over time. Thus, in Asia, where seasonal price changes are relatively more predictable than in Africa, there is still widespread concern over the ability of poor households to cope during the lean season immediately before the harvest, despite the fact that this lean season is very predictable". (p.18)

The impact of financial development initiatives (access to savings pools or insurance) on production and investment decisions, food security, and consumption smoothing has been reviewed in Karlan et al (2016).

We also included in our review articles addressing the impact of macroeconomic variability broadly speaking, as we figured out that omitting them would have led to ignoring part of the scarce information on the way economic instability can affect the economic structure and its performances. Talking about the volatility of commercial situations (may that be reflected by the terms of trade,⁵⁹ by the exchange rate, or by the share of exports in the gross domestic product), or even about the volatility of growth might very well look out of purpose. Yet these phenomena can sometimes be understood as consequences of food price volatility, in large net exporting or importing countries for instance. In the absence of dedicated research on the consequences of food price volatility, these studies can help shed light on the issue.

Eventually, we also included studies investigating the impact of climate shocks on growth or on the formation of human capital, even if they did not consider explicitly the price channel. Indeed, as the climate has a direct influence on the volume of agricultural production (and thus on its price), these studies give us complementary indications on the impact of food price shocks.

Proposed outline:

The neo-classical theories of economic growth consider that the improvement in a society's standards of living is made possible by the accumulation of productive capital on the one hand and by technological progress and productivity gains on the other hand. In the words of Jacks, O'Rourke & Williamson (2009): "Indeed, the development literature offers abundant contemporary microeconomic evidence linking income volatility to lower investment in physical capital, human capital and even research and development."

Along these lines, it appeared logical to organize this paper in the following way: first, we will study the economic theories and the empirical validations that link price volatility to productive investment. Second, we will try to understand why volatility can modify the constitution of the human capital stock (encompassing health, education, or even mere survival), at the root of innovation and technological progress. Last, we will expose the empirical proofs that link volatility to long run economic growth.

1. Impact of volatility on the accumulation of productive capital

a) General theory of investment in a volatile environment

It is rather difficult to conclude about the impact of price volatility on investment in a purely theoretical way. Indeed, considering volatility as the manifestation of an increased macroeconomic risk, one could expect, as explained in Deaton (1992), that the precautionary savings would increase. The increase of savings on its own would induce a decrease in the interest rates (the price of capital), and would thus lead to an increase in the actual realized investment. Nevertheless, it would be a mistake to consider that the accumulated savings would be integrally available on the capital markets. Indeed, precautionary saving aims at constituting a

⁵⁹ i.e. the imports' price level divided by the exports' price level.

buffer that must be quickly usable in case of emergency (if prices do indeed increase). As a consequence, precautionary saving must be liquid, and one can doubt it would feed in the investments in productive capital, illiquid by nature (Timmer, 2002). What is more, the constitution of precautionary saving supposes the ability for firms and households to save, that is to say wages enough above the subsistence threshold, which is obviously not the case for many inhabitants of the least advanced countries.

Additionally, risk in itself has a strong impact on the demand for capital. The classical theory of investment goes that there is a strict trade-off between the return on an investment and its safeness: the less risky the investment, the lower the risk premium so that in expectation and in equilibrium, marginal investors are indifferent between two projects featuring different risk-return features. An important qualification of this theory is that you need to know the probability distribution that rules the payoffs.⁶⁰

In the situation where the investors have convex utility functions (i.e. with risk aversion), they tend to prefer investments with lower but safer returns. A rise in volatility for a given level of overall profitability would therefore induce a reduction in the amount of investment. This phenomenon could be amplified should we consider that economic agents adapt their risk aversion to the general perception of risk (i.e. the risk aversion parameters are endogenous to the aggregate level of risk). In a riskier, more volatile environment, we could observe a systemic decrease in agents' willingness to take on risk, leading to a decrease in the level of available funding.

The volatility increase is problematic for investment for yet another reason: considering the work of Lucas (1973) about the extraction of information from the price signal, Timmer (2002) explains that investment decisions could be blurred by a wrong estimation of long term trends, estimations that are more complicated because of the disorderly movements of prices. In such circumstances, it is not the quantity of investment that is at stake, but rather its quality. Savings still go to capital markets and still are allocated to projects, but not necessarily to the more sensible ones (those whose returns are, *ex post*, the greatest). In his analysis of the links between speculation and food price volatility, Spratt (2013) writes: "The clear need is for prices to accurately reflect real demand conditions, and therefore to send correct signals. Artificially high or low prices send spurious price signals, while excessive volatility distorts these signals: in order to respond to high prices by raising supply, producers need some degree of certainty that price levels will be maintained." This phenomenon could be linked with the recent concerns about current accounts disequilibrium (savings glut): the excess saving is channeled towards investments that are riskier and riskier, and yet do not provide a high yield.

Eventually, it is extremely important to account for the non-linearities and the constraints that characterize investment decisions, such as irreversibility (e.g. for physical investment), or limits to the credit supply that could prevent agents to take full advantage of beneficial situations, and would thus prevent them to cover the risk of negative states of the world (Aizenman & Marion,

⁶⁰ cf. the distinction introduced by Knight (1921) between risk and uncertainty: in the former, the economic agents are able to distribute objective probabilities on the different states of the world; in the latter, they are not able to do so.

1999). These constraints are particularly present in countries where markets are not sufficiently developed, or where the sovereign risk is high. Easterly et al. (2000) show for instance that the development of financial markets is the major contributing factor to the reduction of growth volatility (up to a certain level where the leverage effects become a source of “macro-vulnerability”). The potential for loss aversion⁶¹ (a cognitive feature that generally makes people ‘value’ a one-dollar-gain more than a one-dollar-loss) can amplify the impact of these non-linearities at the microeconomic level.

Many theoretical models of physical investment have been proposed to describe the mechanisms presented above, under various hypotheses. Pindyck (1988) shows that when investments are irreversible (with asymmetric adjustment costs for instance), a greater volatility can lead to a reduction of physical capital investment (see also Bernanke (1983) and Pindyck (1991)). The model developed in Pindyck and Solimano (1993) indicates that volatility should increase the required return of investments, thus lowering investment spending in the short run. On the other hand, Hartman (1972) and Abel (1983) demonstrate that, when supposing symmetrical adjustment costs, risk neutral firms, and perfectly competitive markets, it is possible to come across situations where volatility actually increases investment. Aizenman & Pinto (2004) indeed explain that if the profit function is convex, volatility can increase expected profits. Caballero (1991) concludes that when we suppose that firms are risk neutral, volatility increases investments if we have both perfect competition and increasing returns to scale. In Caballero’s own words, “The relationship between changes in price uncertainty and capital investment under risk neutrality is not robust... it is very likely that it will be necessary to turn back to risk aversion incomplete markets and lack of diversification to obtain a sturdier negative relationship between investment and uncertainty.”

The role of financial development in the relationship between commodity price volatility and growth has been investigated in Aghion et al (2010) in a model with two types of investments (long term, productivity enhancing and short term). The authors point to the fact that under credit constraints, the share of long term investment to total investment turns from being counter-cyclical into being pro-cyclical, thus amplifying the impact of economic shocks on productivity and growth.

We conclude that macroeconomic volatility tends to be detrimental to investment, except under very specific circumstances that in general are not gathered in developing countries (complete and perfect markets, risk neutrality ...).

b) Some empirical results on this general relationship

In this section, we present some empirical evidence on the relationship between investment and volatility in a broad sense. As we already stressed, there is only a very limited number of studies investigating the consequences of food price volatility in itself, let alone on physical

⁶¹ See Gul (1991).

capital investment. In order to provide some insights on the issue at stake, we therefore had to broaden the spectrum of our survey, and consider other kinds of volatility measures, that can be somewhat logically correlated to food price volatility, although not perfectly. If the volatility of terms of trade affects aggregate investment, then one could hypothesize that the volatility of food prices would affect agricultural investment in a similar way. Another way to justify this scope broadening would be to underline that food price volatility can induce macroeconomic instability by means of terms of trade variations, exchange rate fluctuations, or policy emergency responses for instance (see e.g. von Braun and Tadesse, 2012). Hence, looking at the consequences of macroeconomic volatility can be a roundabout way of assessing the potential consequences of food price volatility.

We have seen in the previous section that theoretically, the net impact of price volatility on investment was not straightforward. The empirical investigations of the link between macroeconomic volatility and aggregate investment are also rather mixed.

Analyzing aggregate investment and growth volatility over time for different panels of countries, Ramey & Ramey (1995) fail to exhibit a statistically significant correlation between the two macro-level variables. They conclude that volatility affects growth through its impact of the total factor productivity rather than through the investment channel.⁶² On the contrary, redefining macroeconomic instability as the volatility of foreign trade, Dawe (1996) pointed at a positive correlation with investment. A more instable macroeconomic environment was associated with a higher level of investment, a result which he attributed to an increase in the aggregate level of savings, potentially for precautionary reasons. Interestingly though, despite the increase in investment, he observed a decrease in the growth rate, and thus leaned towards the theory of price signal blurring, with a decrease in investment quality. More recently, Blattman et al (2007) used a macro-level dataset with an economic history perspective (between the end of the 19th and the beginning of the 20th century) and demonstrated that the English financial markets (the main funding platform at the time) were less likely to fund peripheral countries with large terms of trade volatility. The authors concluded that British direct foreign investment had been the main channel through which volatility had affected growth.

As one can see, the evidence is rather ambiguous and the results depend strongly upon the period, method, and volatility indicator. Aizenman & Marion (1999) shed new lights on the relationship between investment and macroeconomic volatility by disaggregating the former into its public and private components, and analyzing more systematically the different volatility measures.⁶³ They conclude that aggregate investment is not much correlated to volatility, whereas decomposed data are. Private investment is greatly reduced by a stronger volatility, whatever the index used as a control, whereas public investment generally evolves in the same

⁶² Pindyck and Solimano (1993) showed that the volatility of the marginal profitability of capital had a significant detrimental effect on investment for low income countries, but not for OECD countries.

⁶³ Aizenman et Marion focus on three types of volatility: that of government consumption expenditure, as a fraction of GDP (fiscal policy instability), that of the nominal growth of money (monetary policy instability) and that of the real exchange rate (trade policy instability). Each of these indices was calculated using the standard deviation of the residuals of first order auto-regressive processes. The third measure is the most accurate for our analysis of the impact of food price volatility on investment.

direction as volatility. This study shows that the response of investment to volatility could very well have been confused by the contra-cyclical reactions of governments, who were compensating the decrease in private investment with increases in public investment. Another decomposition of total investment (between long-term productivity-enhancing and short-term) is proposed by Aghion et al (2010). The authors also conclude that although the total amount of investment is not much altered by macroeconomic shocks, the composition thereof varies greatly depending on the degree of financial development, leading to a more volatile growth with even lower mean for those countries with tighter credit constraints. Hausman and Gavin (1996) had previously shown that the link between GDP volatility and investment could disappear when controlling for the depth of local financial markets (see also Easterly et al, 2000).

In the theoretical presentation, we had seen that the response of investment could depend on the market structure considered. The results of Aizenman & Marion (1999) question the role of public institution and governing bodies in both the observed volatility and in the correlation between investment and volatility. Some insights are given for instance by Myers (2006), when he writes that “food price fluctuations may lead to macroeconomic fluctuations and political instability that, in turn, retard investment and reduce the rate of economic growth”. As for Rodrick (1999), he advances the hypothesis that the instability or the weakness of governments increases the verification and enforcement costs, which could limit the investment possibilities in economic downturns. Aizenman & Pinto (2004) note that “[...] strong institutions dampen volatility, while weak ones enhance its negative consequences.”

On the microeconomic side, Minton and Schrand (1999) analyzed a dynamic panel of American firms and were able to show that higher cash-flow volatility was associated with higher funding costs. Even when controlling for this increased cost of capital, cash-flow volatility was still associated with lower investments (specifically capital expenditures, R&D and advertisement). According to the authors, “cash flow volatility is related to investment because it increases the likelihood that a firm will need to access capital markets and it also increases the costs of doing so”(p.455). Interestingly, even with one of the most mature capital markets, revenue volatility appears to drastically reduce the propensity to invest.

The hypotheses on the market structure, the financial development, the reversibility of investments, as well as the reliability of governments and their ability to support the formation of productive capital in the downturns of the economic cycle can therefore modify the conclusions concerning the consequences of volatility on overall investment, which could explain the different results obtained.

c) The particular case of agricultural investment

This section focuses on the economic literature dedicated to the impact of agricultural price volatility on producers' investment decisions. Indeed, if we can apply the results linking price volatility and investment to the agricultural sector, it is nevertheless necessary to note that this sector has specific characteristics because of the very nature of the goods it produces. In developing countries, agricultural land has the dual function of creating revenue and

guaranteeing the family's food rations. It is thus necessary to distinguish between two types of production, cash crop and food crop, as they enter into competition in the allocation of land and labor.

Fafchamps (1992) developed an analytical framework for investment under uncertainty allowing for the explanation of widely observed feature of the agricultural Third World: the poorest farmers dedicate a larger share of their land and labor to the production of food crop. This phenomenon can seem paradoxical since food crops are generally more vulnerable to climate shocks and have lower yield. Fafchamps explains that the incompleteness or even absence of robust markets in least advanced countries forces farmers to rely primarily on themselves to feed (self-sufficiency). In other words, they cannot take the risk of producing high yield crops unless they secured their food supply. One could hypothesize a land acreage threshold above which it would be possible to consider a partial conversion toward cash crops. Yet below this threshold, farmers are locked in a poverty trap, with a specialization in low return, high volatility food crops, and sometimes not even enough to cover the household needs. Poulton et al (2006) estimate these net deficit producers (who do not produce enough to meet their own food needs) around 70 to 80% of rural households in Africa.

Fafchamps's model demonstrates that food crops are a rational means of insurance against the probability of bad harvest, even if the insurance process is greatly (and even almost perfectly) correlated with what it is supposed to insure (indeed, we are talking of local markets for which the risk of bad harvest is highly likely to be systemic). The importance of growing one's own food as a means to reduce the exposure to price risk had also been recognized by Roumasset (1976).

Price instability affects agricultural investment patterns at the microeconomic level, in particular when markets are incomplete or isolated. The response to increased volatility will depend on the characteristics of the farming population. As remarked by Poulton et al. (2006), "from a theoretical prospective, food price volatility will have different consequences for surplus and deficit households. It will tend to discourage investment in staple production by surplus households, who are important sources of food both locally and national, but will encourage deficit households to continue devoting scarce resources to staple food production, thus impeding progress towards diversification into higher value crops. Thus, food price volatility could be a major impediment to many poor households climbing out of poverty."⁶⁴ Anecdotal evidence is provided by Place, Adato and Hebinck (2007) who use formal surveys to document the lower propensity of the poor in Kenya to grow a cash crop, to use hybrid seeds, or to use fertilizer.

Looking at the broader picture, food price volatility could also lead to a dramatic decrease of investment all along the agricultural value chain, thus maintaining the overall sector in a trap combining low productivity and high volatility (cf. Poulton et al., 2006).

It is commonly said that poor producers' inability to predict and smooth their revenues leads them to limit their investment in the productive scheme, and focus their production on low risk

⁶⁴ see also Gouel (2013)

technologies (see e.g. FAO (2011), p.19), and this is indeed what Fafchamps' model indicated. On the empirical side, though, the impact of food price volatility on agricultural investment has seldom been investigated.

Kurosaki and Fafchamps (2002) demonstrated that the crop choice was influenced by the level of price and yield risk borne by the households in Pakistan Punjab, and estimated that the elimination of risk could increase the acreage dedicated to cash crop up to 30% for the median household. Using Ethiopian household data, Dercon and Christiaensen (2011) were also able to demonstrate a link between vulnerability and technology uptake: those households whose consumption was most responsive to shocks were making less use of fertilizers (even after controlling for household characteristics). Fertilizers indeed increase yields on average, but they do not really protect against a weather shock. In the bad state of the world, they therefore represent a sunk cost, and contribute to lowering returns further, which vulnerable farmers cannot afford. Rosenzweig and Binswanger (1993) developed a framework linking the agricultural asset portfolio allocation to weather risk, which they applied to Indian data. They were able to show that the riskiness of the portfolio was indeed inversely correlated with the weather risk borne by the farmer.

The results of the randomized field experiment by Giné and Yang (2009) are less conclusive: they offered loans to purchase high-yield hybrid seeds to Malawian farmers, with half the loans being tied to a weather-insurance (at an actuarially fair price, but still making the loan more expensive). They were surprised to find that the uptake of the yield improving loan was more than a third lower with insurance. Yet they conclude that this result is most likely due to the limited liability of the farmer associated with the higher cost of the insured loan, and not to the fact that reduced risk would lower the investment in higher yield technologies.

Additional studies investigated the impact of a climate (or economic) shock on the investment strategies of agricultural households. Zimmerman & Carter (2003) indeed documented that farmers' investment behaviors did vary depending on initial allocations, with wealthy farmers investing in productive capital (high yield) in order to smooth their consumption while the poorest stock grains (more liquid, but with a lower yield), and smooth their capital rather than their consumption.⁶⁵ Along the same line, Hoddinott (2006) documented a significant increase in cattle sales during the severe rainfall shock that hit Zimbabwe in 1994-1995, especially among those households owning initially more than two animals. The sale enabled some households to smooth consumption and to reduce the draught impact on health outcomes (which the author interprets as a change in asset portfolio: less physical capital, but a preservation of human capital). The case studies reported in FAO (2009) showed also that during food crises, poor households tended to sell part of their productive assets (livestock) as a coping strategy,⁶⁶ yet the dominance of an asset-smoothing strategy over a consumption-smoothing one appears to be context-specific (FAO, 2011), and indeed the actual behavior of farmers is often a

⁶⁵ Rosenzweig & Wolpin (1993) had previously shown that limited access to credit had prevented Indian farmers to resort to investment in productive capital (bullocks) as an insurance mechanism against income variation, which maintained revenues at low levels and fed in volatility (cf. also Myers, 2006).

⁶⁶ This behavior was observed in Armenia, Ghana, Nicaragua and Zambia, but not reported in Bangladesh.

mix of both. Fafchamps, Udry and Czukas (1998) showed that livestock sales had only compensated for a small fraction of the income losses that resulted from a major draught in Burkina-Faso. These results were confirmed by Kazianga and Udry (2006), who found very little evidence of consumption smoothing (over half the value of the income shock being directly passed to consumption): most of the shock absorption had come from extra labor and variations in grain buffer stocks. A more recent analysis of the data by Carter and Lybbert (2012) pointed to the co-existence of consumption smoothing and asset smoothing regimes depending on the asset level: the poor tend to hold on to their scarce assets at the expense of current consumption, while the rich stabilize consumption almost perfectly thanks to livestock sales.

Let's now turn to the link between volatility and output. Building on Sandmo (1971) and Newbery & Stiglitz (1981), Subervie (2008) explains that, from a static point of view, the supply response to price volatility depends on the producers' risk aversion characteristics: farmers who more specifically fear risk will tend to work more (and thus to increase supply) so as to hedge against particularly bad states of the world, while those with a moderate risk aversion will tend to reduce their production. The author adds however that from a purely dynamic perspective, supply is more likely to be negatively correlated to price instability since it "discourag[es] investment and innovation ha[s] a more uncertain return."⁶⁷ Using country-specific production and price indices over a broad range of agricultural commodities in a dynamic panel setting, Subervie (2008), is able to exhibit a negative correlation between price variability and output. Additionally, she shows that the effect of world agricultural prices' variability on production is all the more important that the country lacks proper infrastructure, that inflation is not controlled and that financial markets are not sufficiently developed. These circumstances characterize in general the developing countries, which makes producers particularly vulnerable to volatility. Haile et al (2016) builds on the difference in planting months for four food commodities to generate country- and commodity-specific price data. They build a dynamic panel model to investigate the impact of own and cross price (and volatility) on production, and also decompose the effects on planted areas and yields. They also conclude to a negative impact of price instability on the producers' planting decisions, yields, and consequently production. Subervie (2008) and Haile et al (2016) are among the very scarce macro-level cross-country investigations of the impact of volatility (beyond the effect of price shocks).

To take a step aside and conclude this section, let's mention the comprehensive analysis by Binswanger et al (1993) on Indian data, which shed light on a causal channel linking agroclimatic endowment to investment. They demonstrate that sectors endowed with generous agroclimatic conditions (e.g. rare flood or draught events) had attracted more public infrastructure spending, which in turn had incentivized banks agencies to set up, and eventually fostered private investment. Vulnerable areas, on the contrary, received less attention with long lasting consequences on their ability to invest and receive investment flows.

⁶⁷ Other authors investigated the link between risk and output, or the impact of insurance on the quantity of output. See for instance Hau (2006).

2. Impact of volatility on the building of the human capital stock

a) Welfare impact and food security

We did not find many investigation of the likely impact of food price volatility on the livelihoods in developing countries, yet a very large number of studies aimed at assessing the impact of the price hikes on welfare and poverty (see e.g. the reviews by von Braun and Tadesse (2012) or Johnson Idan (2014)). In this section, we start with a review the different methods used to assess the welfare impact of food price shocks. We then turn to the scarce studies on the impact of volatility *per se*.

Simulating the consequences of a price shock

When trying to estimate the impact of a food price shock on the populations, the first and necessary step to take consists in gathering information on the actual consumption and production patterns at the household level. Indeed, the likely vulnerability to food price shocks depends on the share of food expenditure in the consumption basket, as well as on the origin of the food consumed (whether self-produced or bought from the markets). This initial stock-take exercise makes it possible to identify and characterize the net food sellers, who are likely to gain when prices rise, and the net food buyers, more likely to lose. Several developing countries conducted nationally representative surveys, which made it possible to identify vulnerable populations.⁶⁸ Such an *ex ante* vulnerability analysis enabled for instance Poulton et al (2006) to document that, for the vast majority of the African rural population food expenditures amounted to more than 50% of the household budget, and to warn about the dreadful resource exhaustion that could induce a significant rise in food prices, even temporary.⁶⁹ Similarly, Verma & Hertel (2009) reported that food amounted for about 70% of the budget for the poorest quartile of the Bangladeshi population. Prakash (2011) and FAO (2011) provided some cross-country comparisons of the dependence of the poor's budget on food expenditure in the developing world. The food expenditure share of the lowest quintile of the populations generally oscillates between 60% and 70%.

These surveys sometimes also enable to refine the vulnerability assessment. For instance, Poulton et al. (2006) further estimated that, due to liquidity constraints, 15 to 20% of rural African households are forced to sell a fraction of their harvest even though they know their production does not cover their own needs. Those people correspond to the most vulnerable fringe of the population as they even suffer of the regular agricultural cycle price variations: they

⁶⁸ When nationally representative data was not readily available, some academics undertook smaller scale, non-necessarily representative ad-hoc surveys (e.g. Elijah, 2010), but the methods are not necessarily transparent or standardized.

⁶⁹ See for instance Hertel, Preckel and Reimer (2001), even if the references are a little dated: in particular, the authors refer to Cranfield (1998), an analysis on 1985 international data. The authors add that the strong reliance of poor households on cereals, which Tyers and Anderson (1992) showed are more relatively volatile, made them even more vulnerable.

have to sell just after the harvest to get cash (when market prices are low), knowing that they will have to buy back when they run out of their reserves (when prices are high).⁷⁰

The descriptive information contained in the surveys was also used at a more macroeconomic level, to assess the net impact of price shocks on a country as well as their redistributive consequences on its population. Looking at data on nine low-income countries, Aksoy and Isik-Dimelik (2008) argued that, although the poor net food buyers outnumbered the net food sellers, more than 50% of these poor net food buyers were actually marginal food buyers (with less than 10% of income spent on food, and thus a limited vulnerability to price shocks). Their data further indicated that the net food buyers were on average richer than the net sellers, thus implying that a price shock would actually redistribute wealth on average. This kind of analysis can be helpful in targeting international aid to those countries most at risk on an aggregate basis. Yet reasoning in terms of averages can be very misleading, since average redistribution does not preclude that many poor could still become even poorer or face starvation. For already deprived populations, it does not require much of an income loss to fall into severe poverty (see also Naylor and Falcon, 2010).

Going beyond static assessment of vulnerability, Deaton (1989) proposed a method to estimate the first order household-level impact of a given food price increase. He introduced the concept of net benefit ratio, a variable built at the household level by applying the producer price change ΔPPI , to Q_H^p , the quantity of food produced (thus measuring the potential gain from the increase), and subtracting the quantity of food bought Q_H^b , times ΔCPI , the consumer price change (which therefore measures the increased cost of purchasing food). This amount is then normalized by the total expenditure (or income) of the household.

$$NBR_H = \frac{Q_H^p \times \Delta PPI - Q_H^b \times \Delta CPI}{Income_H}$$

More than simply identifying the net buyers and net sellers, this method provides a monetary estimate of the net gains or losses undergone because of the price shock (assuming production and consumption do not react to the price change), see e.g. FAO (2008). Deaton's net benefit ratio is adopted by Zezza et al (2008) to compare, across 11 developing countries, the welfare impact of a theoretical 10% price shock for the main tradable food staples. Their analysis concludes to the higher vulnerability of the poor (both income and asset poor). They are more likely to experience losses, and the losses will be proportionally larger. De Janvry and Sadoulet (2009) resort to the same method to simulate the welfare impact of the 2008 food crisis had the international prices been passed through entirely to the Indian market. They point to the vulnerability of urban households, and estimate that the vast majority of Indian farmers would have also been negatively affected by such a shock. See also Levinsohn and McMillan (2005) about the distributional consequences of the food price level in Ethiopia.

These simulations are very useful first approximation of the welfare impact of a food price shock since they enable policymakers to identify particularly vulnerable populations and design

⁷⁰ See Matz, Kalkuhl and Abegaz (2015) who provide evidence of the strong seasonality of food consumption among rural households, linked to both the agricultural cycle and the lack of credit.

targeted support to them. Yet the computations do not account for the fact that consumption patterns react to price levels: when a good becomes more expensive in real terms, one tends to buy less of it. As long as price changes remain in a reasonable range, the approximation stays valid. Yet when one considers shifts of the order of magnitude observed during the 2008 food crisis, it is no longer possible to ignore the adaptation of consumption to prices. Most authors who neglect own price (or real income) elasticity in their simulations argue that they only consider direct short term impacts. In the very short term indeed, it is likely that consumption patterns will stay the same despite the price change. In the medium term, though, one must account for the reaction of consumers to the new prices. Assuming constant quantities tends to overestimate the welfare impact of a price shock, as adapting quantities is clearly a coping strategy.

To gain more precision, Cudjoe et al (2010) plugged own-price and income elasticity estimates in their simulation of the welfare impact of the 2008 crisis in Ghana. A similar path was followed by de Janvry and Sadoulet (2010) with Guatemalan data. Even after accounting for induced changes in consumption patterns, some groups still end up severely affected by the price hike.

It is possible to refine further the simulations by considering the potential substitution between foodstuffs: indeed the evolution of relative prices dictates reallocations in the food basket in the short to medium run. The quantity that is consumed of a good not only depends on its own price, but also on the price of its close substitutes (e.g. a local staple). Once again, the adaptation of the consumption pattern tends to dampen the first order impact of a price shock.

Dimova and Gbakou (2013) showed that the welfare impact of the food price rise in Côte d'Ivoire appeared less detrimental (and even positive for some categories of households) when broadening the scope of the simulation to include all food products rather than focusing on rice alone. This, they argue, points toward households' ability to substitute rice for cheaper local staples, and to limit the effect of cash crop price increases. Along the same line, Pons (2011) and Weber (2015) added substitution to the analysis of Indian data by de Janvry and Sadoulet (2009). Although the refined simulations do not change the conclusion about the higher vulnerability of rural households relative to urban ones, the demand modeling provides some hints about the consequences of the price hike on the worsening of the diet quality. More specifically, Weber (2015) finds that households would tend to substitute high value food items (milk, meat, fruits) for cheaper cereals. The nutritional impacts of food price shocks will be surveyed in more detail below.

Instead of looking at the overall distribution of gains and losses, some authors focused on a more synthetic indicator of the evolution of social welfare: the poverty rate, which is simply computed by confronting the simulated post-shock real incomes to a standard poverty threshold. Ivanic et al (2012) simulated the impact of the 2010 food price rise on the poverty headcount in 28 countries (including price and substitution effects). They conclude that "on balance, the adverse welfare impact on the net consumers outweighs the benefits to net producers resulting in an increase in the number of poor and in the depth of poverty." (p.2311)

Rather than measuring welfare in monetary terms (real income gains and losses), some authors looked at calorie intake. Simulating the new consumption basket (with or without elasticity parameters), they convert quantity purchased into energy, in order to better relate to the concept of food insecurity⁷¹ (see e.g. FAO, 2008). Harttgen and Klasen (2012) developed a rough methodology posing that a doubling of each foodstuff's price would translate into a halving of the corresponding nutrient intake, and comparing the simulated household-level outcomes with standard minimal energy requirements.⁷² Anriquez, Daidone and Mane (2013) introduce proper own-price elasticity parameters taken from previous studies in their nutritional analysis of the price spikes in eight developing countries. Their simulations point to increased undernourishment across countries, income groups and location (urban vs. rural), with food price spikes inducing both a reduction in the quantity consumed and in the variety of food intake.

However refined the models, the simulations of monetary or calorie losses are not necessarily the best indicators of the real impact of a food price change on livelihoods. Including more and more elasticity parameters can be a tempting solution to capture the complexity of consumption decisions; it is yet not sure that the simulations would come closer to the reality.

First, it is unclear that elasticity estimates derived from cross-sections actually reflect the reaction of a given household to a shock. Furthermore, cross-sectional elasticity estimates are not bounded to remain constant over large fluctuations in income, or across major crises: for instance, Dimova et al (2014) documented large variations in the income, own-price, and cross-price elasticity estimates they obtained for Bulgaria around the economic crisis and structural adjustment period, indicating that the crisis induced significant changes in consumer behaviors for various food groups and nutrients and across the income distribution (see also the estimates by Shabnam et al (2016) who argue that the two food crises made Pakistani households' nutrient intake more sensitive to prices).

Another serious critique to simulated impacts of crises is that they cannot easily account for medium-term market adjustments. Aksoy and Isik-Dimelik (2008) indeed acknowledge that the contraction of demand from those who suffer from the shock can have a second round effect on those who would win in first approximation, while Ivanic et al (2012) regret that their simulation cannot account for longer term wage adjustment (e.g. a rise in prices should push agricultural wages up, and thus compensate partially for the loss in real income for day laborers).

Despite their limitations, simulations, however rough they may be, are efficient tools to provide policymakers with a first estimate of the likely consequences of a significant shock. They enable them to take action quickly and target the likely vulnerable populations. Indeed, contemporaneous information would probably be more accurate, but the inherent timeframe of a proper post-shock survey data collection would definitely delay the course of political action.

⁷¹ The canonical definition of food insecurity can be found, for instance in FAO (2003): "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (p.29). The same definition is recalled in FAO (2009), p.8.

⁷² The minimal and average energy requirements.

Yet, ex post, the analysis of new household information can however help understand the challenges better and tailor more accurate emergency responses for the future.

Analysis of post-shock data: measuring the actual consequences

Simple static examinations of cross-sectional data that happened to be collected at the time of the crisis provide researchers with interesting information on the actual consumption patterns under acute stress. Such an analysis of contemporary data was conducted by Dimova and Gbakou (2013) for Côte d'Ivoire, and by Raihan (2009) on Bangladesh.

Using successive survey rounds, or even sometimes the pacing of interviews along a survey campaign,⁷³ several studies measured the actual evolution of food consumption patterns through the crises, using them as natural experiments. Resorting to such strategies, Alem and Söderbom (2012) demonstrated that households headed by a woman, or by a casual worker had been particularly vulnerable to the 2008 price shocks in Ethiopia (see also Kumar and Quisumbing, 2013). In Ouagadougou (Burkina-Faso), Martin-Prevel et al (2012) documented a significant decrease in both food security and in dietary diversity between 2007 and 2008, a conclusion shared by D'Souza and Joliffe (2012) for Afghanistan. Similarly, Tandon and Landes (2014) documented a significant decrease in diet diversity in India because of a reduction of non-staple consumption attributed to the 2008 food crisis. Matz et al (2015) observed that in 2012, food price rises in Ethiopia were associated with significant decreases in the number of meals taken, and a switch toward the consumption of less preferred food in both rural and urban areas. See also the results by Brinkman et al (2010) on the negative correlation between local food prices and the food consumption score⁷⁴ in Haiti, Nepal and Niger. Eventually, Juárez Torres (2015) computed nutrient elasticity estimates over seven rounds of a Mexican household survey to document the differential consumption patterns and sensitivities across the income ladder.

Aside from the standard cross-sectional analyses, let's mention some more original methods: Shabnam et al (2016) applied a time-varying quantile regression demand model for food to Pakistani data in order to investigate the evolution of calorie and macro-nutrient consumption before and after the 2008 food crisis with year-specific elasticity estimates. DeMatteis (2014) used a time-series approach (error correction model) to investigate the link between food prices (domestic and international) and nutrition-related data at the country level. He demonstrated that higher prices were associated with lower food availability in most countries, and to a significant increase in food deficit in low-income countries.

To conclude this section, let's mention two synthetic articles: On the one hand, the review by Dorward (2012) summarizes the theoretical and empirical findings on the short-and medium-term impacts of staple food price shocks. He points to the vulnerability of the poor, especially in economies that underwent large price shocks and did not benefit from a "broad based growth process". The vulnerability of net food buyers is highlighted, while there does not seem to be

⁷³ See e.g. Jensen and Miller (2008) or D'Souza and Joliffe (2012)

⁷⁴ The FCS is a survey-based indicator of the diversity and frequency of the food consumed over the previous week

much evidence a second round beneficial effect due to the price and wage adjustment. On the other hand, Green et al (2013) realized a meta-analysis over 136 studies reporting 3495 own-price elasticities from 162 different countries (no substitution). They find significantly higher elasticities in poor countries, and also point to a greater reduction of food consumption among poorer households within a given country.

Impact of variability per se:

Applying a CGE model to Bangladeshi data, Verma & Hertel (2009) demonstrated that agricultural price volatility and income volatility translated into more uncertain food intake. They also stressed that the initial state of malnutrition observed among the poorest made them all the more vulnerable to price increases and price fluctuations. The economic literature even went as far as posing equations linking volatility with the survival probability of the poorest, as indicated by Myers (2006) [cf. McGregor (1998)]. Indeed, it is not counterintuitive to imagine that food price variability could induce a reduction of nutritional rations, even below the subsistence intake level, especially in the most vulnerable households, and thus could impact the survival rate. For example, Glomm & Palumbo (1993) adapted the intertemporal consumption model with random income and endogenized the survival probability (consumption in one period determines the survival rate in following periods). If credit markets are inexistent (and even if we keep the possibility of storage available), the agents constitute a health capital stock at the expense of their precautionary savings, which limits their investment capacity.

Bellemare, Barrett & Just (2010) showed on Ethiopian data that households are indeed “on average significantly price risk-averse over the prices of specific commodities as well as over co-fluctuations in the prices of the same commodities.” They were willing to pay between 6 and 32% of their income to get full price stabilization for the seven major agricultural crops to their mean value.⁷⁵ The risk aversion of Indian producers had been demonstrated by the model developed by Rosenzweig & Wolpin (1993) concerning the dynamic investment in the asset “bullock”.

Self-assessed food insecurity:

Instead of looking at actual changes in consumption, some authors addressed the issue of self-reported food insecurity. After all, in many aspects of social sciences, the perception that people have of a phenomenon can often be as important as the actual observed consequences. Such a change in perspective can be found for instance in Headey (2011) who uses Gallup World Poll and finds that actually fewer people reported food insecurity in the world in 2007/2008 than in 2005/2006. The detrimental impact of the high food prices was partially offset by the high

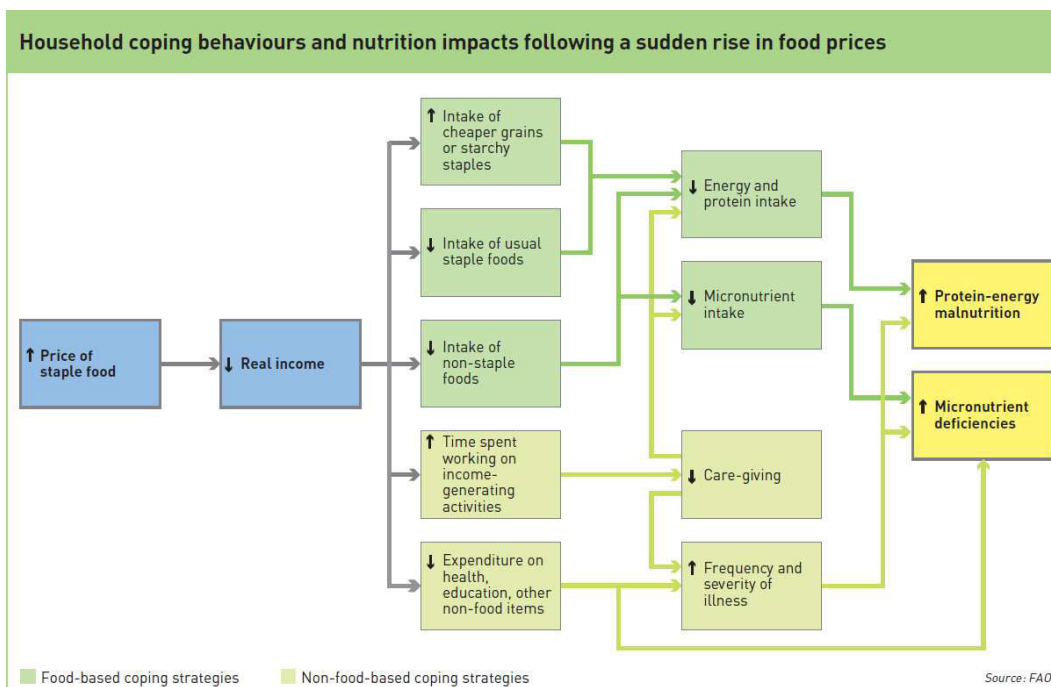
⁷⁵ The agricultural commodities taken into account by Bellemare are coffee, maize, horse beans, barley, wheat, teff and sorghum. They are not all staple food crops.

economic growth rates observed through the developing world: large and populous countries managed to limit the price hikes domestically and also benefitted from dynamic growth. Similarly, Verpooten et al (2013) analyzed the evolution of self-reported food insecurity in 18 Sub-Saharan African countries between 2005 and 2008 using the Afro-barometer data. The study concluded that although higher average prices were associated with an increased incidence of reported food insecurity over the previous 12 months, they were also associated with a lower probability of reporting a severe food insecurity status. Self-reported food insecurity variables could also be used as explanatory variables (see e.g. Akter and Basher (2014) who found that the self-assessed dummy for having experienced acute food shortage in 2007 did come out as significantly lowering the household expenditure growth between 2007 and 2010 in Bangladesh).

b) Human capital accumulation, health and education.

There again, despite the general focus and hype on volatility, the extant literature on the consequences of volatility per se was only seldom studied. Yet the impact of price shocks received impressive attention from academics. Agricultural price shocks and volatility not only jeopardize the economic welfare and the access to food of the poorest, it also has more pernicious effects on capabilities, in the sense of Sen (1993). Jensen (2000) talks of “investment in children”, a phrase that encompasses both youngsters’ continuous education and proper feeding. In his own words, “investment in children and the development of human capital are the cornerstones of enhancing well-being and breaking the cycle of poverty, and they are also central to national growth and economic development.”

Graph 14A: Mapping of coping behaviors



Source: FAO (2008), Figure 24 p.28

In a remarkable synthesis, Meerman and Aphane (2012) describe the impacts of rising food prices in terms of coping mechanisms at the household level.⁷⁶ A first reaction it to reduce quality and shift to cheaper, less preferred, food items. If more adjustment is needed, households also reduce the quantity consumed. Understandably, reducing the number of meals and the quantities served can have dramatic health consequences, but substitution can also prove very harmful: as noted in Shabnam et al (2016), “Substitutes in taste may not be close substitutes for nutrients, and therefore food substitution may alter nutrient intake”. The rise in food prices is generally associated with a less diversified food intake, with food expenditures being concentrated on cereals and high carbohydrate items that fill the stomach, at the expense of other foods which provide other necessary micronutrients such as vitamin A, Iron, Zinc. Macro and micro-nutrient deficiency (even temporary) is known to induce severe and permanent diseases.

Within a given household, all family members are not affected the same way: food shortage is generally associated with significant intra-household food reallocation. The redistribution pattern within the family is very likely to depend on the prevailing cultural values, but those most prone to be shock absorbers are definitely women and children across the developing world. To some extent, it makes sense that the limited food ration be directed toward the principal breadwinner to maintain the resources of the household. Yet undernutrition among women and children can lead to long-term consequences, both physical and cognitive (fetal and infant development).

Meerman and Aphane also review second order consequences of food price shocks. The tight budget constraint leads to a decrease in school attendance combined with an increase in child labor. A lower real income at the household level tends to decrease health-related expenditures (drugs or visits to the doctor).⁷⁷ It is also generally associated with an increase in women laborforce, with detrimental consequences on the household health status: indeed, women are traditionally the primary care-givers and wage labor implies that they have less time to care after the children, prepare their meals or breastfeed them. In some extreme cases, the budget constraints can even lead to the sale of productive assets and a reinforcement of the poverty dynamics. Prakash (2011) summarizes all these impacts neatly when he writes that that a “diminished income in already low-income countries can result in malnutrition, mortality, withdrawal of children from education and sustained high unemployment.”

In the paragraphs below, we propose a thorough review of the various consequences briefly introduced above.

Anthropometric evidences of nutritional deficiency:

A substantial strand of academic literature investigated the visible health consequences of the changes in consumption induced by price variations. This literature generally focuses on

⁷⁶ See also e.g. the graphical depiction in FAO (2008), p.28 as well as FAO (2009), p.26 sqq.

⁷⁷ see e.g. Tandon and Landes (2014) who demonstrates the significant decrease in health expenditure associated with the food price rise in India, in 2008

standard anthropometric indices constructed through various combinations of age, weight and height data.

The most famous such index is the body mass index (BMI), which corresponds to the ratio of weight over the square of height. According to the WHO the “normal” range of this ratio (for male and female adults indifferently) is 18.5 to 25 kg.m⁻². People below the lower bound of this interval are said to be underweight (severely thin when below 16 kg.m⁻²), and those beyond the 25 kg.m⁻² threshold are declared overweight (obese when the ratio is larger than 30 kg.m⁻²). Another three indices are used to assess the actual growth of children relative to world (or national) standards: the weight-for-age Z-score (WAZ), the height-for-age Z-score (HAZ), and the weight-for-height Z-score (WHZ).⁷⁸ These standard scores are tabulated by the WHO and measure how far a child is (in terms of standard deviation) from the mean of the reference population. Low height for age is generally interpreted as the cumulative impact of under-nutrition during the entire life of the child, from the mother’s womb. It is widely understood as an indication of the child’s health capital. “Stunting” corresponds to the status of children whose HAZ falls two standard deviations below the mean (or median) and therefore reflects severe chronic deprivation. On the contrary, the WHZ is deemed a good indicator of the flow of investment in children’s health. A low weight for age ratio points to acute weight loss due to temporary undernutrition. Children with a WHZ below -2 (two standard deviations below the mean) are falling in the “wasted” category. A combination of the previous two indices, the WAZ is less straightforwardly interpretable. Indeed, a low weight for age ratio can result from either long-lasting or acute undernutrition.

Jensen (2000) used local weather shocks across Côte d’Ivoire as a natural experiment to assess the impact of rainfall on the children WHZ ratio in this rural economy extremely dependent on rain-fed agriculture. Undernutrition in the shock regions soared dramatically, even doubling for boys. Hodinott (2006) documented a significant, but temporary, reduction in women’s BMI following the 1994-1995 draught in Zimbabwe, as well as a significant drop in growth velocity among young children. Looking at the impact of the more recent 2007-2008 food crisis in Bangladesh, Sulaiman et al (2009) observed an increase in the prevalence of wasting among rural children, especially in the middle of the income distribution: despite the price increase, households had consumed more rice, and thus significantly reducing their consumption of non-grain foods (typically lentils and fish).⁷⁹ Chibuye (2014) documented a lowering of the HAZ of under-5 children in Zambia between 2006 and 2010. Arndt et al (2016) highlighted the short run impact of the 2008 food crisis on child malnutrition in Mozambique (as measured by the WHZ and WAZ scores). Vellakkal et al (2015) used longitudinal cohort data of children from Andhra Pradesh (India) to observe the evolution of the wasting rates (low WHZ)

⁷⁸ The distribution of raw ratios is normalized by subtracting the population mean from all the observations, and dividing the result by the population standard deviation.

Mathematically, the z-score associated with a raw number b is therefore:

$$b_z = \frac{b - \mu}{\sigma},$$

where μ and σ are respectively the population’s mean and standard deviation.

⁷⁹ Analyzing the consequences of the late 1990’s economic crisis in Indonesia, Sari et al (2010) also demonstrate a negative correlation between child stunting and the proportion of household income spent on non-grain food.

with the food crisis: from 19.4% in 2002 and 18.8% in 2006 wasting prevalence jumped to 28.0% in 2009. Juárez Torres (2015) demonstrated the strong sensitivity of poor children's weight gains to cereal price changes in Mexico. Analyzing survey data from Bangladesh, Thorne-Lyman et al (2010) found that dietary diversity was strongly correlated with income. Campbell et al. (2010) further showed that stunting in children as well as maternal underweight were strongly correlated with higher expenses on rice (and lower non-rice food expenditures).

The long term consequences of undernutrition are numerous. Of course, death is the most dramatic, but there are also more pernicious effects. Growth impairment seriously reduces individuals' physical aptitudes. Additionally, undernutrition impacts cognitive abilities and compromises educational successes. Meerman and Aphane (2012) eventually point to recent surveys linking childhood undernutrition with type 2 diabetes.

Food prices and micronutrient deficiencies:

The nutrition literature investigated further the link between high food prices and longer term health outcomes, especially by looking at micro-nutrient intakes.

Meerman and Aphane (2012) review some of the most well know implications of macro and micronutrient deficiencies: for instance, lack of vitamin A is commonly associated with sight deficiency, up to blindness. It also induces impairment of the immunological functions, and leads to higher mortality risk among mothers and children. Similarly, severe iron deficiency is linked to anemia with consequences on the cognitive and physical development of children. It is also associated with increased tiredness and lower productivity.

Iannotti et al. (2012) estimated income-nutrient elasticity parameters in Guatemala to simulate the impact of the 2007-2008 food crisis: they conclude to a likely increase in the probability of nutrient inadequacy, especially zinc and vitamin A. Vitamin A is found mainly in animal products (livers, eggs, fish, whole fat dairy products). West and Mehra (2010) had previously documented the strong relationship between lower consumption of non-grain food and the higher risk of night blindness due to vitamin A deficiency among women of reproductive age.

Child Mortality:

The investigations on the child death toll of the recent major food crises are extremely limited. Yet, taking a step back and considering that food crises are actually one sort of real income shock, it is possible to find very enlightening pieces of research: Ferreira and Schady (2009) developed an analytical framework linking child mortality to economic downturns through the channel of traditional caregivers laborforce participation: on the one hand, lower household income tends to increase laborforce participation within the family (including mothers, who are traditional care-givers), while on the other hand lower wages also reduce the

opportunity cost of not working (i.e. staying at home and caring for the children). The eventual relationship between economic cycles and investment in children's health is therefore the net result competing income and substitution effects. Ferreira and Schady argue that in developed economies with functioning credit markets, the income effect can be eliminated through borrowing against future revenues, and indeed they observe that in the US for instance, economic downturns are associated with decreases in child mortality. In low income countries, on the contrary, the income effect dominates the substitution effect, and child mortality thus increases in recessions (see e.g. Bhalotra (2010) or Baird et al (2011) for India). In between these two extremes (i.e. for middle income countries), the final direction of the relationship is undetermined a priori – see Schady and Smitz (2010) see also Cutler et al (2002) for a specific analysis of Mexico.

The aforementioned studies investigated the general correlation between income and child mortality over long periods. We now turn more specifically on the impact of food crises, which, according to Christian (2010) can affect directly child mortality through three main nutritional channels: childhood under nutrition (leading to stunting and wasting); childhood micronutrient deficiency; and even before this could happen, intrauterine growth restriction (linked to maternal under nutrition and micronutrient deficiency). The only empirical assessment we found on the 2008 food crisis is the analysis by Fledderjohann et al (2016) on Indian data concluding that every 1% increase in total food prices was associated with a 0.49% increase in neonatal mortality.⁸⁰

The evidence of maternal labor and lower care-giving availability as a transmission channel from economic shock to lower health outcomes is rather circumstantial. Indeed, economic downturns are said to increase female laborforce participation, but the evidence is mixed (see for instance the conflicting results in Bhalotra and Umaña-Aponte (2012) and in another undated paper by the same authors).⁸¹ Jensen (2000) documented that, in regions of Côte d'Ivoire affected by a serious draught, the percentage of sick children brought to the medical consultations had dramatically decreased by about a third, while the nutritional status was reported to deteriorate significantly. However, his analysis did not quantitatively link these observations to maternal labor. Pongou et al (2006) provide some useful insights with their work on the impact of the 1990's economic crises and structural adjustments programs in Cameroon, as they found that child malnutrition had been significantly linked to a variable coding for maternal health-seeking behavior (MHSB).

⁸⁰ Note that the authors did not find significant impact of the aggregate price on infant or under-5 children mortality rates. Yet, when decomposing the price shocks across food groups, they exhibited a significant detrimental impact of the price of meat and dairies on the mortality rates of all children age groups.

⁸¹ Bhalotra and Umaña-Aponte (2012) estimated that female laborforce participation was pro-cyclical in Sub-Saharan Africa, contrary to the belief that economic shocks push women to enter the market to complement their husband's income. However, in an undated working paper on a broader scope of developing and emerging countries, the same two authors came up to an opposite conclusion about Sub-Saharan Africa. They also found that the relationship between income and female laborforce participation was heavily depending on women's educational attainment. For women with less than secondary education, a drop in income was associated with increased participation, but the opposite was true for women with higher education.

The most thorough empirical investigation of the channel between economic shock and mortality is probably Cutler et al (2002), who analyze Mexican demographic data spanning from 1980 to 2000. They demonstrated a strong correlation between female labor force participation and the increase in mortality rate for the vulnerable age groups (infants and elders). They were able to test the “missing care-giver” hypothesis, but the data did not support it, and they concluded that increased female laborforce participation might actually simply indicate economic shocks of a larger magnitude (i.e. large shocks simultaneously induce female labor and increased mortality for the vulnerable populations).

Impact of food prices on education:

Ferreira and Schady (2009) describe a two periods setting in which households face tradeoff: they can either put their child to work right away (in which case they do not pay tuition fees, and receive unskilled labor wage in both period 1 and 2); or they can send their kids to school, and derive skilled labor wage in period 2 only. A recession lowers parents’ and children’s wages, inducing both an income effect and a substitution effect going in the opposite direction: indeed, as the traditional breadwinners’ income decreases, the family is incentivized to send more members to work; yet the opportunity cost of schooling shrinks simultaneously, as the wage a child could make is lower. The authors argue that with functioning credit markets, inter-temporal consumption will be smoothed (parents will borrow from future incomes). The income effect should therefore vanish, and the substitution effect will dominate (thus leading to an increase in schooling). On the other hand, when credit markets do not exist or are imperfect), the variation in schooling is theoretically undetermined. Reviewing the empirical evidence, they indeed show analyses on least advanced countries conclude to a detrimental effect of economic crises on education, while the relationship goes in the reverse direction for the US, and appears undetermined for middle-income countries. In other words, investment in children appears counter-cyclical in developed countries, while it is pro-cyclical in poorer markets with limited access to credit (see Jacoby and Skoufias (1997) for an analysis of the consequences of income seasonal variations in terms of children school attendance in rural India; see also Thomas et al (2004) which documented a significant decline in household spending on education during the Indonesian crisis – especially among the poorest).

Jensen (2000) complemented his analysis of “investment in children’s health” through an analysis of the schooling consequences of the rainfall shocks in rural Côte d’Ivoire. He demonstrated that class attendance had decreased by about a third in the regions that suffered the draught relatively to others. Exploring a limited field survey he conducted across Bangladesh in the aftermath of the 2008 food crisis, Raihan (2009) documented that about 90% of households reported a detrimental impact of the food price increase on their children’s education. About half households experienced dropout of their children, and nine out of ten reported that their children education had to be interrupted for health/nutrition reasons. In addition to the health-related reasons put forward, 20% of households admitted that they could not meet education expenses,

and 20% recognized that they had to involve their kids in money making activities. Summing the actual tuition fees with the child wage rate, Raihan estimated the opportunity cost of schooling to be about one fourth of the household's monthly expenses. The declarative results are complemented by an analysis of school attendance sheets. The data show a tremendous decline in secondary level enrolment (about 15% fewer kids in 2008 relative to 2007) and an increase in first term dropout rate of about 6 percentage points between 2007 and 2008.

This section established that price shocks and income volatility do have disastrous consequences on children's health and education across the developing world. Investment in capability appears particularly reactive to disposable income. These interruptions in the flow of investment in children cannot but have extremely serious consequences on the pace of development at the macroeconomic level.⁸² In Jensen's words, "[...] to the extent that even temporary schooling interruptions or shortfalls in medical care or nutrition have lasting impacts, and given the importance of such investments for human development, the results suggest that aid and public insurance programs should be used to help households overcome adverse economic shocks."

c) Volatility, inequality and exclusion

Again, the specific empirical evidence linking food price volatility to inequalities is scarce. We can only get insights on the issue by broadening the scope of the survey, to encompass either macroeconomic volatility or food price shocks.

Macroeconomic volatility, as measured by the volatility of the growth process for instance, has indeed proved positively correlated to the rise of inequalities. Laursen and Mahajan (2005) demonstrated that the revenue share of the poorest quintile was significantly lower when volatility was larger. The relationship was particularly strong in least advanced countries: the correlation was funneled by inflation and appeared to be dampened by the development of the financial system as well as by the extent of the safety nets. Similarly, but focusing more specifically on Latin American countries, IDB (1995) as well as Hausman and Gavin (1996) had shown that GDP volatility was also strongly correlated to a persistent increase in inequalities, with the main transmission channel assumed to be education. Bourguignon et al (2004) investigated the consequences of agricultural commodities' volatility on inequality. They documented the vulnerability of poor export-dependent countries,⁸³ and argued for a broader use of risk-augmented income distribution to assess the consequences of volatility within a given country. Their model indeed pointed that the poor bore a larger share of the risk burden.

⁸² Research papers comparing effectively the short term impacts to the longer term outcomes (on education, on health) are fairly scarce. Frankelberg and Thomas (2017) propose such an analysis for the specific case of Indonesia, considering both the financial crisis of 1998 and the Tsunami of 2004. They insist on the remarkable resilience of the Indonesians and the coping mechanisms they implemented to mitigate short- and longer term impacts to the young generations.

⁸³ See also Fafchamps (2000)

At the microeconomic level, Zimmerman & Carter (2003) developed a stochastic model to simulate the wealth trajectories of farmers given the macroeconomic environment. They exhibited an initial capital threshold (a Micawber threshold)⁸⁴ that split the population into two groups. Those below were trapped into poverty and gradually sold all their assets while those above could expand theirs. In the case of Burkina Faso, they located the threshold to around 4 hectares of arable land.

In the section on welfare impacts of food price shocks, we mentioned that most studies had concluded to the greater vulnerability of the poor, less able to insulate their consumption from the price variations. Food amounts to a larger share of their expenses and when prices rise, they end up downgrading the quality of their diet, reducing the number of meals, cutting other expenses (education, healthcare,...), or selling their already scarce assets. Price shocks are thus generally deemed to exacerbate economic inequality as well as to jeopardize poor households' development prospects. Kumar and Quisumbing (2013) also demonstrated that food price shocks affected gender inequality in Ethiopia: Female-headed household, which on average started from a worse situation than their male-headed counterpart in terms of schooling, wealth and social networks were also more likely to experience food shortages, suffered from longer periods of deprivation. They were consequently more likely to cut back on food consumption, even for children meals. In the words of Zezza et al (2008), "while richer households may cope with the price shock by cutting on other non-essential expenditures or drawing on their savings, this option is less open to the poorest, who may be driven into further depleting their meager asset base, or cutting on essential expenditures such as education. This is especially true for poor female-headed households, who are particularly hard hit from the increase in food prices. This, and the longer term impact of inadequate food consumption, would definitely translate into lower productivity and income generation potential in the medium- to long-term."

Food price shocks and their differential impact along the income ladder can also have insidious stigmatizing social consequences, such as the exclusion of the poorest from the traditional ceremonies. In their qualitative assessment of the impact of the 2011 food crisis on the urban poor in Ethiopia, Hadley et al (2012) stressed the consequences of the food crisis on the overall social structure. Many interviewees reported that the situation prevented them from participating in the social life of the community. For instance, tradition goes that people who attend funerals prepare some food that they bring to the family of the deceased. As they had nothing to bring, several people gave up going to the social rituals. In a similar fashion, it became more complicated to share food items, let alone meals, with relatives or neighbors, thus distorting the social networks, and insulating further the poorest from the community.

⁸⁴ The concept of "Micawber Threshold" was introduced by Lipton (1993) as a reference to a character in Charles Dickens' David Copperfield.

3. Empirical evidence of the impact of volatility on economic growth

As we mentioned in our introduction, the classical models go that economic growth relies on technical progress and the constitution of an appropriate stock of capital (in the convergence phases). In the previous two chapters, we described how food price shocks, macroeconomic volatility, and sometimes more precisely food price volatility seriously dampened the accumulation of capital stock on the one hand, and the investment in human capital on the other, both in the short run in the long term. Those tragic intermediary consequences should therefore translate into a lower long run economic growth.

Many articles demonstrate a large negative impact of macroeconomic volatility on a country's economic performances. Ramey and Ramey (1995) investigated the relationship linking GDP growth to its volatility. They showed, on two different panels (world and OECD), that indeed a more volatile growth process was also less dynamic on average. IDB (1995) and Hausman and Gavin (1996) came to a similar conclusion for Latin America, as did a more recent analysis by Hnatkowska & Loayza (2004).

Other studies defined macroeconomic volatility more precisely as terms of trade volatility (thus relating the concept of volatility more closely to a price issue). There again, volatility was proved to significantly hamper the growth process. Guillaumont et al (1999) concluded that terms of trade and political instability partly explained the difference in growth rates between Africa and other developing countries between 1970 and 1990. Blattman et al (2007) showed that commercial specialization in commodities (whose price is particularly volatile) could explain a large part of the economic divergence observed in the World over the 19th and 20th centuries: they exhibited strong negative correlation between a country's terms of trade volatility and its GDP growth. More recently, Brückner and Carneiro (2015) exhibited a strong negative relationship between terms of trade volatility and growth cross-sectionally (relationship that vanishes when including country fixed effects). Still considering the impact of trade volatility Dawe (1996) concluded that an increase in exports instability of the order of magnitude of 1% of GDP per year leads to a growth slow-down of about 250 basis points.

Among all the studies we reviewed, the one that most closely relates to the growth consequences of food price volatility is probably Timmer (2002) who estimated that the rice price stabilization scheme implemented in Indonesia in the 70s had induced a growth increase between ½ and 1 percentage point. Grabowski and Self (2016) neatly explained the mechanisms through which food price stability could enable the structural change of an economy from agriculture to manufacturing and services. According to them, food price instability is associated with a lower level of investment in the agricultural sector. Agricultural production thus requires a large share of the laborforce and therefore dampens the transition to manufacturing. By contrast, productivity gains in the primary sector would free up workers who would move to the cities and apply to industry jobs. They also highlight the positive consequences of stable food price on health and education, and thus on the quality of the labor that will eventually be hired by the manufacturing companies. Looking more specifically at Indonesia between 1969 and 2014, they

show that indeed, rice price volatility was significantly associated with a lower share of manufacturing in the GDP.

Turning to the causes of macroeconomic volatility, Koren and Tenreyo (2007) demonstrated that developing countries' more volatile growth process was largely explained by the fact that they underwent more frequent aggregate shocks. Jacks et al (2009) indeed noted that, relative to the industrial economies, terms of trade volatility had been more than three times higher in Latin America, South Asia and Africa. They attributed the exacerbated variability to a less diversified economic structure, centered primarily on particularly volatile activities such as the production of commodities. In a way, this phenomenon is a consequence of the Heckscher-Ohlin theorem, which explains that countries specialize in and export the goods that use intensively the factors they are largely endowed with. Developing countries, who are largely endowed with low qualification labor force and land (relatively to qualified labor and capital), export the products that use these factors intensely.

Not only did developing countries face more macroeconomic volatility overall, the impact of an increased volatility was also comparatively more incapacitating for them. Hnatkovska & Loayza (2004) indeed found that the correlation between the GDP growth rate and its variability was globally negative, yet they proved that the relationship was not homogeneous along the income ladder: among least advanced countries, a more volatile growth pattern was also lower on average, while the reverse was true for rich countries. Rodrick (1999) insisted on the importance of social and institutional factors in the resilience of countries to macroeconomic shocks (see also Acemoglu et al, 2003). Brückner and Carneiro (2015) pointed to a strong and significant role of financial development in explaining the cross-sectional differences in the relationship between terms of trade volatility and growth. Aghion et al (2009, 2010) indeed showed that the detrimental impact of real exchange rate (resp. commodity price) volatility on economic growth was stronger in countries with a less developed financial sector (and tighter credit constraints).⁸⁵ It thus seems legitimate to analyze the vulnerability of various countries to volatility in addition to their exposure to it, as Combes and Guillaumont (2002) invite us to.

The smaller vulnerability of industrial countries relatively to developing ones could be explained on the one hand by the fact that price shocks could have reinforced the specialization patterns induced by the comparative advantages, and on the other hand by the ability of developed countries to recourse to financial markets or to elaborated contracts to hedge against the risk of price volatility.

Food price shocks and conflict:

The link between food price shocks and conflicts has been incidentally studied over the past 20 years (see e.g. Brinkman and Hendrix, 2011 for a review). Indeed, as most researchers

⁸⁵ See also Hausman and Gavin (1996) on the specific case of Latin America.

attempted to demonstrate a causal link from revenue to conflicts, they ended up instrumenting income with international commodity price shocks (including food commodities), and with weather shocks.

Low per capita incomes and slow economic growth are the two most robust correlates of civil war (Blattman and Miguel, 2010). Pinstруп-Andersen and Shimokawa (2008) also documented that the likelihood of armed conflict onset was significantly increased by economic poverty as well as by deteriorated health and nutritional status.

Three competing theories are usually used to explain how income can affect the likelihood of civil unrest: the opportunity cost to rebel, the State's ability to defend itself and the "State as a prize" theory (Bazzi and Blattman, 2014). The first theory goes that a wealthier population has more to lose with rebellion than poorer people. Hence, by lowering the opportunity cost of rebelling, a negative income shock can trigger civil unrest. The second theory links civil wars not to the population's average income, but rather to the State's revenue. A wealthier State has more leeway to support a strong military, to buy off the opposition, or to hire a militia. Hence, according to this theory, more revenues accruing to the State would make it more resilient. Eventually, the "State as a prize" theory poses that a wealthier State should be more desirable to opposition groups, and higher State income should therefore correlate with more numerous attempts to seize it (this is labeled the "rapacity effect" in Dube and Vargas, 2013). In order to disentangle the effects of the different theories (and manage the strong potential endogeneity) many authors instrumented income with commodity prices (agricultural or extractive) or with meteorological variables. These analyses enable us to assess the impact of food price shocks (or agricultural production shocks) on conflicts.

Miguel et al (2004) instrumented income growth with an annual rainfall index in Sub-Saharan Africa. They found that rainfall growth had been associated with fewer conflicts and were able to exhibit a strong causal link between income growth and conflict. Ciccone (2008) argued however that the effect of rainfall growth on civil conflict was not robust, contrary to that of rainfall shocks.⁸⁶

Instead of weather shocks, several studies investigated the consequences of price shocks affecting trade (most often commodity price shocks). Besley and Persson (2008) demonstrated that violence generally increased with more expensive import (thus supporting the opportunity cost theory), but also with higher export prices (a finding coherent with the State as a prize theory). Similarly, Brückner and Ciccone (2010) documented that civil wars in Sub-Saharan Africa were more likely to burst following a drop in the price of exported commodities. Analyzing district level Colombian data, Dube and Vargas (2013) showed that the likelihood of civil violence was higher in the agricultural regions when international coffee prices (and thus farmer's real income) fell, thus supporting the opportunity cost theory.⁸⁷ Bazzi and Blattman (2014) proposed a more systematic investigation of the directional impact of export price shocks

⁸⁶ "a 50% drop in rainfall levels raises the probability of civil conflict onset in the following year by 7 percentage points"

⁸⁷ The impact of oil price shocks is the opposite: higher international oil prices induce more violence in the areas where oil-extracting activities are dominant, indicating the prevalence of the rapacity effect. These findings are in line with the theoretical model developed by Dal Bó and Dal Bó (2004)

on conflicts, in order to disentangle between the three competing theories. Their results indicate that the joint effect of the opportunity cost and State resilience theories dominates the impact of the State as a prize theory, as higher export prices appear to lower conflicts. Additionally, they show that the main consequence of price shocks is not to increase the likelihood of conflict onset, but rather to extend the duration of existing conflicts. Carter and Bates (2011) argued however that it was necessary to include policy responses while modeling the impact of trade-related variables on civil wars, in order to account for the possible disconnect between domestic and border prices. Indeed, policies targeting urban consumers significantly decrease the risk of civil war. Several authors suggested that it was indeed a matter of political survival for governments to be seen to be trying to do something to address large income shocks (e.g. Poulton et al (2006) and Gouel (2013)).

Another strand of the literature focused more specifically on food riots.⁸⁸ Bush (2010) illustrated that food riots of the late 2000s were likely sparked by the surge in food prices, but that the crowds' messages were much broader (e.g. more civil and political freedom, less globalization). Looking at the 2008 and 2011 episodes, Lagi et al (2011) conceptualized food-related protests as a non-linearity. They hypothesized the existence of a price-threshold above which riots are likely to spring. Their hypothesis is that “widespread unrest does not arise from long-standing political failings of the system, but rather from its sudden perceived failure to provide essential security to the population”. Using his own food riot index, Bellemare (2015) was able to demonstrate that, between 1990 and 2011, high food prices had indeed caused more food riots over the world.⁸⁹ Looking at international macro-level panel data, Arezki and Brückner (2011) demonstrated that a rise in food prices was correlated with social unrest but also more generally to a deterioration in the quality of the political institutions.

Hendrix and Haggard (2011) analyzed data on urban unrest from 55 large cities spread across 49 developing countries between 1961 and 2010. They observed that food price rises were more likely to provoke civil unrest in democracies than in autocracies: they demonstrate that autocracies disproportionately implemented policies favoring the urban population relative to the rural ones, thus targeting their support to the denser areas, mechanically more prone to civil unrest. These findings are in line with Carter and Bates (2011) who showed that a policy bias toward the urban population significantly weakened the causal link between food prices and civil wars. Berazneva and Lee (2013) found that likelihood of a country experiencing food riots during the 2007-2008 food crisis was significantly correlated with its the food production index, as well as its poverty level and its degree of urbanization. Contrary to Hendrix and Haggard (2011), they observed that riots were more likely to burst in more oppressive regimes.

In a very recent publication, McGuirk and Burke (2017) investigated the impact of food price shocks on violence across Africa, distinguishing between “factor conflicts” (“large-scale conflict

⁸⁸ Note that Barbet-Gros and Cuesta (2014) tried to provide an operational definition of food riots and built a dataset of 55 such events between 2007 and 2014. Yet their index does not seem to have been much used in the academic literature.

⁸⁹ Bellemare (2015) is the only article we found that attempted to relate food price volatility to food riots, yet he was not able to conclude to a significant impact.

battles associated with the permanent control of territory”) and “output conflicts (“violence over the appropriation of surplus”). To some extent, their work covers both civil wars and food riots and enables them to document the strong impact of income shocks on conflicts. They found that, in food producing areas, high food prices tended to decrease conflict over the permanent control of territory: as farmers experience a positive income shock, the opportunity cost of soldiering becomes larger. Nevertheless, they note an increase in food riots and theft, indicating tensions on poor consumers’ budget constraints. In non-producing areas, both types of conflicts become more likely when prices rise, as the income shock is negative across the board.

Considering the potentially dreadful consequences of food price shocks in terms of civil wars and violence, several academics support the idea of international food aid responses. Yet, they point to some biases in aid allocation, and advocate for a support that would be much more focused on recipients’ needs rather than on donors’ surpluses (Blattman and Miguel, 2010, p.32). Nunn and Qian (2010) documented for instance that US food aid flows were largely determined by lagged US wheat production and donors’ strategic objectives. In a companion paper, Nunn and Qian (2014) were able to demonstrate a strong and significant causal link between the provision of food aid by the US and the incidence of civil conflict in the recipient country. The authors qualify this finding by showing that US food aid has no impact on the onset of conflicts, but rather on their duration. Taken together, these results are in line with observers’ accounts of fighting groups stealing food aid either en route or from the civilians once it has been distributed. This large scale diversion of food aid is said to fuel conflicts as it provides militias with resources to keep on the fight.

Given the empirical evidence that agricultural price shocks may cause civil unrest and wars, and knowing the dire impacts of civil wars and violence on economic growth (see Blattman and Miguel, 2010, or Gates et al, 2012), one can conclude to an indirect (but strong) effect of food price variations on growth and development.

Is it really optimal to care about volatility?

If it becomes clear that agricultural price volatility, and more generally macroeconomic volatility, is detrimental to economic growth and human development, one still needs to wonder whether the costs of a possible price stabilization mechanism could overcome the benefits of such a stabilization scheme.

Lucas (1987) and Newberry and Stiglitz (1981) show, by linearizing the equations around the equilibrium points, that price stabilization could be redundant, and that its costs would by no means be compensated by the alleged benefits. Newberry and Stiglitz add that the principal beneficiaries of such a price stabilization system could very well be the developed countries that are importing, and that some developing countries could actually be worse-off. Concerning the intra-national evolutions, Bellemare et al. (2010) conclude from their study on Ethiopia that the majority of the benefits from a stabilization of agricultural prices would be concentrated on the wealthiest 40% of the population. Furthermore, the study by Kannapiran (2000) on Papua-New

Guinea, shows that the commodity price stabilization mechanism had only a negligible effect on macroeconomic data (consumption and investment).

Yet, Aizenman et Pinto (2004) question the legitimacy of Newberry and Stiglitz' linearization (which is only valid around the equilibrium) and Myers (2006) explains that if the traditional welfare analysis (static) concludes that price stabilization does not lead to significant gains, nor benefits particularly the poorest (it would mainly benefit the large producers), when taking into account the threshold effects (food security) and the dynamic aspects (growth) in the analysis, the conclusion gets modified. Price stabilization could lead to very large improvements in the welfare of the poorest.⁹⁰ Ahmed (1988) had concluded from his study on rice price in Bangladesh that stabilization was beneficial and that the theoretical oppositions that were mentioned were not supported by his data.

Last, this literature review would not be complete if we were not to take into account the probable evolutions of agricultural price volatility. It is then very relevant and accurate to look at the alarming predictions on climate change that the international scientific community makes available to all. Indeed, climate change is most likely to lead to an increased frequency of extreme meteorological events such as draught and floods. When inserting estimates by the IPCC (International Panel on Climate Change) in a computable general equilibrium model, Ahmed, Diffenbaugh & Hertel (2009) manage to quantify the vulnerability of the poorest to potential changes in climate volatility. Their results indicate that some developing countries could see an increase in poverty. This increase could reach 5 percentage points for Mexico and up to 14 for Zambia. The authors show that the category of urban wage earners would be most affected: poverty could double in that category for Mexico, Malawi and Zambia for instance.

⁹⁰ "In summary, standard welfare analysis confirms the frequent findings in the literature that food price stabilization usually has small potential economic efficiency gains, has limited impacts on the poor, and generates the most benefits for large-scale food producers (Newberry and Stiglitz, 1981; Kannapiran, 2000; Larson et al., 2004). The potential gains from stabilization may be higher when poor consumers who produce little food spend a large proportion of their income on food, and are highly risk averse, make up a high proportion of the population. Include growth and food security effects, however, and the situation changes. Even small improvements in the rate of economic growth can generate large welfare gains. Similarly, even small increases in the probability of survival can generate relatively large welfare gains for food insecure households." Myers (2006), p.206

Conclusion

The impacts of food price volatility, although much talked about, have not been systematically investigated by the academic literature. To nevertheless provide insights on the likely consequences of the increased variability of food prices over the past decade, we broadened the scope of the survey so as to include conclusions regarding macroeconomic volatility, as well as food price shocks.

Our general analysis indicates that food price volatility could have very strong consequences on economic growth and development. Increased price risk generally tends to discourage private investment and distort production patterns, especially so in developing countries. As insufficient agricultural investment and production shortages have been pointed as potential explanations for the recent price shocks, volatility could very well be a self-reinforced process. Simultaneously, food price shocks proved to significantly alter the constitution of human capital, with particularly damaging consequences on nutrition and schooling. They were also associated with civil conflicts and more generally to social unrest. Bearing in mind that food price shocks are actually the realization of price risk, the likely consequences of food price volatility on long term development appear daunting.

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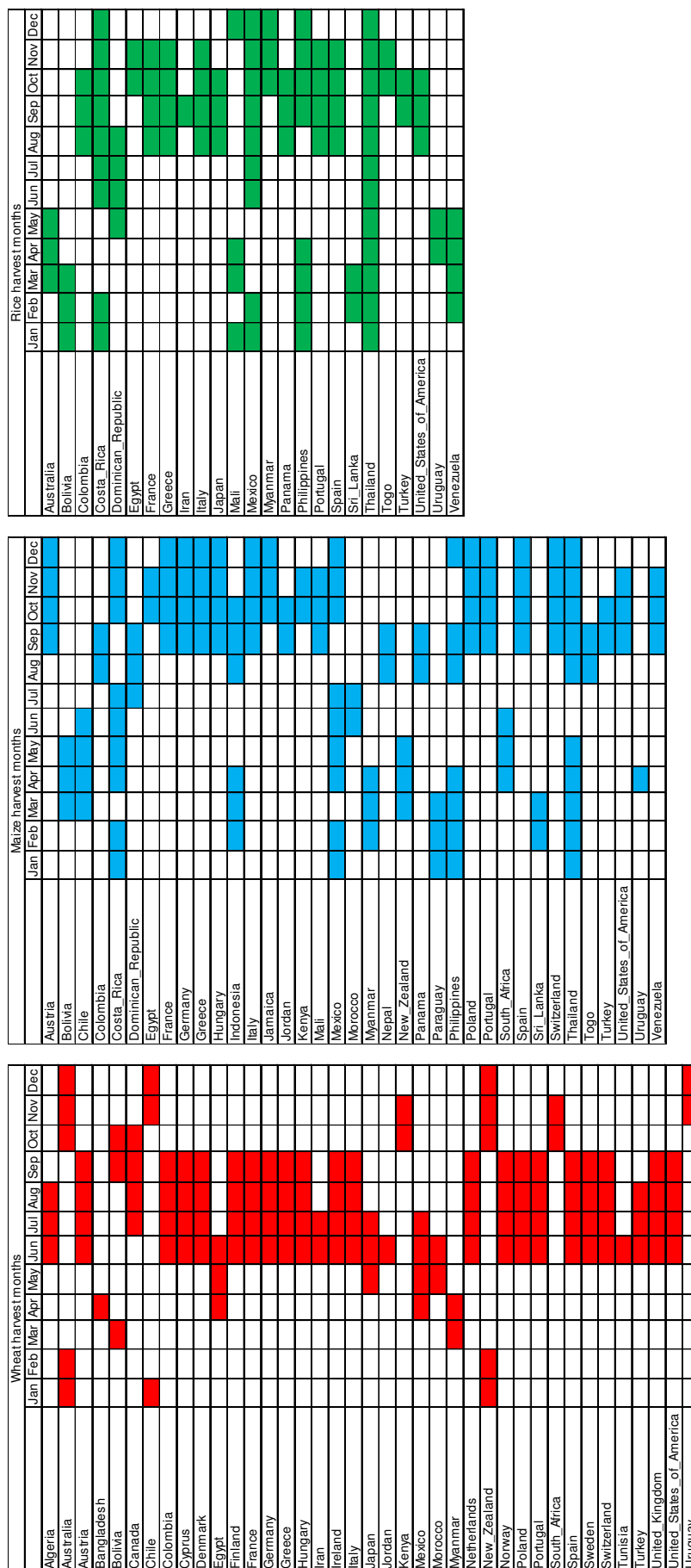
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APPENDIX 2: DEPICTION OF HARVEST MONTHS FOR SELECTED COUNTRIES

Graph 15A: Crop calendars (from de Winne and Peersmann, 2016)



APPENDIX 3: DATA COVERAGE FOR THE DOMESTIC PRODUCER PRICES

Table 23A: Full coverage over the period

	Countries with full coverage over 1970-2013			Countries with full coverage over 1970-1990			Countries with full coverage over 1991-2013		
	maize	rice	wheat	maize	rice	wheat	maize	rice	wheat
Algeria			X	X	X	X			X
Argentina							X		X
Australia		X	X	X	X	X		X	X
Austria	X		X	X	X	X	X		X
Bangladesh			X	X	X	X			X
Bolivia (Plurinational State of)	X	X	X	X	X	X	X	X	X
Burkina Faso				X	X				
Cambodia				X	X				
Cameroon				X	X				
Canada			X	X		X			X
Chile	X		X	X	X	X	X		X
China							X	X	
Colombia	X	X	X	X	X	X	X	X	X
Congo				X	X				
Costa Rica	X	X		X	X		X	X	
Cote Ivoire				X	X				
Cyprus			X			X			X
Denmark			X			X			X
Dominican Republic	X	X		X	X		X	X	
Egypt	X	X	X	X	X	X	X	X	X
El Salvador								X	
Finland			X			X			X
France	X	X	X	X	X	X	X	X	X
Germany	X		X	X		X	X		X
Ghana				X	X				
Greece	X	X	X	X	X	X	X	X	X
Honduras				X	X	X			
Hungary	X		X	X	X	X	X		X
India				X	X	X			
Indonesia	X			X	X		X		
Iran (Islamic Republic of)		X	X	X	X	X		X	X
Ireland			X			X			X
Israel				X		X			
Italy	X	X	X	X	X	X	X	X	X
Jamaica	X			X	X		X		
Japan		X	X	X	X	X		X	X
Jordan	X		X	X		X	X		X
Kenya	X		X	X	X	X	X		X
Lao People's Democratic Republic				X	X				
Lebanon				X		X			
Madagascar				X	X	X			
Malawi				X	X	X			
Mali	X	X		X	X	X	X	X	
Mauritius				X	X				
Mexico	X	X	X	X	X	X	X	X	X
Morocco	X		X	X	X	X	X		X
Myanmar	X	X	X	X	X	X	X	X	X
Namibia				X		X			
Nepal	X			X	X	X	X		
Netherlands			X	X		X			X
New Zealand	X		X	X		X	X		X
Nigeria				X	X	X			
Norway			X	X		X			X
Pakistan				X	X	X			
Panama	X	X		X	X		X	X	
Paraguay	X			X	X	X	X		
Peru							X	X	X
Philippines	X	X		X	X		X	X	
Poland	X		X	X		X	X		X
Portugal	X	X	X	X	X	X	X	X	X
Republic of Korea				X	X	X			
Romania				X	X	X			
Rwanda				X	X	X			
Senegal							X		
South Africa	X		X	X	X	X	X		X
Spain	X	X	X	X	X	X	X	X	X
Sri Lanka	X	X		X	X		X	X	
Sweden			X			X			X
Switzerland	X		X	X		X	X		X
Thailand	X	X		X	X		X	X	
Togo	X	X		X	X		X	X	
Trinidad and Tobago				X	X				
Tunisia			X			X			X
Turkey	X	X	X	X	X	X	X	X	X
United Kingdom			X			X			X
United States of America	X	X	X	X	X	X	X	X	X
Uruguay	X	X	X	X	X	X	X	X	X
Venezuela (Bolivarian Republic of)	X	X		X	X	X	X	X	
Yemen							X		X
Total général	37	25	39	66	54	55	42	28	42

Over the second sub-period, we indicate those countries with 22 points (+) and 21 points (°)

Table 24A: Almost full coverage over the second sub-period

Additional countries with full coverage only over 1991-2013			
	wheat	maize	rice
Albania		°	
Argentina	X	X	
Australia		°	
Cambodia			°
Chile			°
China	°	X	X
Cote Ivoire		°	°
Croatia	°		
Czech Republic	°	°	
El Salvador		+	X
Estonia	+		
Gambia		°	°
Ghana		°	°
Hungary			°
Indonesia			+
Iran (Islamic Republic of)		+	
Iraq		+	
Israel	°	°	
Kenya			°
Latvia	°		
Mongolia	°		
Nepal	+		+
Nicaragua		+	°
Nigeria	°	+	+
Paraguay	+		+
Peru	X	X	X
Romania	°	°	
Russian Federation	+	°	
Senegal		X	°
Slovakia	°	°	
Slovenia	+	+	
The former Yugoslav Republic of Macedonia	+	+	°
Viet Nam		+	
Yemen	X	X	
TOTAL	18	23	17

APPENDIX 5: SUMMARY CONCLUSIONS OF THE ADF TESTS

**Table 28A: Conclusions of ADF tests, full period (1970-2013)
44 data points**

Unit root tests results for the log level and first difference price series (and exchange rates) over the full 44 years period (1970-2013)
The table reports the MacKinnon approximate p-values (ADF with trend and no lag for the log-level series ; simple DF for the first-difference series)

cereal	wheat				maize				rice				Exchange rate
	domestic producer price (natural log)		international market price at time of harvest (natural log)		domestic producer price (natural log)		international market price at time of harvest (natural log)		domestic producer price (natural log)		international market price at time of harvest (natural log)		
price	\$	LCU	\$	LCU	\$	LCU	\$	LCU	\$	LCU	\$	LCU	
unit													
Algeria	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Australia	I(1)***	I(1)***	I(1)***	I(1)***							I(1)***	I(1)***	I(1)***
Austria	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Bangladesh	I(0)***	I(0)***	I(0)**	I(1)***									I(1)***
Bolivia	I(0)**	I(1)***	I(1)***	I(1)**	I(0)**	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**
Myanmar	I(1)***	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***
Canada	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Sri Lanka					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Chile	I(1)***	I(1)***	I(1)***	I(1) ^o	I(0)***	I(1)***	I(1)***	I(1)**					I(>1)
Colombia	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1) ^o
Costa Rica					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Cyprus	I(0)**	I(0)**	I(1)***	I(1)***									I(1)***
Denmark	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Dominican Rep					I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Egypt	I(1)***	I(1)***	I(1)***	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Finland	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
France	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Germany	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Greece	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***
Hungary	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)**
Indonesia					I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Iran	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Ireland	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Italy	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Jamaica					I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Japan	I(1)***	I(1)***	I(1)***	I(0)**					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Jordan	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Kenya	I(1)***	I(1)***	I(1)***	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***					I(1)***
Mali					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Mexico	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Morocco	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Nepal					I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Netherlands	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
New Zealand	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Norway	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Panama					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	NA
Paraguay					I(0)***	I(1)***	I(1)***	I(1)***					I(1)***
Philippines					I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Poland	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Portugal	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
South Africa	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Spain	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Sweden	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Switzerland	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Thailand					I(1)***	I(1)***	I(1)***	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***
Togo					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Tunisia	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Turkey	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
United Kingdom	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
USA	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	NA
Uruguay	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Venezuela					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***

I(0)*** (resp. I(0)**) means that the ADF test (trend and no lag) over the log-level series allows to reject the null of unit root at the 1% confidence level (resp. at the 5% confidence level).

I(1)*** (resp. I(1)**; I(1)*; I(1)^o) indicates that 1) the ADF test on the log-level series failed to reject the presence of a unit root at the 5% confidence level; and 2) the DF test on the first difference series allows to conclude to stationarity at the 1% confidence level (respectively at the 5%, 10% and 15% confidence levels).

The other series are considered integrated at a higher order, and are noted I(>1).

Table 29A: Conclusions of ADF tests, first sub-period (1970-1990)
21 data points

Unit root tests results for the log level and first difference price series (and exchange rates) over the first sub-period (1970-1990)
 The table reports the MacKinnon approximate p-values (ADF with trend and no lag for the log-level series ; simple DF for the first-difference series)

cereal	wheat				maize				rice				Exchange rate
	domestic producer price		international market price at time of harvest		domestic producer price		international market price at time of harvest		domestic producer price		international market price at time of harvest		
	(natural log)		(natural log)		(natural log)		(natural log)		(natural log)		(natural log)		
unit	\$	LCU	\$	LCU	\$	LCU	\$	LCU	\$	LCU	\$	LCU	
Algeria	I(1)***	I(1)**	I(1)**	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(>1)
Australia	I(1)**	I(1)*	I(1)°	I(1)°	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Austria	I(1)**	I(1)*	I(1)**	I(1)**	I(1)**	I(1)**	I(1)***	I(1)**					I(1)**
Bangladesh	I(0)***	I(0)***	I(1)***	I(1)***	I(0)**	I(0)**	I(1)**	I(1)***	I(0)***	I(0)**	I(1)**	I(1)***	I(1)***
Bolivia	I(1)***	I(1)*	I(1)*	I(>1)	I(0)**	I(1)*	I(1)***	I(>1)	I(1)***	I(1)*	I(1)***	I(>1)	I(>1)
Myanmar	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)*	I(1)***	I(1)**	I(1)**	I(1)**
Cameroon					I(1)***	I(1)***	I(1)***	I(1)***	I(>1)	I(>1)	I(1)**	I(1)*	I(1)*
Canada	I(1)**	I(1)*	I(1)**	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***					I(1)*
Sri Lanka					I(1)***	I(1)***	I(1)***	I(1)***	I(1)*	I(1)**	I(1)***	I(1)***	I(1)***
Chile	I(1)***	I(1)*	I(1)°	I(>1)	I(0)**	I(1)*	I(1)***	I(>1)	I(1)***	I(>1)	I(1)***	I(>1)	I(>1)
Colombia	I(1)***	I(1)°	I(1)**	I(1)*	I(1)***	I(1)*	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(1)**	I(>1)
Congo					I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)*
Costa Rica					I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)*	I(1)**
Cyprus	I(1)*	I(1)°	I(1)**	I(1)**									I(1)*
Denmark	I(1)**	I(1)*	I(1)**	I(1)**									I(1)°
Dominican Rep					I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***
Egypt	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Finland	I(1)**	I(1)**	I(1)**	I(1)**									I(>1)
France	I(1)**	I(1)**	I(1)**	I(1)**	I(1)**	I(1)°	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(1)**	I(1)*
Germany	I(1)**	I(1)**	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**					I(1)*
Ghana					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)°	I(1)***
Greece	I(1)***	I(1)*	I(1)**	I(1)*	I(1)°	I(>1)	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)*	I(>1)
Honduras	I(>1)	I(>1)	I(1)***	I(1)**	I(1)***	I(1)*	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**	I(>1)
Hungary	I(>1)	I(>1)	I(1)**	I(1)*	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(>1)	I(1)**	I(1)**	I(>1)
India	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(1)**	I(1)**	I(1)**	I(1)°
Indonesia					I(1)**	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(1)**	I(1)***
Iran	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***
Ireland	I(1)***	I(1)***	I(1)**	I(1)*									I(1)*
Israel	I(1)***	I(>1)	I(1)**	I(>1)	I(1)***	I(>1)	I(1)***	I(>1)					I(>1)
Italy	I(1)**	I(1)**	I(1)**	I(1)*	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(1)**	I(1)*
Cote Ivoire					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)**	I(1)*
Jamaica					I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)***	I(1)**	I(1)*	I(1)**
Japan	I(1)*	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)**	I(1)**	I(1)***
Jordan	I(1)***	I(1)*	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)**					I(1)°
Kenya	I(1)***	I(1)**	I(1)°	I(>1)	I(1)***	I(1)**	I(1)***	I(1)**	I(>1)	I(>1)	I(1)**	I(1)**	I(>1)
Cambodia					I(>1)	I(1)*	I(1)***	I(1)**	I(>1)	I(1)*	I(1)**	I(1)**	I(1)***
Rep of Korea	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**
Lao PDR					I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(0)***	I(1)**	I(1)***	I(1)***
Lebanon	I(1)**	I(>1)	I(1)**	I(>1)	I(1)***	I(>1)	I(1)***	I(>1)					I(>1)
Madagascar	I(1)**	I(1)*	I(1)°	I(>1)	I(1)***	I(1)**	I(1)***	I(1)*	I(1)**	I(1)*	I(1)***	I(1)**	I(1)°
Malawi	I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(0)***	I(1)***	I(1)***	I(1)**	I(>1)
Mali	I(1)**	I(1)**	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)°	I(1)***	I(1)**	I(1)**
Mauritius					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)*
Mexico	I(1)***	I(1)*	I(1)***	I(1)°	I(1)**	I(1)°	I(1)***	I(>1)	I(1)***	I(1)*	I(1)**	I(>1)	I(>1)
Morocco	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)°
Namibia	I(1)**	I(1)**	I(1)°	I(1)°	I(1)***	I(1)***	I(1)***	I(1)***					I(1)**
Nepal	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)*
Netherlands	I(1)**	I(1)**	I(1)**	I(1)**	I(1)**	I(1)**	I(1)***	I(1)**					I(1)*
New Zealand	I(1)***	I(1)*	I(1)°	I(>1)	I(1)***	I(1)**	I(1)***	I(1)***					I(>1)
Nigeria	I(0)***	I(1)***	I(1)***	I(1)*	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)°	I(1)°
Norway	I(1)***	I(1)**	I(1)**	I(1)*	I(1)**	I(1)*	I(1)***	I(1)**					I(>1)
Pakistan	I(1)***	I(1)***	I(1)***	I(1)***	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Panama					I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	NA
Paraguay	I(1)**	I(1)**	I(1)°	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Philippines					I(1)***	I(1)***	I(1)**	I(1)*	I(1)***	I(1)**	I(1)**	I(1)*	I(>1)
Poland	I(1)***	I(>1)	I(1)**	I(>1)	I(1)***	I(>1)	I(1)***	I(>1)					I(>1)
Portugal	I(1)***	I(1)*	I(1)**	I(1)*	I(1)***	I(1)*	I(1)***	I(1)*	I(1)**	I(1)°	I(1)**	I(1)*	I(>1)
Romania	I(1)**	I(1)*	I(1)**	I(1)*	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)**	I(1)°
Rwanda	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)°	I(1)*	I(1)***	I(1)***	I(1)**
South Africa	I(1)**	I(1)**	I(1)°	I(1)°	I(1)**	I(1)**	I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)**	I(1)**
Spain	I(1)**	I(1)°	I(1)**	I(1)*	I(1)**	I(1)°	I(1)***	I(1)*	I(1)***	I(1)**	I(1)**	I(1)*	I(>1)
Sweden	I(1)*	I(>1)	I(1)**	I(1)*									I(>1)
Switzerland	I(1)**	I(1)**	I(1)**	I(1)**	I(1)**	I(1)**	I(1)***	I(1)**					I(1)**
Thailand					I(1)**	I(1)**	I(1)***	I(1)**	I(1)*	I(1)*	I(1)***	I(1)**	I(1)***
Togo					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Trinidad and T					I(1)*	I(1)*	I(1)***	I(1)***	I(1)*	I(1)**	I(1)**	I(1)**	I(1)***
Tunisia	I(1)***	I(1)*	I(1)***	I(1)**									I(1)°
Turkey	I(1)**	I(1)**	I(1)**	I(1)*	I(1)**	I(1)*	I(1)***	I(1)*	I(1)***	I(1)***	I(1)***	I(1)*	I(1)°
United Kingdom	I(1)**	I(1)*	I(1)**	I(1)*									I(1)°
USA	I(1)*	I(1)*	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	NA
Burkina Faso					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)**	I(1)*
Uruguay	I(1)**	I(1)**	I(>1)	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***
Venezuela	I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***

Table 30A: Conclusions of ADF tests, second sub-period (1991-2013)

23 data points

Unit root tests results for the log level and first difference price series (and exchange rates) over the second sub-period (1991-2013)

The table reports the MacKinnon approximate p-values (ADF with trend and no lag for the log-level series ; simple DF for the first-difference series)

cereal	wheat				maize				rice				Exchange rate
	domestic producer price (natural log)		international market price at time of harvest (natural log)		domestic producer price (natural log)		international market price at time of harvest (natural log)		domestic producer price (natural log)		international market price at time of harvest (natural log)		
	\$	LCU	\$	LCU	\$	LCU	\$	LCU	\$	LCU	\$	LCU	
Algeria	I(1)***	I(1)***	I(1)***	I(1)***									I(1)°
Argentina	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Australia	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Austria	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)**					I(1)**
Bangladesh	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Bolivia	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)°	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(>1)
Myanmar	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)°	I(1)**
Canada	I(1)***	I(1)***	I(1)***	I(1)***									I(1)**
Sri Lanka					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Chile	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***					I(1)*
Colombia	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)**	I(1)*
Costa Rica					I(1)***	I(1)***	I(1)***	I(1)***	I(>1)	I(>1)	I(1)***	I(1)***	I(>1)
Cyprus	I(1)***	I(1)***	I(1)***	I(1)***									I(1)**
Denmark	I(1)***	I(1)***	I(1)***	I(1)**									I(1)***
Dominican Rep					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Egypt	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)°	I(1)***	I(1)***	I(1)°
El Salvador									I(1)***	I(1)***	I(1)***	I(1)***	NA
Finland	I(1)***	I(1)***	I(1)***	I(1)**									I(1)***
France	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Germany	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)**					I(1)**
Greece	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Hungary	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)*					I(>1)
Indonesia					I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Iran	I(1)***	I(1)*	I(1)***	I(1)**					I(1)***	I(1)***	I(1)***	I(1)**	I(>1)
Ireland	I(1)***	I(1)***	I(1)***	I(1)***									I(1)**
Italy	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Jamaica					I(1)***	I(1)***	I(1)**	I(1)***					I(0)***
Japan	I(1)***	I(1)**	I(1)***	I(1)***					I(1)***	I(1)**	I(1)***	I(1)***	I(1)*
Jordan	I(0)**	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Kenya	I(1)***	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(0)**
Mali					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***
Mexico	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Morocco	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
Nepal					I(1)***	I(1)***	I(1)***	I(1)**					I(1)***
Netherlands	I(1)***	I(1)***	I(1)***	I(1)**									I(1)**
New Zealand	I(1)***	I(1)**	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***					I(1)**
Norway	I(1)***	I(1)**	I(1)***	I(1)***									I(1)***
Panama					I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	NA
Paraguay					I(0)**	I(1)***	I(1)***	I(1)***					I(1)*
Peru	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)*	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(0)***
Philippines					I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)**	I(1)***	I(1)**	I(1)***
Poland	I(1)***	I(1)***	I(1)***	I(1)**	I(1)***	I(1)***	I(1)**	I(1)**					I(1)**
Portugal	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Senegal					I(1)***	I(1)***	I(1)***	I(1)***					I(1)***
South Africa	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(1)**
Spain	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**
Sweden	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Switzerland	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**					I(1)***
Thailand					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)**	I(1)**
Togo					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Tunisia	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
Turkey	I(1)***	I(1)**	I(1)***	I(>1)	I(1)***	I(1)°	I(1)***	I(1)*	I(1)***	I(1)°	I(1)***	I(1)°	I(>1)
United Kingdom	I(1)***	I(1)***	I(1)***	I(1)***									I(1)***
USA	I(1)**	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	NA
Uruguay	I(1)***	I(1)***	I(1)***	I(1)*	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)*
Venezuela					I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***
Yemen	I(1)***	I(1)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***					I(>1)
China					I(0)**	I(0)**	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***	I(1)***

APPENDIX 6: SUMMARY OF THE CO-INTEGRATION TESTS (ADF ON THE RESIDUAL)

**Table 31A: Conclusions of the co-integration tests, full period (1970-2013)
44 data points**

Cointegration tests for the price series with DF and ADF (with and without trend, up to 3 lags)

	Prices in dollars						Prices in LCU					
	DF on the residual			Min ADF on the residual			DF on the residual			Min ADF on the residual		
	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice
Algeria	NO CI			CI*			CI°			CI°		
Australia	CI***		CI**	CI***		CI***	CI***		CI***		CI***	CI***
Austria	NO CI	CI*		NO CI	CI*		NO CI	CI*		NO CI	CI*	
Bangladesh	CI***			CI***			CI***			CI***		
Bolivia	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***
Myanmar	CI***	CI***	CI°	CI***	CI***	CI**	CI***	CI***	CI***	CI***	CI***	CI***
Canada	CI°			CI*			CI°			CI*		
Sri Lanka		CI°	CI**		CI°	CI***		CI*	CI**		CI*	CI**
Chile	CI**	CI***		CI***	CI***		CI***	CI***		CI***	CI***	
Colombia	CI**	CI**	NO CI	CI***	CI**	CI**	CI***	CI***	CI***	CI***	CI***	CI***
Costa Rica		CI***	NO CI		CI***	CI*		CI***	CI***		CI***	CI***
Cyprus	CI**			CI**			CI***			CI***		
Denmark	CI*			CI*			CI*			CI**		
Dominican Rep		CI**	CI°		CI***	CI*		CI***	CI*		CI***	CI*
Egypt	CI°	CI***	NO CI	CI*	CI***	CI***	CI**	CI***	CI***	CI**	CI***	CI***
Finland	NO CI			NO CI			NO CI			NO CI		
France	CI*	CI**	CI*	CI*	CI**	CI*	CI**	CI**	CI**	CI**	CI**	CI**
Germany	CI°	CI**		CI°	CI**		CI**	CI**		CI**	CI**	
Greece	NO CI	CI**	CI**	NO CI	CI**	CI**	NO CI	CI**	NO CI	CI**	NO CI	NO CI
Hungary	CI***	CI***		CI***	CI***		CI***	CI***		CI***	CI***	
Indonesia		CI***			CI***			CI***			CI***	
Iran	CI°		CI°	CI°		CI°		CI°		CI**		CI°
Ireland	CI***			CI***			CI***			CI***		
Italy	CI*	CI°	CI*	CI**	CI*	CI*	CI*	CI°	CI*	CI**	CI°	CI*
Jamaica		NO CI			CI*			CI*			CI***	
Japan	NO CI		NO CI	NO CI		CI**	NO CI		NO CI	NO CI		CI°
Jordan	CI***	CI**		CI***	CI***		CI***	CI**		CI***	CI***	
Kenya	CI*	CI*		CI***	CI***		CI**	CI***		CI***	CI***	
Mali		CI**	NO CI		CI**	NO CI		CI**	CI*		CI**	CI*
Mexico	CI***	NO CI	CI***	CI***	CI*	CI***	CI***	NO CI	CI**	CI***	NO CI	CI***
Morocco	CI***	CI**		CI***	CI**		CI***	CI**		CI***	CI***	
Nepal		CI**			CI**			CI***			CI***	
Netherlands	CI°			CI°			CI**			CI**		
New Zealand	CI***	CI**		CI***	CI***		CI***	CI**		CI***	CI***	
Norway	NO CI			CI°			NO CI			CI°		
Panama		NO CI	NO CI		CI*	CI*		NO CI	NO CI		CI*	CI*
Paraguay		CI***			CI***			CI***			CI***	
Philippines		CI***	NO CI		CI***	CI**		CI***	CI***		CI***	CI***
Poland	CI**	CI***		CI***	CI***		CI***	CI***		CI***	CI***	
Portugal	NO CI	CI*	NO CI	NO CI	CI*	CI°	NO CI	NO CI	CI*	NO CI	CI°	CI*
South Africa	CI**	CI***		CI**	CI***		CI***	CI***		CI***	CI***	
Spain	CI*	CI°	NO CI	CI*	CI*	NO CI	CI*	CI°	CI°	CI**	CI**	CI°
Sweden	CI*			CI*			CI*			CI*		
Switzerland	NO CI	CI*		CI°	CI*		NO CI	NO CI		NO CI	NO CI	
Thailand		CI***	CI***		CI***	CI***		CI***	CI***		CI***	CI***
Togo		CI***	CI**		CI***	CI***		CI***	CI**		CI***	CI**
Tunisia	NO CI			NO CI			NO CI			NO CI		
Turkey	CI***	CI**	CI*	CI***	CI**	CI**	CI***	CI***	CI*	CI***	CI***	CI*
United Kingdom	CI*			CI**			CI**			CI**		
USA	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***
Uruguay	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***
Venezuela		CI**	CI*		CI**	CI*		CI**	CI***		CI**	CI***

TOTAL NO CI	9	3	9	6	0	2	8	4	3	7	2	1
TOTAL CI	30	34	16	33	37	23	31	33	22	32	35	24

Table 32A: Conclusions of the co-integration tests, first sub-period (1970-1990)
21 data points

Cointegration tests for the price series with DF and ADF (with and without trend, up to 3 lags)
 First sub-period (1970-1990)

	Prices in dollars						Prices in LCU					
	DF on the residual			Min ADF on the residual			DF on the residual			Min ADF on the residual		
	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice
Algeria	NO CI	NO CI	NO CI	NO CI	CI*	CI**	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI
Australia	CI***	CI**	CI***	CI***	CI**	CI***	CI***	CI**	CI***	CI***	CI**	CI***
Austria	NO CI	NO CI			CI**	NO CI	NO CI	NO CI		CI***	CI**	
Bangladesh	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***
Bolivia	CI***	CI**	CI**	CI***	CI***	CI**	CI***	CI***	CI***	CI***	CI***	CI***
Myanmar	CI*	NO CI	NO CI	CI*	NO CI	NO CI	CI*	NO CI	CI*	NO CI	CI***	CI***
Cameroon		NO CI	NO CI		NO CI	CI*		NO CI	NO CI	NO CI	CI°	
Canada	NO CI	CI***		NO CI	CI***		NO CI	CI***	NO CI	CI***		
Sri Lanka		CI*	NO CI		CI*	CI*		NO CI	CI*	NO CI	CI*	
Chile	CI°	CI***	CI**	CI***	CI***	CI**	CI***	CI***	CI**	CI***	CI***	CI***
Colombia	CI°	NO CI	NO CI	CI**	NO CI	NO CI	CI***	CI*	CI°	CI***	CI*	CI**
Congo		CI°	NO CI		CI***	NO CI		CI*	NO CI		CI***	NO CI
Costa Rica		CI*	NO CI		CI**	NO CI		CI***	CI**		CI***	CI**
Cyprus	NO CI			CI***			NO CI			CI*		
Denmark	NO CI			CI*			CI°			CI**		
Dominican Rep		NO CI	NO CI		CI***	CI***		CI***	CI*		CI***	CI**
Egypt	NO CI	CI**	NO CI	NO CI	CI**	NO CI	NO CI	CI**	CI**	NO CI	CI**	CI***
Finland	NO CI			NO CI			NO CI			NO CI		
France	NO CI	NO CI	NO CI	CI*	CI*	CI**	CI°	CI°	NO CI	CI**	CI**	CI**
Germany	CI°	CI**		CI*	CI**		CI*	CI**		CI**	CI***	
Ghana		CI°	NO CI		CI°	CI**		CI*	CI*	CI*	CI*	CI***
Greece	NO CI	NO CI	NO CI	NO CI	NO CI	CI***	NO CI	CI*	CI***	NO CI	CI**	CI***
Honduras	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	CI*	NO CI	NO CI
Hungary	CI*	NO CI	NO CI	CI**	CI**	NO CI	NO CI	CI**	NO CI	NO CI	NO CI	NO CI
India	CI***	CI***	CI*	CI***	CI***	CI*	CI***	CI**	NO CI	CI***	CI***	CI°
Indonesia		CI*	NO CI		CI***	NO CI		CI*	CI*		CI**	CI*
Iran	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI
Ireland	CI°			CI*			CI*			CI**		
Israel	CI*	NO CI		CI***	CI***		CI***	NO CI		CI***	CI**	
Italy	NO CI	NO CI	NO CI	CI°	CI°	NO CI	NO CI	CI°	CI°	CI**	CI**	CI°
Cote Ivoire		NO CI	CI*		CI°	CI**		NO CI	CI*		CI°	CI***
Jamaica		NO CI	NO CI		CI*	CI*		NO CI	NO CI		CI**	CI°
Japan	NO CI	NO CI	NO CI	CI***	CI**	CI**	CI*	NO CI	NO CI	CI***	CI***	CI***
Jordan	NO CI	CI*		NO CI	CI*		NO CI	CI*		NO CI	CI**	
Kenya	NO CI	NO CI	NO CI	CI*	CI*	CI***	CI°	CI*	NO CI	CI**	CI*	CI***
Cambodia		NO CI	NO CI		NO CI	NO CI		CI°	NO CI		CI°	NO CI
Rep of Korea	NO CI	NO CI	NO CI	CI***	NO CI	CI**	NO CI	NO CI	NO CI	CI**	CI**	CI°
Lao PDR		CI**	CI**		CI**	CI**		CI°	CI*		CI*	CI**
Lebanon	CI*	CI°		CI*	CI*		CI***	CI°		CI***	CI*	
Madagascar	NO CI	NO CI	NO CI	NO CI	CI**	CI*	CI**	CI°	CI**	CI***	CI°	CI**
Malawi	NO CI	CI°	CI***	CI***	CI***	CI***	NO CI	CI*	CI**	CI**	CI*	CI***
Mali	NO CI	NO CI	NO CI	CI***	NO CI	NO CI	NO CI	NO CI	NO CI	CI**	NO CI	NO CI
Mauritius		NO CI	NO CI		CI**	CI*		CI*	NO CI		CI***	CI**
Mexico	NO CI	NO CI	CI*	CI**	CI***	CI***	CI***	CI**	CI*	CI***	CI***	CI***
Morocco	CI**	NO CI	NO CI	CI*	CI°	CI*	CI**	NO CI	CI°	CI**	CI°	CI***
Namibia	NO CI	NO CI		CI*	CI**		CI*	NO CI		CI**	CI°	
Nepal	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	CI**	NO CI	CI**	CI***	CI**
Netherlands	CI°	NO CI		CI**	NO CI		CI*	CI°		CI**	CI**	
New Zealand	CI°	NO CI		CI***	CI*		CI***	CI°		CI***	CI**	
Nigeria	CI*	CI**	CI°	CI*	CI**	CI°	CI**	CI**	CI°	CI**	CI**	CI°
Norway	NO CI	NO CI		NO CI	CI***		NO CI	NO CI	NO CI	NO CI	CI*	
Pakistan	NO CI	NO CI	NO CI	CI***	NO CI	CI***	CI***	NO CI	CI*	CI***	CI**	CI***
Panama		NO CI	NO CI		CI°	CI*		NO CI	NO CI		CI°	CI*
Paraguay	NO CI	CI***	CI*	NO CI	CI***	CI*	NO CI	CI***	CI*	CI**	CI***	CI*
Philippines		CI**	NO CI		CI***	CI***		CI***	CI***		CI***	CI***
Poland	NO CI	CI**		NO CI	CI**		CI*	CI*		CI**	CI***	
Portugal	NO CI	NO CI	NO CI	NO CI	NO CI	CI***	NO CI	CI*	CI*	CI**	CI**	CI**
Romania	CI***	CI°	NO CI	CI***	CI***	CI***	NO CI	NO CI	NO CI	CI***	CI**	CI***
Rwanda	NO CI	NO CI	NO CI	CI*	CI**	NO CI	NO CI	NO CI	NO CI	CI*	CI***	NO CI
South Africa	NO CI	CI°	NO CI	CI**	CI**	CI*	CI*	CI*	CI°	CI**	CI**	CI°
Spain	NO CI	NO CI	NO CI	CI*	CI**	CI***	NO CI	NO CI	NO CI	CI**	CI*	NO CI
Sweden	NO CI			CI*			NO CI			CI**		
Switzerland	NO CI	NO CI		CI**	CI**		NO CI	NO CI		CI***	CI***	
Thailand		NO CI	CI*		CI**	CI***		NO CI	CI**		CI**	CI***
Togo		CI**	NO CI		CI**	CI*		CI**	NO CI		CI***	CI*
Trinidad and T		NO CI	NO CI		CI**	NO CI		NO CI	NO CI		CI**	NO CI
Tunisia	NO CI			CI**			CI*			CI*		
Turkey	CI**	CI*	NO CI	CI**	CI*	NO CI	CI***	CI**	CI*	CI***	CI**	CI**
United Kingdom	NO CI			CI**			NO CI			CI**		
USA	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***
Burkina Faso		NO CI	NO CI		NO CI	CI**		NO CI	CI*		NO CI	CI*
Uruguay	NO CI	CI**	CI*	NO CI	CI***	CI***	NO CI	CI**	CI***	NO CI	CI***	CI***
Venezuela	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	CI°	NO CI	NO CI	CI*
TOTAL NO CI	36	39	40	16	17	17	26	27	22	10	10	10
TOTAL CI	19	27	14	39	49	37	29	39	32	45	56	44

Table 33A: Conclusions of the co-integration tests, second sub-period (1991-2013)
23 data points

Cointegration tests for the price series with DF and ADF (with and without trend, up to 3 lags)
 Second sub-period (1991-2013)

	Prices in dollars						Prices in LCU					
	DF on the residual			Min ADF on the residual			DF on the residual			Min ADF on the residual		
	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice
Algeria	NO CI			CI**			CI°			CI***		
Argentina	NO CI	CI***		NO CI	CI***		NO CI	CI***	NO CI	CI***		
Australia	CI***		CI*	CI***		CI*	CI***		CI***		CI**	
Austria	CI°	CI**		CI**	CI***		CI°	CI**	CI***	CI**		
Bangladesh	CI***			CI***			CI***		CI***			
Bolivia	NO CI	NO CI	NO CI	NO CI	NO CI	CI**	NO CI	NO CI	NO CI	NO CI	NO CI	CI*
Myanmar	CI***	CI**	CI***	CI***	CI**	CI***	CI***	CI**	CI**	CI***	CI***	CI**
Canada	NO CI			CI*			NO CI			CI*		
Sri Lanka		CI*	CI**		CI**	CI**		NO CI	NO CI		CI**	NO CI
Chile	CI**	CI**		CI**	CI**		CI*	NO CI	CI*	CI°		
Colombia	CI*	CI**	CI°	CI**	CI**	CI*	CI**	NO CI	CI°	CI***	CI*	CI°
Costa Rica		CI*	NO CI		CI*	CI*		CI**	NO CI		CI**	CI***
Cyprus	CI***			CI***			CI***			CI***		
Denmark	CI*			CI***			CI*			CI***		
Dominican Rep		CI***	CI°		CI***	CI*		CI°	NO CI		CI***	CI*
Egypt	CI*	CI**	CI**	CI*	CI**	CI**	CI*	CI**	CI°	CI*	CI**	CI°
El Salvador			CI**						CI**			CI***
Finland	CI*			CI***			CI**			CI***		
France	CI**	CI**	NO CI	CI**	CI**	NO CI	CI**	CI**	NO CI	CI**	CI**	NO CI
Germany	CI*	CI**		CI***	CI***		CI*	CI**		CI***	CI***	
Greece	NO CI	CI**	NO CI	NO CI	CI**	NO CI	NO CI	CI*	NO CI	NO CI	CI*	CI**
Hungary	CI***	CI***		CI***	CI***		CI***	CI***		CI***	CI***	
Indonesia		CI***			CI***			CI***			CI***	
Iran	CI*		CI***	CI***		CI***	CI**		CI***			CI***
Ireland	CI***			CI***			CI***			CI***		
Italy	CI**	CI**	CI*	CI***	CI**	CI*	CI**	CI**	CI*	CI***	CI***	CI*
Jamaica		NO CI			CI*			CI*			CI***	
Japan	NO CI		NO CI	NO CI		NO CI	NO CI		NO CI	CI**		CI**
Jordan	CI***	CI*		CI***	CI***		CI***	CI*		CI***	CI***	
Kenya	NO CI	CI*		CI***	CI***		CI*	CI**		CI***	CI***	
Mali		CI**	CI***		CI**	CI***		CI***	CI**		CI***	CI**
Mexico	CI**	NO CI	CI***	CI**	CI***	CI***	CI*	NO CI	NO CI	CI*	CI°	CI*
Morocco	CI***	CI*		CI***	CI**		CI***	CI°		CI***	CI**	
Nepal		CI**			CI***			CI***			CI***	
Netherlands	CI**			CI**			CI**			CI**		
New Zealand	CI***	CI***		CI***	CI***		CI***	CI***		CI***	CI***	
Norway	CI**			CI**			CI**			CI**		
Panama		NO CI	NO CI			CI°		NO CI	NO CI		CI°	NO CI
Paraguay		CI***			CI***			CI***			CI***	
Peru	CI*	CI*	CI***	CI*	CI***	CI***	CI**	CI**	CI**	CI**	CI***	CI***
Philippines		CI**	CI°		CI**	CI°		CI°	NO CI		CI***	NO CI
Poland	CI***	CI***		CI***	CI***		CI***	CI*		CI***	CI**	
Portugal	CI**	CI*	NO CI	CI**	CI**	NO CI	CI**	CI°	NO CI	CI***	CI**	NO CI
Senegal		CI**			CI**		CI**	CI**			CI***	
South Africa	CI**	CI***		CI**	CI***		CI**	CI**		CI***	CI***	
Spain	CI**	CI*	NO CI	CI**	CI**	CI°	CI**	CI°	NO CI	CI**	CI**	CI°
Sweden	CI**			CI***			CI***			CI***		
Switzerland	NO CI	NO CI		NO CI	NO CI		NO CI	NO CI	NO CI	NO CI	NO CI	
Thailand		CI***	CI***		CI***	CI***		CI***		CI***	CI***	CI***
Togo		CI***	CI**		CI***	CI***		CI**	CI**		CI***	CI***
Tunisia	NO CI			CI**			NO CI			CI*		
Turkey	CI*	CI*	CI°	CI***	CI*	CI***	CI**	CI°	NO CI	CI***	CI**	CI*
United Kingdom	CI**			CI**			CI**			CI***		
USA	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***	CI***
Uruguay	CI***	CI*	CI**	CI***	CI*	CI***	CI***	NO CI	CI°	CI***	CI**	CI***
Venezuela		CI**	CI*		CI**	CI**		CI***	CI**		CI***	CI**
Yemen	NO CI	NO CI		CI*	CI*		NO CI	NO CI		CI***	CI***	CI**
China		CI**	CI°		CI**	CI**		CI**	NO CI		CI**	CI**
TOTAL NO CI	10	6	8	5	2	5	8	9	14	4	2	5
TOTAL CI	32	36	20	37	40	23	34	33	14	38	40	23

**APPENDIX 7: SUMMARY OF THE CO-INTEGRATION TESTS
(PESARAN, SHIN, SMITH BOUNDS TESTING PROCEDURE)**

Table 34A: Bounds testing on the full period (unrestricted intercept, no time trend)

	\$			LCU			ER		
	wheat	maize	rice	wheat	maize	rice	wheat	maize	rice
	10%	10%	10%	10%	10%	10%	10%	10%	10%
Algeria	"CI**"			"CI**"			NO CI		
Australia	"CI**"		NO CI	"CI**"		NO CI	"CI**"		"CI**"
Austria	NO CI	NO CI		NO CI	NO CI		NO CI	NO CI	
Bangladesh	NO CI			NO CI			"CI**"		
Bolivia	"CI**"	"CI**"	NO CI	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"	NO CI
Canada	NO CI			NO CI			NO CI		
Chile	"CI**"	"CI**"		"CI**"	"CI**"		"CI**"	"CI**"	
Colombia	"CI**"	"CI**"	NO CI	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"
Costa_Rica		"CI**"	NO CI		"CI**"	"CI**"		"CI**"	NO CI
Cyprus	"CI**"			"CI**"			NO CI		
Denmark	NO CI			NO CI			NO CI		
Dominican_Republic		NO CI	NO CI		"CI**"	"CI**"		NO CI	NO CI
Egypt	NO CI	NO CI	NO CI	"CI**"	"CI**"	NO CI	"CI**"	NO CI	"CI**"
Finland	NO CI			NO CI			NO CI		
France	"CI**"	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	"CI**"	NO CI
Germany	NO CI	NO CI		"CI**"	"CI**"		"CI**"	"CI**"	
Greece	NO CI	"CI**"	"CI**"	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI
Hungary	"CI**"	"CI**"		"CI**"	"CI**"		"CI**"	NO CI	
Indonesia		"CI**"			"CI**"			"CI**"	
Iran	"CI**"		NO CI	"CI**"		"CI**"	NO CI		NO CI
Ireland	"CI**"			"CI**"			"CI**"		
Italy	"CI**"	NO CI	"CI**"	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI
Jamaica		NO CI			"CI**"			NO CI	
Japan	NO CI		"CI**"	NO CI		NO CI	NO CI		NO CI
Jordan	NO CI	NO CI		"CI**"	"CI**"		NO CI	NO CI	
Kenya	"CI**"	NO CI		"CI**"	"CI**"		"CI**"	"CI**"	
Mali		"CI**"	NO CI		NO CI	NO CI		"CI**"	NO CI
Mexico	"CI**"	NO CI	"CI**"	"CI**"	"CI**"	"CI**"	NO CI	NO CI	"CI**"
Morocco	"CI**"	"CI**"		"CI**"	"CI**"		NO CI	"CI**"	
Myanmar	"CI**"	NO CI	NO CI	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"
Nepal		NO CI			NO CI			NO CI	
Netherlands	NO CI			NO CI			"CI**"		
New_Zealand	"CI**"	NO CI		"CI**"	NO CI		"CI**"	"CI**"	
Norway	"CI**"			NO CI			NO CI		
Panama		"CI**"	NO CI		"CI**"	NO CI			
Paraguay		"CI**"			"CI**"			NO CI	
Philippines		NO CI	"CI**"		"CI**"	"CI**"		NO CI	"CI**"
Poland	"CI**"	"CI**"		"CI**"	"CI**"		"CI**"	"CI**"	
Portugal	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI
South_Africa	"CI**"	"CI**"		"CI**"	"CI**"		NO CI	NO CI	
Spain	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI
Sri_Lanka		NO CI	"CI**"		"CI**"	"CI**"		"CI**"	"CI**"
Sweden	NO CI			NO CI			NO CI		
Switzerland	NO CI	NO CI		NO CI	NO CI		NO CI	NO CI	
Thailand		NO CI	NO CI		"CI**"	"CI**"		"CI**"	NO CI
Togo		"CI**"	"CI**"		"CI**"	"CI**"		"CI**"	"CI**"
Tunisia	"CI**"			NO CI			NO CI		
Turkey	"CI**"	NO CI	NO CI	"CI**"	"CI**"	NO CI	"CI**"	NO CI	NO CI
United_Kingdom	NO CI			NO CI			NO CI		
United_States_of_America	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"	"CI**"			
Uruguay	"CI**"	"CI**"	"CI**"	NO CI	"CI**"	"CI**"	NO CI	"CI**"	NO CI
Venezuela		"CI**"	NO CI		"CI**"	"CI**"		"CI**"	NO CI
TOTAL NO COINTEGRATION	16	20	16	18	10	11	23	17	15
TOTAL COINTEGRATION	23	17	9	21	27	14	15	18	8

Table 35A: Bounds testing on the sub-periods (unrestricted intercept, no time trend)

	1970-1990						1991-2013					
	\$			LCU			\$			LCU		
	wheat 10%	maize 10%	rice 10%	wheat 10%	maize 10%	rice 10%	wheat 10%	maize 10%	rice 10%	wheat 10%	maize 10%	rice 10%
Algeria	NO CI	"CI"	"CI"	"CI"	"CI"	NO CI	"CI"			"CI"		
Argentina							NO CI	NO CI		"CI"	"CI"	
Australia	NO CI	"CI"	"CI"	NO CI	NO CI	"CI"	NO CI		NO CI	"CI"		NO CI
Austria	NO CI	"CI"		NO CI	NO CI	"CI"	"CI"	"CI"		NO CI	NO CI	
Bangladesh	NO CI	"CI"	"CI"	NO CI	NO CI	NO CI	NO CI			"CI"		
Bolivia	"CI"	NO CI	NO CI	NO CI	"CI"	"CI"	"CI"	NO CI	NO CI	"CI"	"CI"	NO CI
Burkina_Faso		NO CI	NO CI		NO CI	"CI"						
Cambodia		NO CI	NO CI		NO CI	NO CI						
Cameroon		NO CI	NO CI		NO CI	"CI"						
Canada	"CI"	NO CI		"CI"	NO CI		"CI"			NO CI		
Chile	NO CI	"CI"	"CI"	NO CI	NO CI	NO CI	"CI"	"CI"		"CI"	NO CI	
China								"CI"	"CI"		"CI"	NO CI
Colombia	NO CI	"CI"	NO CI	NO CI	"CI"	NO CI	"CI"	"CI"	"CI"	"CI"	"CI"	NO CI
Congo		NO CI	"CI"		"CI"	"CI"	"CI"	"CI"				
Costa_Rica		"CI"	NO CI		NO CI	"CI"		NO CI	"CI"		"CI"	NO CI
Cote_Ivoire		"CI"	NO CI		"CI"	NO CI						
Cyprus	NO CI			"CI"			NO CI			NO CI		
Denmark	"CI"			"CI"			"CI"			NO CI		
Dominican_Republic		NO CI	NO CI		NO CI	NO CI		"CI"	"CI"		NO CI	NO CI
Egypt	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	"CI"	NO CI	NO CI	"CI"
El_Salvador									NO CI			NO CI
Finland	NO CI			NO CI			"CI"			NO CI		
France	"CI"	NO CI	NO CI	"CI"	NO CI	NO CI	"CI"	"CI"	NO CI	"CI"	"CI"	NO CI
Germany	NO CI	NO CI		NO CI	NO CI		"CI"	"CI"		NO CI	"CI"	
Ghana		NO CI	NO CI		NO CI	NO CI						
Greece	NO CI	NO CI	NO CI	"CI"	NO CI	NO CI	"CI"	"CI"	NO CI	NO CI	NO CI	NO CI
Honduras	NO CI	NO CI	NO CI	"CI"	NO CI	"CI"	"CI"					
Hungary	"CI"	"CI"	NO CI	"CI"	"CI"	NO CI	NO CI	"CI"		NO CI	"CI"	
India	NO CI	"CI"	NO CI	"CI"	"CI"	NO CI						
Indonesia		"CI"	NO CI		"CI"	"CI"		"CI"			NO CI	
Iran	NO CI	"CI"	NO CI	NO CI	NO CI	NO CI	NO CI		"CI"	"CI"		"CI"
Ireland	NO CI			"CI"			"CI"			"CI"		
Israel	NO CI	"CI"		"CI"	NO CI							
Italy	"CI"	"CI"	NO CI	"CI"	NO CI	"CI"	"CI"	"CI"	"CI"	"CI"	"CI"	"CI"
Jamaica		NO CI	"CI"		NO CI	"CI"		NO CI			"CI"	
Japan	"CI"	"CI"	"CI"	NO CI	NO CI	NO CI	NO CI		NO CI	NO CI		NO CI
Jordan	NO CI	NO CI		"CI"	"CI"		NO CI	NO CI		NO CI	NO CI	
Kenya	"CI"	NO CI	NO CI	"CI"	NO CI	NO CI	NO CI	NO CI		"CI"	NO CI	
Korea	"CI"	"CI"	"CI"	"CI"	"CI"	NO CI						
Lao_PDR		NO CI	"CI"		"CI"	NO CI						
Lebanon	NO CI	NO CI		NO CI	NO CI							
Madagascar	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI						
Malawi	NO CI	NO CI	NO CI	"CI"	NO CI	"CI"						
Mali	"CI"	"CI"	NO CI	NO CI	"CI"	"CI"		NO CI	NO CI		"CI"	NO CI
Mauritius		NO CI	NO CI		NO CI	NO CI						
Mexico	NO CI	"CI"	NO CI	NO CI	"CI"	NO CI	"CI"	"CI"	"CI"	NO CI	NO CI	"CI"
Morocco	NO CI	"CI"	NO CI	NO CI	"CI"	NO CI	"CI"	NO CI		"CI"	"CI"	
Myanmar	"CI"	NO CI	NO CI	"CI"	"CI"	NO CI	"CI"	NO CI	"CI"	"CI"	NO CI	"CI"
Namibia	NO CI	NO CI		"CI"	NO CI							
Nepal	NO CI	"CI"	NO CI	"CI"	"CI"	NO CI		NO CI			NO CI	
Netherlands	"CI"	NO CI		"CI"	NO CI		"CI"			"CI"		
New_Zealand	"CI"	NO CI		"CI"	"CI"		"CI"	NO CI		"CI"	"CI"	
Nigeria	NO CI	NO CI	NO CI	NO CI	"CI"	NO CI						
Norway	NO CI	NO CI		"CI"	NO CI		"CI"			"CI"		
Pakistan	NO CI	NO CI	"CI"	NO CI	NO CI	"CI"						
Panama		"CI"	NO CI		"CI"	NO CI		"CI"	NO CI		"CI"	NO CI
Paraguay	NO CI	"CI"	NO CI	NO CI	"CI"	NO CI		NO CI			NO CI	
Peru							"CI"	NO CI	NO CI	NO CI	NO CI	"CI"
Philippines		"CI"	NO CI		"CI"	"CI"		"CI"	"CI"		NO CI	"CI"
Poland	"CI"	NO CI		NO CI	NO CI		"CI"	"CI"		"CI"	"CI"	
Portugal	NO CI	NO CI	NO CI	"CI"	NO CI	"CI"	NO CI	"CI"	"CI"	NO CI	NO CI	NO CI
Romania	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI						
Rwanda	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI						
Senegal								NO CI			NO CI	
South_Africa	NO CI	NO CI	NO CI	NO CI	NO CI	NO CI	"CI"	"CI"		"CI"	NO CI	
Spain	NO CI	"CI"	NO CI	"CI"	"CI"	"CI"	"CI"	"CI"	NO CI	"CI"	"CI"	NO CI
Sri_Lanka		"CI"	"CI"		NO CI	NO CI		"CI"	NO CI		NO CI	NO CI
Sweden	"CI"			"CI"			"CI"			"CI"		
Switzerland	"CI"	"CI"		NO CI	"CI"		NO CI	NO CI		NO CI	NO CI	
Thailand		NO CI	NO CI		NO CI	"CI"		"CI"	"CI"		"CI"	"CI"
Togo		NO CI	NO CI		"CI"	NO CI		"CI"	"CI"		"CI"	"CI"
Trinidad_and_Tobago		"CI"	NO CI		"CI"	NO CI						
Tunisia	NO CI			NO CI			NO CI			NO CI		
Turkey	NO CI	NO CI	"CI"	"CI"	"CI"	"CI"		NO CI	NO CI	"CI"	NO CI	NO CI
United_Kingdom	"CI"			"CI"			NO CI			NO CI		
United_States_of_America	NO CI	"CI"	NO CI	NO CI	"CI"	NO CI	"CI"	"CI"	"CI"	"CI"	"CI"	"CI"
Uruguay	"CI"	NO CI	NO CI	NO CI	NO CI	NO CI	"CI"	"CI"	NO CI	"CI"	NO CI	NO CI
Venezuela	"CI"	NO CI	NO CI	NO CI	NO CI	NO CI		NO CI	"CI"		"CI"	"CI"
Yemen							NO CI	NO CI		NO CI	"CI"	
TOTAL NO COINTEGRATION	36	38	42	28	39	36	15	19	13	18	21	17
TOTAL COINTEGRATION	19	28	12	27	27	18	27	23	15	24	21	11

APPENDIX 8: PASS-THROUGH ESTIMATES OVER THE FULL PERIOD: ECM AND FIRST-DIFFERENCE

The following tables report the pass-through (PT) estimated under three different specifications for the full period (1970-2013).

The first block corresponds to the error correction model (*eq. 8*). The first line indicates the MacKinnon approximate p-value for the DF test on the residuals from the log-level regression of the producer price on the world price. The cases where this value is larger than 10% are highlighted in red, thus indicating lack of support to the co-integration hypothesis (and casting doubts on the ECM specification). The second and third lines report the short-term (ST) and long-term (LT) parameters respectively.

The second block lays the results from the first-difference model (*eq. 7*), when only the contemporary term is included as a regressor (static). The immediate pass-through corresponds to θ_0 . Eventually, the last block presents the results from the first-difference model (*eq. 7*), with one lag of the explanatory variable. The ST pass-through that is reported is θ_0 while the LT coefficient is the quantity $\theta_0 + \theta_1$ (see e.g. Nakamura and Zerom, 2010). Robust standard errors are indicated below the point estimates in italics (additional estimations were run with 2 and 3 lags, but the results are not reported).

Overall, the different models yield fairly similar results. Long-run pass-through are generally not statistically significant from one, while short-run parameter lay between 0 and 1, and are often statistically significantly different from these bound values.

Table 36A: Pass-through estimates, wheat, 1970-2013

Estimates of the pass-through (PT) from world commodity price to domestic producer price (all expressed in current dollars) - 1970-2013
The first block corresponds to an error-correction model, the second block to a regression in first-difference without lags, and the third to a regression in first-difference with one lag

WHEAT	WHEAT																	WHEAT continued																						
	Algeria	Australia	Austria	Bangladesh	Bolivia	Canada	Chile	Colombia	Cyprus	Denmark	Egypt	Finland	France	Germany	Greece	Hungary	Iran	Ireland	Italy	Japan	Jordan	Kenya	Mexico	Morocco	Myanmar	Netherlands	New_Zealand	Norway	Poland	Portugal	South_Africa	Spain	Sweden	Switzerland	Tunisia	Turkey	UK	USA	Uruguay	
ADF CI (p-val)	0.164	0.000	0.247	0.000	0.001	0.115	0.012	0.012	0.018	0.091	0.130	0.613	0.051	0.105	0.296	0.001	0.140	0.004	0.069	0.677	0.083	0.137	0.550	0.009	0.006	0.109	0.002	0.321	0.011	0.316	0.012	0.086	0.081	0.289	0.216	0.008	0.054	0.000	0.001	
PT_ECM_ST	0.178 *	0.541 **	0.227 *	0.199 *	0.332 **	0.799 °	0.051 *	0.245 **	0.161 *	0.404 **	0.364 *	0.169 *	0.353 **	0.376 **	0.436 **	0.588 °	0.234 *	0.540 **	0.365 **	-0.258 *	0.291 *	0.574 **	0.121 *	0.077 *	0.176 *	0.385 **	0.055 *	0.573 **	0.223 *	0.397 **	0.283 *	0.373 **	0.117 *	0.225 **	0.484 **	1.011 °	0.665 °			
standard error	0.151	0.167	0.231	0.118	0.131	0.111	0.404	0.101	0.170	0.153	0.206	0.169	0.171	0.163	0.147	0.212	0.127	0.173	0.152	0.133	0.092	0.140	0.135	0.106	0.164	0.139	0.072	0.146	0.153	0.166	0.175	0.089	0.070	0.097	0.135	0.045	0.210			
PT_ECM_LT	1.137 *	1.016 °	0.161	0.571 °	0.789 °	0.891 °	1.298 °	0.968 °	0.633	0.566 °	1.455 °	0.524	0.624 °	0.501	0.595	1.152 °	0.914 °	0.552 **	0.576 °	-2.922 *	0.289 *	0.809 °	0.141 *	0.354 *	0.877 °	1.002 °	0.386 *	0.809 °	0.641	0.886 °	0.537 °	0.718 °	0.116 *	0.306 *	0.943 °	0.698 °	0.955 °	1.083 °		
standard error	0.414	0.082	0.861	0.154	0.164	0.272	0.321	0.151	0.444	0.248	0.665	1.111	0.302	0.287	0.443	0.186	0.264	0.221	0.244	1.759	0.199	0.209	0.236	0.309	0.154	0.593	0.104	0.216	0.155	0.244	0.171	0.161	0.168	0.157	0.207	0.139	0.189	0.166	0.240	
PT_Δ_static	0.170 *	0.885 °	0.201 *	-0.128 *	0.406 **	0.858 °	0.333	0.140 *	0.264 **	0.414 **	0.271 *	0.187 *	0.281 **	0.366 **	0.480 **	0.354 **	0.190 *	0.366 **	0.389 **	-0.066 *	0.093	0.190	0.162	0.140	0.099	0.449	0.071	0.108	0.140	0.169	0.139	0.117	0.146	0.133	0.164	0.147	0.141	0.156		
standard error	0.093	0.190	0.162	0.140	0.149	0.099	0.449	0.071	0.108	0.140	0.169	0.139	0.117	0.146	0.133	0.164	0.112	0.147	0.141	0.156	0.066	0.199	0.209	0.236	0.309	0.154	0.593	0.104	0.216	0.155	0.244	0.171	0.161	0.168	0.157	0.207	0.139	0.189	0.166	0.240
PT_Δ_ST	0.153 *	0.756 °	0.215 *	-0.086 *	0.338 **	0.809 °	0.130 *	0.099 *	0.187 *	0.415 **	0.280 *	0.165 *	0.291 **	0.371 **	0.473 **	0.313 *	0.177 *	0.404 **	0.368 **	-0.068 *	0.153	0.183	0.165	0.141	0.100	0.413	0.068	0.118	0.144	0.175	0.140	0.122	0.151	0.137	0.165	0.111	0.150	0.145	0.160	
standard error	0.092	0.183	0.165	0.155	0.141	0.100	0.413	0.068	0.118	0.144	0.175	0.140	0.122	0.151	0.137	0.165	0.111	0.150	0.145	0.160	0.092	0.209	0.236	0.309	0.154	0.593	0.104	0.216	0.155	0.244	0.171	0.161	0.168	0.157	0.207	0.139	0.189	0.166	0.240	
PT_Δ_LT	0.303 *	1.172 °	0.141 *	0.115 *	0.588	1.070 °	0.719	0.334 **	0.583 °	0.417 **	0.284 *	0.289 *	0.237 *	0.347 **	0.520 **	0.532 **	0.209 *	0.207 *	0.482 **	-0.202 *	0.199	0.209	0.236	0.309	0.154	0.593	0.104	0.216	0.155	0.244	0.171	0.161	0.168	0.157	0.207	0.139	0.189	0.166	0.240	
standard error	0.199	0.209	0.236	0.275	0.309	0.154	0.593	0.104	0.216	0.155	0.244	0.171	0.161	0.168	0.157	0.207	0.139	0.189	0.166	0.240	0.199	0.209	0.236	0.309	0.154	0.593	0.104	0.216	0.155	0.244	0.171	0.161	0.168	0.157	0.207	0.139	0.189	0.166	0.240	

The first block (blue) reports the results from the ECM model.
The first row indicates the MacKinnon approximate p-value for the DF test on the residuals of the log-level equation.
In red are the p-values larger than 10% (rejection of the co-integration hypothesis)
The second block (orange) displays the immediate pass-through estimate from the static first-difference model.
The last block (purple) corresponds to the estimates from the first-difference model with one lag.
Robust standard errors and indicated below the estimates in italics
° statistically different from 0 at the 5% confidence level
* statistically different from 1 at the 5% confidence level

Table 37A: Pass-through estimates, maize, 1970-2013

Estimates of the pass-through (PT) from world commodity price to domestic producer price (all expressed in current dollars) - 1970-2013

The first block corresponds to an error-correction model, the second block to a regression in first-difference without lags, and the third to a regression in first-difference with one lag

MAIZE	Austria	Bolivia	Chile	Colombia	Costa_Rica	Dominican_Rep	Egypt	France	Germany	Greece	Hungary	Indonesia	Italy	Jamaica	Jordan	Kenya	Mali	Mexico	Morocco
ADF_CI (p-val)	0.061	0.002	0.000	0.016	0.006	0.012	0.008	0.021	0.017	0.018	0.007	0.001	0.107	0.368	0.019	0.062	0.038	0.161	0.029
PT_ECM_ST	0.447**	0.168*	0.807°	0.252**	0.262**	0.201*	0.409**	0.381**	0.331**	0.343**	0.450**	0.462**	0.245*	0.323*	0.265*	0.129*	0.389*	0.462**	0.363**
standard error	0.214	0.155	0.150	0.085	0.111	0.123	0.130	0.152	0.164	0.124	0.162	0.136	0.134	0.195	0.138	0.138	0.199	0.108	0.089
PT_ECM_LT	0.406	1.080°	0.700**	0.702°	1.064°	0.667°	0.982°	0.543**	0.428**	0.505**	0.978	1.221	0.482	2.197°	0.695°	1.409°	1.143°	0.610°	0.366**
standard error	0.478	0.209	0.117	0.185	0.176	0.332	0.190	0.194	0.159	0.179	0.187	0.161	0.287	1.030	0.236	0.491	0.408	0.243	0.181
PT_Δ_static	0.403**	0.040*	0.627°	0.190*	0.155*	0.202*	0.318**	0.326**	0.335*	0.328**	0.329**	0.342**	0.278**	0.222*	0.149*	0.026*	0.289*	0.502**	0.394**
standard error	0.193	0.160	0.210	0.104	0.136	0.152	0.160	0.123	0.201	0.119	0.147	0.149	0.135	0.157	0.135	0.123	0.165	0.095	0.127
PT_Δ_ST	0.429**	0.026*	0.596°	0.185*	0.133*	0.189*	0.317**	0.329**	0.332*	0.318**	0.310**	0.304**	0.266**	0.236*	0.154*	0.033*	0.291*	0.490**	0.391**
standard error	0.188	0.167	0.210	0.105	0.121	0.155	0.160	0.123	0.199	0.121	0.138	0.126	0.133	0.170	0.138	0.122	0.166	0.093	0.127
PT_Δ_LT	0.260*	-0.086*	0.299*	0.261*	0.400**	0.471**	0.285*	0.310*	0.363*	0.388**	0.473*	0.641°	0.351*	0.160*	0.064*	0.160*	0.210*	0.621**	0.350**
standard error	0.298	0.269	0.317	0.148	0.145	0.237	0.184	0.194	0.274	0.180	0.244	0.243	0.194	0.197	0.212	0.129	0.282	0.118	0.164

MAIZE continued

	Myanmar	Nepal	New_Zealand	Panama	Paraguay	Philippines	Poland	Portugal	South_Africa	Spain	Sri_Lanka	Switzerland	Thailand	Togo	Turkey	USA	Uruguay	Venezuela
ADF_CI (p-val)	0.006	0.014	0.013	0.165	0.000	0.001	0.006	0.089	0.001	0.103	0.105	0.090	0.002	0.000	0.012	0.000	0.001	0.042
PT_ECM_ST	0.427**	0.171*	0.419**	0.156**	0.660**	0.344**	0.547**	0.194*	0.415**	0.302**	0.321**	0.073*	0.840°	0.291*	0.108*	0.965*	0.434**	0.140*
standard error	0.112	0.133	0.123	0.056	0.139	0.117	0.203	0.178	0.129	0.137	0.130	0.109	0.188	0.203	0.131	0.045	0.106	0.144
PT_ECM_LT	0.905°	0.563°	0.559	1.423°	1.005°	0.605°	0.401*	0.188	0.614**	0.390*	-0.075	-0.047*	0.775	0.736°	0.374	0.983°	0.535**	1.539°
standard error	0.351	0.262	0.833	0.294	0.126	0.263	0.234	0.533	0.186	0.203	0.693	0.316	0.433	0.143	0.467	0.021	0.227	0.514
PT_Δ_static	0.328**	0.104*	0.367**	0.084*	0.523**	0.373**	0.401**	0.281*	0.304**	0.335**	0.305*	0.170*	0.567**	0.074*	0.121*	0.907**	0.357**	0.004*
standard error	0.144	0.083	0.112	0.059	0.211	0.137	0.171	0.150	0.125	0.132	0.159	0.127	0.162	0.207	0.119	0.043	0.084	0.123
PT_Δ_ST	0.368**	0.109*	0.374**	0.074*	0.480**	0.340**	0.407**	0.250*	0.310**	0.326**	0.336**	0.177*	0.565**	0.069*	0.108*	0.904**	0.348**	0.001*
standard error	0.121	0.087	0.116	0.051	0.229	0.113	0.161	0.153	0.131	0.129	0.146	0.120	0.154	0.210	0.110	0.045	0.081	0.113
PT_Δ_LT	0.734°	0.050*	0.423**	0.252**	0.021*	0.676°	0.373	0.496**	0.354*	0.394**	0.617°	0.134*	0.543	0.146*	0.421**	0.958°	0.278**	0.256*
standard error	0.223	0.108	0.173	0.082	0.424	0.203	0.344	0.196	0.190	0.192	0.292	0.235	0.292	0.333	0.143	0.096	0.116	0.188

The first block (blue) reports the results from the ECM model.
The first row indicates the MacKinnon approximate p-value for the DF test on the residuals of the log-level equation.

In red are the p-values larger than 10% (rejection of the co-integration hypothesis)

The second block (orange) displays the immediate pass-through estimate from the static first-difference model.

The last block (purple) corresponds to the estimates from the first-difference model with one lag.

Robust standard errors and indicated below the estimates in italics

° statistically different from 0 at the 5% confidence level

* statistically different from 1 at the 5% confidence level

Table 38A: Pass-through estimates, rice, 1970-2013

Estimates of the pass-through (PT) from world commodity price to domestic producer price (all expressed in current dollars) - 1970-2013
 The first block corresponds to an error-correction model, the second block to a regression in first-difference without lags, and the third to a regression in first difference with one lag

RICE	Australia	Bolivia	Colombia	Costa_Rica	Dominican_Rep	Egypt	France	Greece	Iran	Italy	Japan	Mali	Mexico
ADF_CI (p-val)	0.014	0.008	0.452	0.389	0.107	0.250	0.072	0.011	0.102	0.097	0.226	0.208	0.002
PT_ECM_ST	0.479**	0.429**	0.409**	0.298**	-0.155*	0.002*	0.330**	0.392**	0.386*	0.416**	0.077*	0.161*	0.490**
standard error	0.109	0.199	0.094	0.112	0.218	0.091	0.091	0.157	0.252	0.141	0.062	0.109	0.135
PT_ECM_LT	0.287	1.144°	1.846°	1.766°	-0.068	0.753	0.502**	0.189*	1.456°	0.841°	-0.131	0.211	0.690**
standard error	0.628	0.225	0.735	0.443	0.560	0.609	0.196	0.188	0.451	0.326	0.604	0.753	0.105
PT_Δ_static	0.448**	0.353*	0.311**	0.153*	-0.064*	-0.050*	0.345**	0.415**	0.365*	0.348**	0.132**	0.209**	0.555**
standard error	0.103	0.242	0.062	0.100	0.232	0.111	0.091	0.206	0.254	0.102	0.051	0.092	0.120
PT_Δ_ST	0.439**	0.359*	0.298**	0.122*	-0.086*	-0.064*	0.352**	0.434**	0.372*	0.352**	0.130**	0.191**	0.530**
standard error	0.105	0.234	0.065	0.102	0.231	0.112	0.096	0.210	0.261	0.102	0.052	0.084	0.128
PT_Δ_LT	0.451**	0.503	0.392**	0.216**	0.196*	0.026*	0.311**	0.338*	0.341*	0.335**	0.148*	0.345**	0.662**
standard error	0.134	0.315	0.098	0.087	0.241	0.143	0.105	0.253	0.310	0.147	0.079	0.088	0.140

RICE continued	Myanmar	Panama	Philippines	Portugal	Spain	Sri_Lanka	Thailand	Togo	Turkey	USA	Uruguay	Venezuela
ADF_CI (p-val)	0.121	0.615	0.181	0.227	0.294	0.023	0.006	0.046	0.067	0.000	0.002	0.062
PT_ECM_ST	0.200*	0.192**	0.254**	0.185*	0.404**	0.343**	0.377**	0.219*	0.166*	0.904°	0.420**	0.248**
standard error	0.203	0.094	0.074	0.143	0.084	0.112	0.136	0.129	0.179	0.122	0.132	0.102
PT_ECM_LT	0.618	1.855°	1.083°	0.319	0.174	0.435**	0.268	0.774°	0.025*	0.882°	0.650**	1.013°
standard error	0.598	0.645	0.493	0.459	0.457	0.152	0.491	0.209	0.401	0.134	0.145	0.301
PT_Δ_static	0.294**	0.147*	0.228**	0.202*	0.450**	0.356**	0.310**	0.186*	0.298**	0.613**	0.343**	0.147**
standard error	0.134	0.099	0.063	0.107	0.090	0.106	0.112	0.125	0.120	0.100	0.114	0.081
PT_Δ_ST	0.185*	0.143*	0.211**	0.201*	0.448**	0.357**	0.338**	0.188*	0.267**	0.631**	0.333**	0.147**
standard error	0.146	0.103	0.057	0.119	0.093	0.102	0.116	0.130	0.121	0.102	0.114	0.087
PT_Δ_LT	0.544**	0.182*	0.363**	0.207*	0.453**	0.489**	0.264**	0.182*	0.499**	0.503**	0.296**	0.216*
standard error	0.207	0.112	0.077	0.156	0.107	0.104	0.118	0.140	0.133	0.143	0.142	0.116

The first block (blue) reports the results from the ECM model.
 The first row indicates the MacKinnon approximate p-value for the DF test on the residuals of the log-level equation. In red are the p-values larger than 10% (rejection of the co-integration hypothesis)
 The second block (orange) displays the immediate pass-through estimate from the static first-difference model.
 The last block (purple) corresponds to the estimates from the first-difference model with one lag.
 Robust standard errors and indicated below the estimates in italics
 ° statistically different from 0 at the 5% confidence level
 * statistically different from 1 at the 5% confidence level

APPENDIX 9: ERROR-CORRECTION MODELS OVER THE FULL PERIOD: ALTERNATIVE MODELS

In this appendix, we display the pass-through estimations obtained when fitting the ECM over:

1. nominal prices and no exchange rate (i.e. the same results as those displayed in Table 36A, Table 37A, Table 38A);
2. nominal prices and nominal exchange rates;
3. real prices and no exchange rate; and
4. real prices and real exchange rates.

Real world commodity prices correspond to the dollar market prices divided by the US consumer price index (CPI), while real domestic producer prices are the dollar prices divided by the domestic CPI. Similarly, the real exchange rate is the nominal exchange rate multiplied by the US CPI and divided by the domestic CPI.

For each alternative model, the ADF test result for co-integration (Mc Kinnon approximate p-value) is reported. P-values larger than 0.1 are highlighted in red.

Table 39A: Alternative ECM estimates: Wheat

WHEAT
1970-2013 - ECM

	(1) Nominal prices, no exchange rate			(2) Nominal prices, nominal exchange rate			(3) Real prices, no exchange rate			(4) Real prices, real exchange rate		
	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT
Algeria	0.16	0.178 (0.51)	1.137 (0.44)	0.17	0.281 (0.148)	1.290 (0.305)	0.51	0.246 (0.106)	3.295 (0.849)	0.05	0.323 (0.15)	0.804 (0.202)
Australia	0.00	0.541 (0.67)	1.016 (0.082)	0.00	0.515 (0.165)	0.992 (0.063)	0.00	0.591 (0.165)	1.202 (0.099)	0.00	0.636 (0.172)	1.378 (0.098)
Austria	0.25	0.227 (0.231)	0.161 (0.861)	0.28	0.314 (0.243)	1.401 (1.262)	0.28	0.327 (0.59)	1.162 (0.427)	0.28	0.273 (0.235)	1.044 (0.407)
Bangladesh	0.00	0.199 (0.18)	0.571 (0.54)	0.00	0.317 (0.159)	0.412 (0.078)						
Bolivia	0.00	0.332 (0.31)	0.789 (0.164)	0.00	0.396 (0.147)	0.793 (0.149)	0.07	1.516 (0.701)	11.700 (1.636)	0.22	1.457 (0.798)	10.217 (2.105)
Canada	0.11	0.799 (0.11)	0.891 (0.272)	0.07	0.774 (0.110)	0.824 (0.232)	0.03	0.863 (0.105)	1.244 (0.165)	0.03	0.922 (0.108)	1.514 (0.218)
Chile	0.01	0.051 (0.404)	1.298 (0.321)	0.00	0.162 (0.304)	0.804 (0.142)						
Colombia	0.01	0.245 (0.10)	0.968 (0.51)	0.02	0.244 (0.128)	1.008 (0.182)	0.14	0.225 (0.124)	3.769 (0.883)	0.11	0.257 (0.154)	4.101 (1.140)
Cyprus	0.02	0.161 (0.170)	0.633 (0.444)	0.00	0.174 (0.152)	0.740 (0.290)	0.02	0.193 (0.10)	0.675 (0.109)	0.01	0.240 (0.104)	0.971 (0.235)
Denmark	0.09	0.404 (0.53)	0.566 (0.248)	0.13	0.430 (0.169)	0.706 (0.298)	0.02	0.567 (0.59)	1.261 (0.144)	0.02	0.533 (0.168)	1.237 (0.13)
Egypt	0.13	0.364 (0.206)	1.455 (0.665)	0.07	0.317 (0.183)	0.781 (0.482)	0.06	0.368 (0.182)	1.866 (0.964)	0.21	0.352 (0.182)	1.985 (1.095)
Finland	0.61	0.169 (0.169)	0.524 (1.11)	0.59	0.178 (0.174)	0.433 (1.080)	0.38	0.225 (0.148)	1.627 (0.486)	0.24	0.217 (0.162)	1.813 (0.676)
France	0.05	0.353 (0.17)	0.624 (0.302)	0.08	0.352 (0.169)	0.632 (0.294)	0.00	0.520 (0.177)	1.165 (0.147)	0.00	0.506 (0.202)	1.186 (0.156)
Germany	0.11	0.376 (0.163)	0.501 (0.287)	0.13	0.458 (0.183)	1.183 (0.436)						
Greece	0.30	0.436 (0.147)	0.595 (0.443)	0.30	0.492 (0.152)	0.839 (0.502)	0.25	0.660 (0.16)	3.384 (0.704)	0.01	0.728 (0.155)	3.192 (0.410)
Hungary	0.00	0.588 (0.212)	1.152 (0.186)	0.00	0.636 (0.197)	0.966 (0.120)						
Iran	0.14	0.234 (0.127)	0.914 (0.264)	0.09	0.227 (0.158)	1.167 (0.454)	0.74	0.231 (0.146)	9.487 (5.608)	0.89	0.195 (0.107)	-22.476 (35.757)
Ireland	0.00	0.540 (0.173)	0.552 (0.221)	0.00	0.513 (0.185)	0.567 (0.222)	0.01	0.696 (0.180)	1.240 (0.325)	0.00	0.713 (0.202)	1.209 (0.256)
Italy	0.07	0.365 (0.152)	0.576 (0.244)	0.07	0.362 (0.166)	0.579 (0.270)	0.03	0.505 (0.165)	1.509 (0.299)	0.02	0.499 (0.175)	1.543 (0.260)
Japan	0.68	-0.258 (0.133)	-2.922 (1.759)	0.75	-0.280 (0.163)	-11.875 (42.177)	0.72	-0.124 (0.15)	-0.058 (0.626)	0.99	-0.235 (0.14)	0.013 (0.394)
Jordan	0.01	0.291 (0.192)	1.289 (0.278)	0.01	0.244 (0.192)	1.449 (0.310)	0.01	0.203 (0.177)	1.126 (0.252)	0.00	0.135 (0.182)	0.526 (0.416)
Kenya	0.05	0.264 (0.140)	1.353 (0.248)	0.02	0.214 (0.126)	0.901 (0.198)	0.47	0.291 (0.127)	3.208 (0.702)	0.02	0.415 (0.145)	2.979 (0.337)
Mexico	0.01	0.574 (0.135)	1.019 (0.159)	0.00	0.524 (0.128)	0.794 (0.117)	0.07	0.807 (0.184)	6.129 (1.525)	0.06	0.818 (0.184)	6.118 (1.377)
Morocco	0.01	0.121 (0.106)	0.354 (0.223)	0.01	0.073 (0.110)	0.405 (0.236)	0.02	0.231 (0.109)	1.296 (0.492)	0.13	0.165 (0.105)	1.366 (0.506)
Myanmar	0.01	0.176 (0.180)	0.877 (0.250)	0.01	0.233 (0.208)	1.022 (0.396)	0.67	0.228 (0.249)	8.048 (3.833)	0.75	0.136 (0.267)	0.590 (3.780)
Netherlands	0.11	0.345 (0.164)	0.471 (0.310)	0.16	0.457 (0.17)	1.201 (0.555)	0.03	0.440 (0.162)	0.909 (0.179)	0.03	0.412 (0.186)	0.934 (0.197)
New_Zealand	0.00	0.385 (0.139)	1.002 (0.156)	0.00	0.430 (0.152)	0.982 (0.120)	0.00	0.443 (0.187)	1.208 (0.206)	0.00	0.466 (0.195)	1.262 (0.174)
Norway	0.32	0.055 (0.072)	0.386 (0.207)	0.31	0.063 (0.070)	0.407 (0.182)	0.17	0.141 (0.078)	1.240 (0.270)	0.15	0.124 (0.075)	1.271 (0.217)
Poland	0.01	0.573 (0.146)	0.809 (0.155)	0.00	0.592 (0.138)	0.869 (0.124)	0.35	1.107 (0.389)	8.453 (1.688)	0.04	0.786 (0.418)	4.037 (2.286)
Portugal	0.32	0.223 (0.153)	0.641 (0.163)	0.32	0.246 (0.152)	0.526 (0.735)	0.03	0.334 (0.164)	1.789 (0.873)	0.01	0.452 (0.165)	2.174 (0.282)
South_Africa	0.01	0.397 (0.152)	0.886 (0.265)	0.01	0.435 (0.153)	0.898 (0.272)	0.19	0.415 (0.153)	2.509 (0.540)	0.21	0.414 (0.156)	3.186 (1.594)
Spain	0.09	0.283 (0.166)	0.537 (0.258)	0.09	0.282 (0.170)	0.540 (0.284)	0.02	0.335 (0.165)	1.113 (0.697)	0.02	0.358 (0.172)	1.198 (0.323)
Sweden	0.08	0.373 (0.175)	0.718 (0.325)	0.08	0.384 (0.189)	0.749 (0.317)	0.01	0.518 (0.203)	1.379 (0.156)	0.01	0.511 (0.217)	1.621 (0.272)
Switzerland	0.29	0.133 (0.089)	0.116 (0.339)	0.42	0.234 (0.103)	2.138 (3.029)	0.56	0.196 (0.092)	0.834 (0.397)	0.79	0.171 (0.106)	0.714 (0.474)
Tunisia	0.22	0.117 (0.070)	0.306 (0.331)	0.15	0.102 (0.065)	0.286 (0.280)						
Turkey	0.01	0.225 (0.097)	0.943 (0.280)	0.00	0.196 (0.113)	0.682 (0.180)	0.41	0.420 (0.144)	12.170 (3.91)	0.01	0.505 (0.185)	11.935 (3.648)
United_Kingdom	0.05	0.484 (0.135)	0.698 (0.16)	0.05	0.473 (0.14)	0.700 (0.188)						
United_States_of_America	0.00	1.011 (0.045)	0.955 (0.030)	0.00	1.011 (0.045)	0.955 (0.030)	0.00	1.051 (0.044)	1.005 (0.020)	0.00	1.051 (0.044)	1.005 (0.020)
Uruguay	0.00	0.665 (0.210)	1.083 (0.177)	0.00	0.690 (0.218)	1.184 (0.270)	0.12	0.978 (0.357)	6.031 (2.60)	0.03	0.966 (0.366)	5.754 (2.79)

The ADF columns report the results from Dickey-Fuller tests applied to the residuals of the equation in log-levels (in the form of the MacKinnon approximate p-values).

In red are the cases where we fail to reject that there is a unit root in the residuals at the 10% confidence level, thus pointing to lack of co-integration between the variables.

Robust standard errors are indicated in parenthesis next to the point estimates.

Table 40A: Alternative ECM estimates: Maize

MAIZE
1970-2013 - ECM

	(1) Nominal prices, no exchange rate			(2) Nominal prices, nominal exchange rate			(3) Real prices, no exchange rate			(4) Real prices, real exchange rate		
	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT
Austria	0.061	0.447 (0.24)	0.406 (0.478)	0.074	0.501 (0.229)	1.064 (0.774)	0.124	0.525 (0.200)	0.923 (0.34)	0.137	0.473 (0.236)	0.844 (0.328)
Bolivia	0.002	0.168 (0.65)	1.080 (0.209)	0.000	0.143 (0.4)	0.826 (0.368)	0.132	0.194 (0.338)	9.033 (19.8)	0.196	0.291 (0.473)	7.267 (5.078)
Chile	0.000	0.807 (0.50)	0.700 (0.17)	0.000	0.855 (0.13)	0.681 (0.052)						
Colombia	0.016	0.252 (0.085)	0.702 (0.185)	0.017	0.164 (0.092)	0.385 (0.25)	0.263	0.259 (0.20)	3.115 (1076)	0.198	0.262 (0.23)	3.479 (17.6)
Costa_Rica	0.006	0.262 (0.11)	1.064 (0.176)	0.000	0.291 (0.102)	0.799 (0.123)	0.632	0.221 (0.15)	3.562 (0.990)	0.761	0.198 (0.13)	2.170 (1322)
Dominican_Republic	0.012	0.201 (0.123)	0.667 (0.332)	0.000	0.134 (0.140)	0.485 (0.244)	0.546	0.289 (0.175)	4.120 (1895)	0.795	0.194 (0.20)	2.079 (2.355)
Egypt	0.008	0.409 (0.130)	0.982 (0.190)	0.001	0.399 (0.23)	0.705 (0.192)	0.223	0.432 (0.173)	2.165 (1008)	0.195	0.435 (0.167)	2.032 (0.970)
France	0.021	0.381 (0.152)	0.543 (0.194)	0.029	0.383 (0.148)	0.602 (0.188)	0.004	0.527 (0.15)	1.046 (0.144)	0.003	0.503 (0.165)	1.058 (0.162)
Germany	0.017	0.331 (0.164)	0.428 (0.159)	0.055	0.360 (0.157)	0.806 (0.349)						
Greece	0.018	0.343 (0.124)	0.505 (0.179)	0.012	0.337 (0.13)	0.477 (0.175)	0.230	0.349 (0.166)	1.540 (1333)	0.027	0.378 (0.173)	1.937 (0.94)
Hungary	0.007	0.450 (0.162)	0.978 (0.187)	0.007	0.406 (0.173)	0.947 (0.23)						
Indonesia	0.001	0.462 (0.136)	1.221 (0.16)	0.000	0.469 (0.129)	1.072 (0.15)	0.481	0.281 (0.156)	2.112 (0.769)	0.422	0.296 (0.160)	2.670 (2.8)
Italy	0.107	0.245 (0.134)	0.482 (0.287)	0.099	0.245 (0.149)	0.478 (0.33)	0.092	0.344 (0.140)	1.377 (0.335)	0.095	0.353 (0.145)	1.394 (0.307)
Jamaica	0.368	0.323 (0.195)	2.197 (1030)	0.060	0.303 (0.180)	0.900 (0.314)	0.594	0.421 (0.212)	2.678 (0.652)	0.692	0.421 (0.234)	3.162 (1006)
Jordan	0.019	0.265 (0.138)	0.695 (0.236)	0.012	0.283 (0.144)	0.783 (0.235)	0.132	0.226 (0.189)	1.172 (0.425)	0.158	0.191 (0.130)	0.825 (0.672)
Kenya	0.062	0.129 (0.138)	1.409 (0.49)	0.004	0.119 (0.128)	0.789 (0.153)	0.494	0.104 (0.189)	2.791 (0.722)	0.011	0.173 (0.185)	2.768 (0.337)
Mali	0.038	0.389 (0.108)	1.143 (0.408)	0.011	0.364 (0.157)	0.976 (0.397)						
Mexico	0.161	0.462 (0.108)	0.610 (0.243)	0.126	0.444 (0.108)	0.541 (0.195)	0.499	0.553 (0.189)	4.150 (3.082)	0.465	0.615 (0.184)	5.069 (2.229)
Morocco	0.029	0.363 (0.089)	0.366 (0.18)	0.024	0.310 (0.094)	0.447 (0.192)	0.152	0.440 (0.19)	1.025 (0.227)	0.163	0.360 (0.20)	0.842 (0.325)
Myanmar	0.006	0.427 (0.12)	0.905 (0.35)	0.005	0.419 (0.125)	0.796 (0.447)	0.865	0.390 (0.14)	8.287 (4.620)	0.213	0.247 (0.156)	-3.162 (3.647)
Nepal	0.014	0.171 (0.133)	0.563 (0.262)	0.001	0.203 (0.149)	0.686 (0.210)	0.283	0.113 (0.116)	1.461 (0.882)	0.635	0.052 (0.136)	-0.264 (14.8)
New_Zealand	0.013	0.419 (0.123)	0.559 (0.833)	0.009	0.434 (0.134)	0.797 (0.387)	0.009	0.423 (0.154)	-0.368 (3.13)	0.009	0.382 (0.147)	-0.393 (3.862)
Panama	0.165	0.156 (0.056)	1.423 (0.294)	0.165	0.156 (0.056)	1.423 (0.294)	0.599	0.045 (0.05)	0.220 (0.197)	0.507	0.062 (0.056)	0.729 (0.804)
Paraguay	0.000	0.660 (0.139)	1.005 (0.126)	0.000	0.786 (0.176)	1.060 (0.16)	0.325	0.744 (0.190)	3.749 (0.948)	0.444	0.827 (0.107)	4.255 (1088)
Philippines	0.001	0.344 (0.11)	0.605 (0.263)	0.000	0.298 (0.18)	0.566 (0.163)	0.326	0.340 (0.12)	1.283 (0.93)	0.238	0.272 (0.17)	2.165 (1007)
Poland	0.006	0.547 (0.203)	0.401 (0.234)	0.004	0.556 (0.212)	0.411 (0.245)	0.483	0.858 (0.318)	7.064 (133)	0.066	0.253 (0.328)	15.880 (8.89)
Portugal	0.089	0.194 (0.178)	0.188 (0.533)	0.092	0.214 (0.176)	0.142 (0.563)	0.196	0.289 (0.18)	0.775 (2.707)	0.036	0.386 (0.165)	1.770 (0.486)
South_Africa	0.001	0.415 (0.129)	0.614 (0.186)	0.001	0.383 (0.139)	0.546 (0.10)	0.410	0.406 (0.146)	1.666 (1.786)	0.353	0.385 (0.135)	2.099 (3.640)
Spain	0.103	0.302 (0.137)	0.390 (0.203)	0.095	0.300 (0.142)	0.372 (0.226)	0.148	0.357 (0.140)	0.895 (0.709)	0.108	0.344 (0.13)	0.946 (0.35)
Sri_Lanka	0.105	0.321 (0.107)	-0.075 (0.693)	0.048	0.310 (0.140)	-0.263 (0.396)	0.180	0.220 (0.18)	3.106 (3.660)	0.951	0.210 (0.14)	5.349 (8.635)
Switzerland	0.090	0.073 (0.109)	-0.047 (0.316)	0.333	0.171 (0.115)	1.712 (2.598)	0.457	0.131 (0.120)	0.703 (0.430)	0.862	0.099 (0.125)	0.682 (0.616)
Thailand	0.002	0.840 (0.188)	0.775 (0.433)	0.000	0.823 (0.183)	0.851 (0.134)	0.000	0.854 (0.142)	0.813 (0.048)	0.000	0.894 (0.135)	0.656 (0.063)
Togo	0.000	0.291 (0.203)	0.736 (0.143)	0.000	0.332 (0.200)	0.802 (0.25)	0.012	0.320 (0.204)	1.186 (0.204)	0.005	0.275 (0.135)	0.749 (0.29)
Turkey	0.012	0.108 (0.13)	0.374 (0.467)	0.005	0.102 (0.128)	0.365 (0.286)	0.503	0.160 (0.174)	11.261 (5.643)	0.038	0.081 (0.245)	8.420 (0.110)
United_States_of_America	0.000	0.965 (0.045)	0.983 (0.02)	0.000	0.965 (0.045)	0.983 (0.02)	0.000	0.992 (0.047)	1.017 (0.017)	0.000	0.992 (0.047)	1.017 (0.017)
Uruguay	0.001	0.434 (0.106)	0.535 (0.227)	0.001	0.428 (0.095)	0.419 (0.234)	0.264	0.275 (0.122)	2.906 (3.342)	0.040	0.265 (0.125)	1.280 (5.379)
Venezuela	0.042	0.140 (0.144)	1.539 (0.51)	0.061	0.133 (0.143)	1.462 (0.483)						

The ADF columns report the results from Dickey-Fuller tests applied to the residuals of the equation in log-levels (in the form of the MacKinnon approximate p-values).
In red are the cases where we fail to reject that there is a unit root in the residuals at the 10% confidence level, thus pointing to lack of co-integration between the variables.
Robust standard errors are indicated in parenthesis next to the point estimates.

Table 41A: Alternative ECM estimates: Rice

RICE
1970-2013 - ECM

	(1) Nominal prices, no exchange rate			(2) Nominal prices, nominal exchange rate			(3) Real prices, no exchange rate			(4) Real prices, real exchange rate		
	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT	ADF	ST-PT	LT-PT
Australia	0.014	0.479 (0.109)	0.287 (0.628)	0.001	0.576 (0.107)	0.795 (0.262)	0.002	0.571 (0.117)	0.683 (0.250)	0.001	0.635 (0.133)	1.128 (0.230)
Bolivia	0.008	0.429 (0.199)	1.144 (0.225)	0.004	0.419 (0.214)	1.060 (0.232)	0.087	1.093 (0.477)	9.803 (15.8)	0.110	1.137 (0.602)	7.861 (2.335)
Colombia	0.452	0.409 (0.094)	1.846 (0.735)	0.057	0.373 (0.096)	0.979 (0.189)	0.103	0.436 (0.077)	2.708 (0.406)	0.089	0.425 (0.086)	2.293 (0.783)
Costa_Rica	0.389	0.298 (0.11)	1.766 (0.443)	0.047	0.369 (0.102)	1.076 (0.165)	0.298	0.360 (0.146)	3.064 (0.604)	0.565	0.272 (0.11)	1.408 (0.617)
Dominican_Republic	0.107	-0.155 (0.218)	-0.068 (0.560)	0.034	-0.183 (0.230)	0.010 (0.413)	0.607	-0.050 (0.210)	5.721 (6.50)	0.833	-0.036 (0.212)	16.635 (43.667)
Egypt	0.250	0.002 (0.09)	0.753 (0.609)	0.011	0.060 (0.090)	0.560 (0.227)	0.134	0.031 (0.122)	1.544 (0.89)	0.131	0.032 (0.122)	1.434 (0.916)
France	0.072	0.330 (0.09)	0.502 (0.196)	0.041	0.353 (0.088)	0.541 (0.246)	0.040	0.472 (0.083)	0.946 (0.15)	0.039	0.473 (0.084)	0.989 (0.176)
Greece	0.011	0.392 (0.157)	0.189 (0.188)	0.011	0.474 (0.162)	0.248 (0.199)	0.257	0.584 (0.21)	1.935 (0.938)	0.001	0.723 (0.207)	2.217 (0.307)
Iran	0.102	0.386 (0.252)	1.456 (0.45)	0.103	0.406 (0.276)	1.661 (0.61)	0.737	0.472 (0.226)	7.952 (3.947)	0.830	0.487 (0.252)	9.293 (6.299)
Italy	0.097	0.416 (0.14)	0.841 (0.326)	0.053	0.436 (0.159)	0.850 (0.324)	0.006	0.529 (0.150)	1.181 (0.237)	0.004	0.527 (0.160)	1.199 (0.237)
Japan	0.226	0.077 (0.062)	-0.131 (0.604)	0.239	0.099 (0.068)	0.812 (3.267)	0.090	0.062 (0.062)	-0.245 (0.173)	0.208	0.011 (0.068)	1.011 (4.805)
Mali	0.208	0.161 (0.109)	0.211 (0.753)	0.048	0.157 (0.128)	0.377 (0.674)						
Mexico	0.002	0.490 (0.135)	0.690 (0.105)	0.001	0.517 (0.102)	0.648 (0.069)	0.219	0.822 (0.173)	5.433 (0.909)	0.164	0.856 (0.136)	5.300 (0.802)
Myanmar	0.121	0.200 (0.203)	0.618 (0.598)	0.001	0.172 (0.244)	0.524 (0.244)	0.735	0.190 (0.183)	4.188 (2.776)	0.852	0.092 (0.166)	-0.922 (2.105)
Panama	0.615	0.192 (0.094)	1.855 (0.645)	0.615	0.192 (0.094)	1.855 (0.645)	0.015	0.047 (0.084)	0.163 (0.06)	0.015	0.039 (0.083)	0.205 (0.145)
Philippines	0.181	0.254 (0.074)	1.083 (0.493)	0.006	0.314 (0.064)	0.787 (0.122)	0.093	0.234 (0.060)	1.375 (0.258)	0.059	0.203 (0.064)	1.719 (0.538)
Portugal	0.227	0.185 (0.143)	0.319 (0.459)	0.050	0.234 (0.134)	0.348 (0.27)	0.062	0.331 (0.117)	1.253 (0.636)	0.006	0.400 (0.129)	1.469 (0.267)
Spain	0.294	0.404 (0.084)	0.174 (0.457)	0.126	0.431 (0.093)	0.307 (0.384)	0.180	0.475 (0.086)	0.549 (1007)	0.108	0.478 (0.089)	0.786 (0.486)
Sri_Lanka	0.023	0.343 (0.11)	0.435 (0.152)	0.019	0.345 (0.11)	0.422 (0.170)	0.484	0.312 (0.12)	1.465 (5.449)	0.812	0.282 (0.128)	-1.219 (8.890)
Thailand	0.006	0.377 (0.136)	0.268 (0.49)	0.000	0.425 (0.149)	0.529 (0.246)	0.000	0.487 (0.132)	0.631 (0.050)	0.000	0.549 (0.13)	0.494 (0.055)
Togo	0.046	0.219 (0.129)	0.774 (0.209)	0.034	0.213 (0.132)	0.792 (0.209)	0.164	0.294 (0.093)	1.000 (0.175)	0.209	0.256 (0.109)	1.295 (0.980)
Turkey	0.067	0.166 (0.122)	0.025 (0.40)	0.061	0.174 (0.195)	0.046 (0.41)	0.463	0.452 (0.183)	9.618 (6.61)	0.005	0.583 (0.124)	9.391 (2.944)
United_States_of_America	0.000	0.904 (0.122)	0.882 (0.134)	0.000	0.904 (0.122)	0.882 (0.134)	0.000	0.950 (0.126)	0.975 (0.077)	0.000	0.950 (0.126)	0.975 (0.077)
Uruguay	0.002	0.420 (0.132)	0.650 (0.145)	0.000	0.441 (0.12)	0.673 (0.115)	0.138	0.336 (0.153)	3.475 (2.402)	0.021	0.398 (0.174)	2.210 (4.295)
Venezuela	0.062	0.248 (0.102)	1.013 (0.30)	0.058	0.246 (0.10)	0.955 (0.320)						

The ADF columns report the results from Dickey-Fuller tests applied to the residuals of the equation in log-levels (in the form of the MacKinnon approximate p-values).
In red are the cases where we fail to reject that there is a unit root in the residuals at the 10% confidence level, thus pointing to lack of co-integration between the variables.
Robust standard errors are indicated in parenthesis next to the point estimates.

APPENDIX 10: HETEROGENEOUS PANELS ESTIMATION (LR-PT WITH PEDRONI'S PDOLS)

Applying Pedroni's Panel dynamic OLS (PDOLS) allows for an estimation of the heterogeneous co-integration parameters (long-term pass-through, corresponding to the β_i s in the equation below), as well as of group mean averages (see Neal, 2014).

$$\ln(pp_{i,t}) = \alpha_i + \beta_i \ln(pi_{i,t}) + \sum_{j=-J}^J \gamma_{i,j} \cdot \Delta[\ln(pi)]_{i,t-j} + \epsilon_{i,t} \quad (19A)$$

Two t-tests are run in parallel of the estimations: one that compares the long-run pass-through to the value of 0, and one that compares it to 1. In Table 42A below, the test statistics are reported to the left (=0) and to the right (=1) of the parameter, and the cases where the null hypothesis of equality cannot be rejected (10% confidence level) are highlighted in red.

Again, in most cases, the long-term parameters are statistically significantly different from 0, but not from one. This said, the correlation coefficients are still very low between the point estimates obtained with Pedroni's method and those coming from the previous analysis (see Table 43A). Once again, the magnitude of the standard errors makes the long-run parameters much less precise.

In the rest of the analysis, a greater emphasis will be put on the estimates obtained from the error correction models, which seem to combine the advantages of parsimony and more precise long-term estimates.

Graph 16A: Long-run pass-through estimates from Pedroni's PDOLS

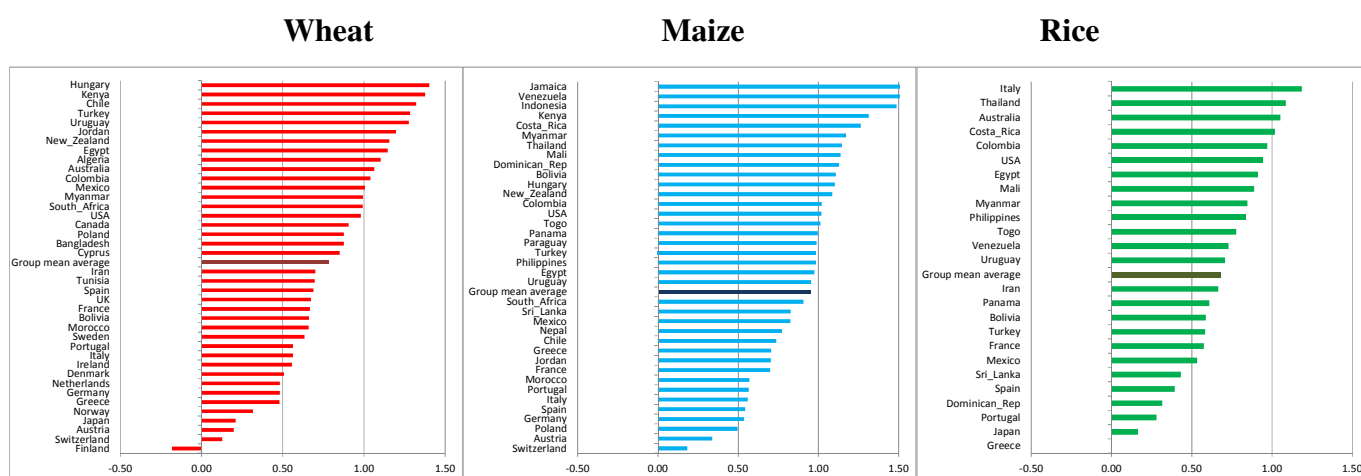


Table 42A: Long-run estimates from Pedroni's PDOLS (1970-2013)

Application of Pedroni's Panel Dynamic Ordinary Least Squares (PDOLS)
on price series in current dollars (USD) over the full period under analysis (1970-2013)
2 lags and leads / 3 lags used in kernel

WHEAT 1521 obs. (39/ind)				MAIZE 1443 obs. (39/ind)				RICE 975 obs. (39/ind)			
	t-test (=0)	PT_LT	t_test (=1)		t-test (=0)	PT_LT	t_test (=1)		t-test (=0)	PT_LT	t_test (=1)
Group mean average	31.440	0.783	-4.466	Group mean average	28.580	0.953	-1.719	Group mean average	13.940	0.683	-6.694
Algeria	3.382	1.103	0.316	Austria	0.830	0.338	-1.626	Australia	4.072	1.051	0.196
Australia	14.110	1.064	0.851	Bolivia	5.320	1.109	0.523	Bolivia	3.244	0.586	-2.290
Austria	0.439	0.198	-1.780	Myanmar	3.732	1.171	0.544	Myanmar	1.581	0.847	-0.286
Bangladesh	6.973	0.876	-0.983	Sri_Lanka	2.174	0.827	-0.456	Sri_Lanka	2.745	0.431	-3.621
Bolivia	7.249	0.661	-3.724	Chile	7.457	0.736	-2.677	Colombia	3.153	0.970	-0.097
Myanmar	3.903	0.995	-0.020	Colombia	5.840	1.021	0.121	Costa_Rica	3.226	1.018	0.056
Canada	3.706	0.905	-0.388	Costa_Rica	6.493	1.264	1.355	Dominican_Rep	0.652	0.316	-1.411
Chile	9.509	1.321	2.313	Dominican_Rep	3.396	1.128	0.385	Egypt	2.243	0.912	-0.217
Colombia	10.370	1.040	0.401	Egypt	3.522	0.974	-0.094	France	2.477	0.575	-1.830
Cyprus	3.696	0.849	-0.656	France	2.748	0.699	-1.181	Greece	-0.546	-0.001	-5.526
Denmark	2.009	0.507	-1.953	Germany	1.886	0.535	-1.638	Iran	1.273	0.664	-0.644
Egypt	2.719	1.146	0.347	Greece	4.039	0.706	-1.682	Italy	3.884	1.185	0.607
Finland	-0.288	-0.181	-1.875	Hungary	4.760	1.101	0.436	Japan	0.312	0.163	-1.599
France	2.712	0.667	-1.354	Indonesia	11.790	1.486	3.857	Mali	1.962	0.889	-0.245
Germany	1.699	0.482	-1.828	Italy	1.908	0.559	-1.503	Mexico	5.707	0.533	-5.005
Greece	1.655	0.480	-1.797	Jamaica	2.891	2.581	1.771	Panama	2.443	0.608	-1.577
Hungary	11.530	1.402	3.303	Jordan	2.771	0.703	-1.171	Philippines	2.850	0.835	-0.565
Iran	2.078	0.701	-0.889	Kenya	3.330	1.314	0.796	Portugal	0.740	0.279	-1.915
Ireland	2.605	0.556	-2.081	Mali	3.183	1.138	0.386	Spain	1.231	0.393	-1.904
Italy	2.391	0.562	-1.861	Mexico	3.914	0.825	-0.833	Thailand	3.926	1.085	0.308
Japan	0.456	0.210	-1.717	Morocco	2.753	0.570	-2.081	Togo	3.782	0.777	-1.087
Jordan	5.392	1.198	0.891	Nepal	3.748	0.773	-1.100	Turkey	2.141	0.584	-1.528
Kenya	4.752	1.377	1.301	New_Zealand	4.816	1.087	0.386	USA	9.178	0.941	-0.573
Mexico	5.599	1.007	0.039	Panama	4.161	0.997	-0.012	Uruguay	3.486	0.707	-1.446
Morocco	4.770	0.660	-2.460	Paraguay	4.517	0.989	-0.050	Venezuela	3.388	0.727	-1.271
Netherlands	1.734	0.483	-1.855	Philippines	4.944	0.984	-0.081				
New_Zealand	9.045	1.155	1.216	Poland	2.646	0.495	-2.700				
Norway	1.346	0.316	-2.911	Portugal	1.826	0.567	-1.396				
Poland	5.016	0.876	-0.707	South_Africa	4.901	0.907	-0.502				
Portugal	1.425	0.563	-1.105	Spain	2.176	0.545	-1.820				
South_Africa	5.294	0.993	-0.038	Switzerland	0.517	0.181	-2.335				
Spain	2.989	0.690	-1.344	Thailand	6.201	1.145	0.786				
Sweden	2.538	0.634	-1.466	Togo	3.966	1.012	0.047				
Switzerland	0.450	0.127	-3.091	Turkey	4.859	0.985	-0.072				
Tunisia	3.467	0.696	-1.512	USA	26.400	1.019	0.501				
Turkey	6.635	1.284	1.468	Uruguay	6.882	0.954	-0.331				
UK	3.463	0.673	-1.686	Venezuela	6.558	1.839	2.992				
USA	33.000	0.980	-0.675								
Uruguay	6.537	1.277	1.418								

The tables report, for each cereal, the country-specific long-term pass-through estimate obtained with Pedroni's Panel dynamic OLS. To the left of the coefficient lays the t-statistic for the null hypothesis that the coefficient is equal to 0, while the column to the right tests the equality of the coefficient to 1. In red are highlighted the cases where we fail to reject that the coefficient is equal to either 0 or 1.

Table 43A: Correlation between the long term PT estimates and the PDOLS estimates

Correlation between the long term pass-through estimates, and Pedroni's PDOLS coefficients

Wheat	PT_ECM_LT	PT_Δ_LT_1L	PT_Δ_LT_2L	PT_Δ_LT_3L
PT_Pedroni	0.616	0.4388	0.4168	0.4154

Maize	PT_ECM_LT	PT_Δ_LT_1L	PT_Δ_LT_2L	PT_Δ_LT_3L
PT_Pedroni	0.8617	0.001	0.2657	0.2949

Rice	PT_ECM_LT	PT_Δ_LT_1L	PT_Δ_LT_2L	PT_Δ_LT_3L
PT_Pedroni	0.4369	0.0373	0.1224	0.165

The tables report the pairwise correlation coefficients (Pearson's) between the pass-through estimates from the different methods

APPENDIX 11: ASYMMETRIC PASS-THROUGH

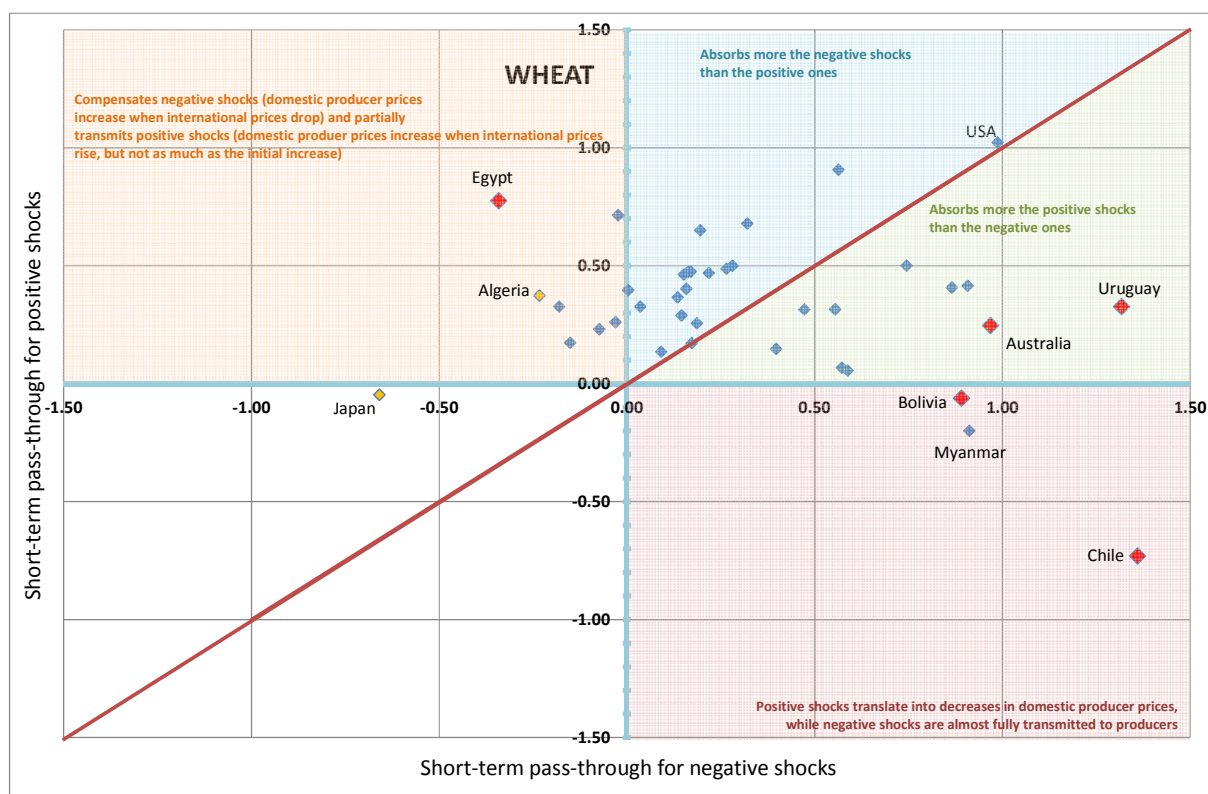
This appendix provides a graphical depiction of the results obtained with an asymmetric error-correction model, and focuses only on short-term pass-through. The model that is estimated (over the period between 1970 and 2013) is the following:

$$\begin{aligned} \Delta \ln(pp_t) = & \alpha \cdot \ln(pi_{t-1}) + \beta \cdot \ln(pp_{t-1}) \\ & + \delta \cdot \Delta[\ln(pp)]_{t-1} + \eta^+ \cdot \Delta[\ln(pi)]_{t-1}^{t+} + \kappa^+ \cdot \Delta[\ln(pi)]_t^{t+} \\ & + \eta^- \cdot \Delta[\ln(pi)]_{t-1}^{t-} + \kappa^- \cdot \Delta[\ln(pi)]_t^{t-} + \gamma \end{aligned} \quad (20A)$$

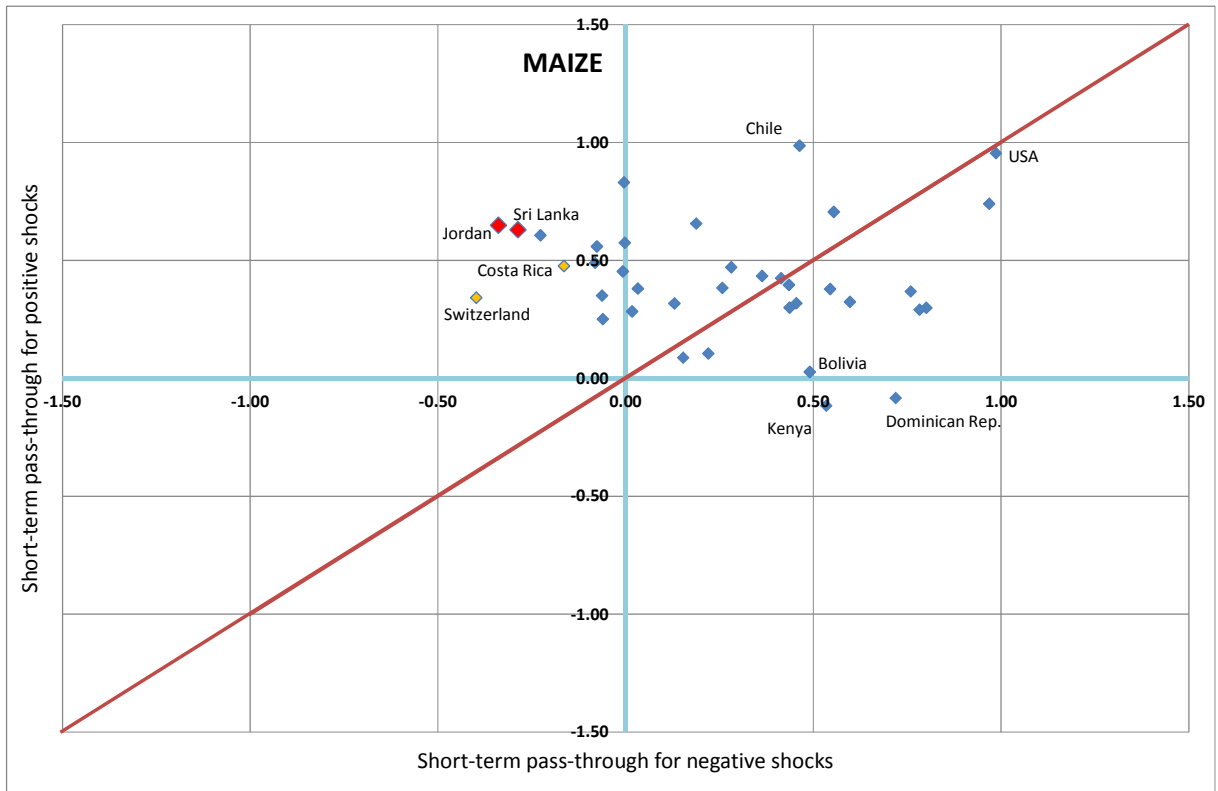
The long-term relationship is maintained, but the impact of the short-term variations of the international price is decomposed into two, depending on whether the contemporaneous variation was positive (increase in international prices) or negative. The lagged independent variables are decomposed similarly upon the sign of the variation at time t (and not $t - 1$). This model thus treats separately periods when current international prices increase, and periods when they decrease. κ^+ and κ^- measure the asymmetric pass-through for positive and negative shocks respectively.

In the graphs below, the pass-through for positive shocks is plotted against the pass-through for negative shocks. The red diagonal thus indicates the locus where pass-through is perfectly symmetric. Each dot corresponds to a country. In red are highlighted cases for which it is possible to reject the null of equality (symmetry) at the 5% confidence level, and in orange at the 10% confidence level.

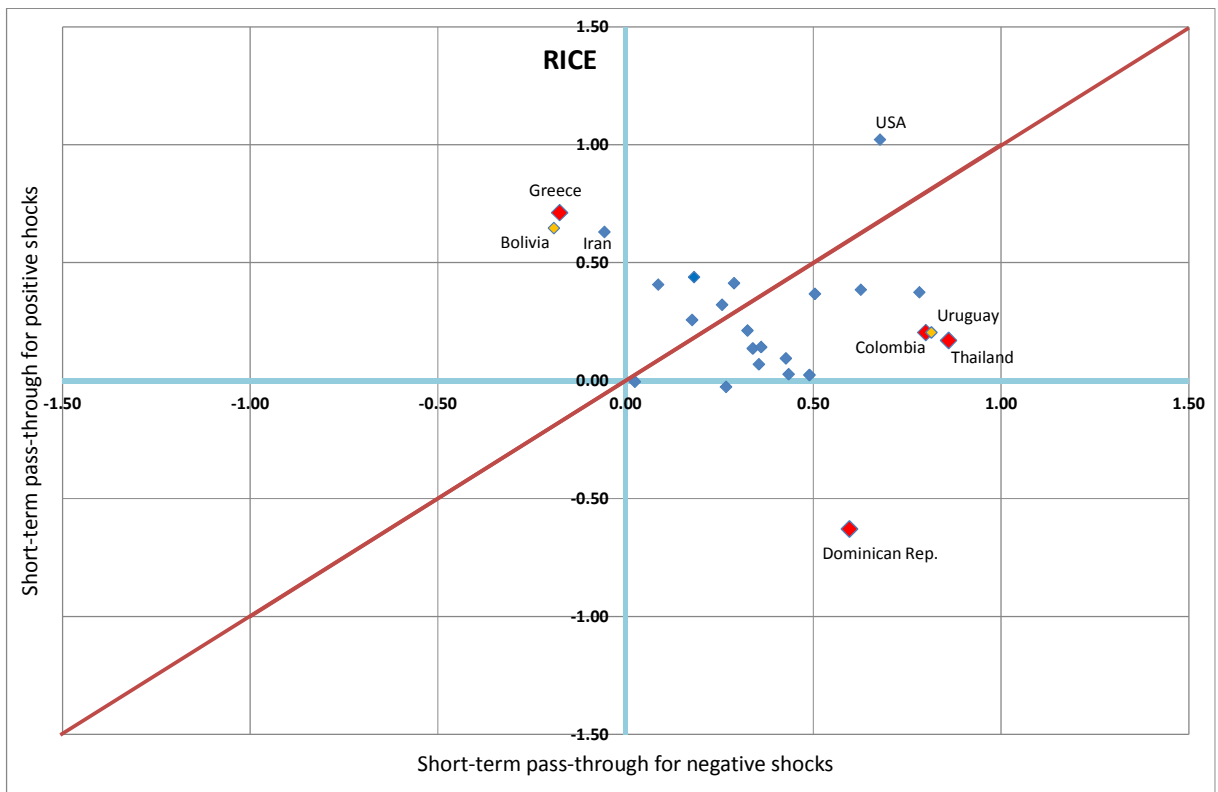
Graph 17A: Asymmetric short-term pass-through estimates, wheat



Graph 18A: Asymmetric short-term pass-through estimates, maize



Graph 19A: Asymmetric short-term pass-through estimates, rice



Appendix 12: Robustness checks

The table below displays the regression results parallel to those displayed in Table 9 when restricting the sample to only those country-commodity pairs that are present in both sub-samples.

Table 44A: Cross-section results, sample restricted to country x commodity pairs observed in both sub-periods

Error-correction model	Country x commodity pairs available in both sub-periods													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.031** (0.013)	0.024* (0.013)	0.021* (0.012)	0.025* (0.014)	0.035* (0.018)	0.020 (0.018)	0.132 (0.190)	-0.118*** (0.030)	-0.124*** (0.031)	-0.127*** (0.030)	-0.109*** (0.033)	-0.108** (0.045)	-0.107** (0.045)	0.353 (0.436)
Wheat dummy	-0.018 (0.054)	0.021 (0.052)	0.038 (0.053)	0.001 (0.056)	-0.020 (0.054)	0.064 (0.053)	-0.002 (0.051)	-0.001 (0.165)	0.029 (0.170)	0.049 (0.167)	-0.028 (0.174)	-0.006 (0.162)	0.017 (0.173)	0.065 (0.164)
Maize dummy	0.023 (0.051)	0.063 (0.050)	0.078 (0.051)	0.008 (0.052)	0.022 (0.051)	0.054 (0.051)	0.005 (0.045)	-0.184 (0.176)	-0.153 (0.183)	-0.136 (0.182)	-0.151 (0.175)	-0.186 (0.174)	-0.115 (0.179)	-0.260 (0.185)
Period dummy (1991-2013)	0.270*** (0.043)	0.275*** (0.042)	0.282*** (0.041)	0.269*** (0.043)	0.275*** (0.042)	0.292*** (0.039)	0.229** (0.098)	0.554*** (0.121)	0.559*** (0.121)	0.566*** (0.121)	0.543*** (0.122)	0.566*** (0.129)	0.570*** (0.130)	0.361 (0.233)
Production / Supply		0.073** (0.037)	0.106 (0.071)			0.121 (0.073)			0.056 (0.051)	0.090 (0.248)			0.041 (0.262)	
(Production / Supply) x Excess			-0.069 (0.077)			-0.089 (0.079)				-0.076 (0.249)			-0.022 (0.265)	
Excess production dummy			0.190** (0.078)			0.214*** (0.080)				0.220 (0.189)			0.171 (0.206)	
Weight in food consumption				-0.198 (0.141)		-0.286** (0.144)					0.269 (0.377)		0.195 (0.440)	
Polity 2 index					-0.002 (0.005)	-0.003 (0.005)						-0.003 (0.014)	-0.004 (0.015)	
Country dummies							YES							YES
Constant	-0.265 (0.201)	-0.264 (0.192)	-0.288 (0.191)	-0.147 (0.213)	-0.336 (0.264)	-0.239 (0.265)	-1.944 (2.783)	2.151*** (0.482)	2.152*** (0.478)	2.127*** (0.444)	1.979*** (0.537)	2.001*** (0.696)	1.848** (0.724)	-4.816 (6.428)
R ²	0.200	0.255	0.287	0.201	0.201	0.293		0.126	0.130	0.136	0.123	0.126	0.133	
N of observations	200	200	200	198	200	198	200	200	200	200	198	200	198	200
Number of countries							52							52
Observations per country							3.850							3.850

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

The table below displays the regression results parallel to those displayed in Table 9 when using average values of GDP per capita, Production / Supply, and weights in food consumption over the sub-periods rather than values in 1980 and 2005 only.

Table 45A: Cross-section results, average measures over the sub-periods

Entire sample of sub-period PT Error-correction model	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.033*** (0.012)	0.029** (0.011)	0.027** (0.011)	0.026** (0.012)	0.020 (0.015)	0.008 (0.015)	0.076 (0.204)	-0.090*** (0.032)	-0.091*** (0.033)	-0.098*** (0.033)	-0.096*** (0.035)	-0.130*** (0.041)	-0.137*** (0.043)	0.268 (0.500)
Wheat dummy	0.022 (0.043)	0.048 (0.042)	0.055 (0.043)	0.042 (0.044)	0.020 (0.043)	0.084* (0.044)	0.035 (0.038)	0.068 (0.141)	0.084 (0.144)	0.082 (0.144)	0.085 (0.145)	0.046 (0.140)	0.068 (0.145)	0.163 (0.134)
Maize dummy	0.069* (0.042)	0.096** (0.041)	0.096** (0.041)	0.046 (0.041)	0.064 (0.042)	0.064 (0.040)	0.063 (0.039)	-0.053 (0.149)	-0.028 (0.153)	-0.033 (0.153)	-0.063 (0.152)	-0.095 (0.148)	-0.071 (0.155)	-0.087 (0.140)
Period dummy (1991-2013)	0.280*** (0.036)	0.269*** (0.035)	0.272*** (0.035)	0.283*** (0.036)	0.264*** (0.037)	0.264*** (0.035)	0.253*** (0.096)	0.526*** (0.099)	0.513*** (0.099)	0.522*** (0.100)	0.526*** (0.099)	0.491*** (0.110)	0.485*** (0.110)	0.450* (0.230)
Production / Supply		0.075*** (0.027)	0.093 (0.062)			0.137** (0.064)			0.052 (0.043)	-0.057 (0.216)			-0.025 (0.223)	
(Production / Supply) x Excess			-0.051 (0.066)			-0.105 (0.069)				0.061 (0.217)			0.022 (0.226)	
Excess production dummy			0.149** (0.065)			0.204*** (0.068)				0.178 (0.183)			0.212 (0.193)	
Weight in food consumption				-0.279** (0.108)		-0.345*** (0.115)					-0.244 (0.378)		-0.070 (0.371)	
Polity 2 index					0.004 (0.003)	0.004 (0.003)						0.011 (0.011)	0.011 (0.011)	
Country dummies							YES							YES
Constant	-0.343** (0.170)	-0.357** (0.162)	-0.365** (0.168)	-0.191 (0.172)	-0.148 (0.213)	-0.063 (0.219)	-1.163 (2.985)	1.679*** (0.488)	1.630*** (0.488)	1.765*** (0.499)	1.797*** (0.544)	2.279*** (0.624)	2.341*** (0.687)	-3.757 (7.339)
R ²	0.240	0.289	0.308	0.252	0.241	0.326		0.081	0.080	0.089	0.080	0.091	0.097	
N of observations	276	275	275	274	273	270	276	276	275	275	274	273	270	276
Number of countries							75							75
Observations per country							3.680							3.680

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

The table below displays results with an alternative specification of trade integration: the ratios of imports to domestic production and the ratio of exports to domestic production (on country x commodity pairs that are present in both sub-periods, and with averages values over the sub-periods for GDP, imports, exports and production variables).

Table 46A: Cross-section results, alternative measures of trade integration

Error-correction model	Pass-through available in both sub-periods			
	Short-term Pass-through		Long-term Pass-through	
LN(GDP per capita)	0.029** (0.013)	0.011 (0.013)	-0.121*** (0.031)	-0.129*** (0.035)
Wheat dummy	-0.017 (0.054)	-0.002 (0.054)	0.000 (0.165)	-0.005 (0.168)
Maize dummy	0.023 (0.051)	0.075 (0.053)	-0.185 (0.176)	-0.182 (0.192)
Period dummy (1991-2013)	0.271*** (0.043)	0.270*** (0.042)	0.552*** (0.121)	0.545*** (0.120)
Imports / Production (average)		-0.005** (0.002)		0.003 (0.005)
Export / Production (average)		0.267*** (0.085)		0.137 (0.176)
Constant	-0.247 (0.204)	-0.018 (0.196)	2.182*** (0.491)	2.276*** (0.506)
R ²	0.199	0.244	0.127	0.131
N of observations	200	200	200	200

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

APPENDIX 13: ROBUSTNESS CHECKS - 2

The tables below display regression results parallel to those displayed in Table 9 taking each cereal separately.

Table 47A: Cross-section results, wheat only

Error-correction model	Wheat Pass-through estimates											
	Short-term Pass-through						Long-term Pass-through					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
LN(GDP per capita)	0.034** (0.017)	0.005 (0.016)	0.005 (0.016)	0.036** (0.018)	0.038 (0.025)	0.026 (0.028)	-0.104** (0.048)	-0.151*** (0.052)	-0.149*** (0.054)	-0.106** (0.048)	-0.027 (0.054)	-0.068 (0.062)
Period dummy (1991-2013)	0.331*** (0.064)	0.345*** (0.057)	0.349*** (0.057)	0.335*** (0.065)	0.337*** (0.065)	0.378*** (0.058)	0.649*** (0.146)	0.671*** (0.139)	0.690*** (0.145)	0.644*** (0.147)	0.729*** (0.160)	0.784*** (0.170)
Production / Supply		0.158*** (0.040)	0.235* (0.120)			0.281** (0.122)		0.256*** (0.086)	0.521 (0.348)			0.556 (0.340)
(Production / Supply) x Excess			-0.065 (0.135)			-0.121 (0.137)			-0.212 (0.351)			-0.214 (0.343)
Excess production dummy			-0.015 (0.129)			0.040 (0.135)			-0.086 (0.290)			-0.126 (0.305)
Weight in food consumption				-0.311 (0.198)		-0.476** (0.218)				0.353 (0.607)		-0.078 (0.777)
Polity 2 index					-0.001 (0.007)	-0.006 (0.007)					-0.025* (0.014)	-0.026 (0.017)
Constant	-0.356 (0.250)	-0.036 (0.230)	-0.073 (0.231)	-0.316 (0.249)	-0.420 (0.353)	-0.304 (0.383)	1.907** (0.755)	2.426*** (0.786)	2.293*** (0.788)	1.861** (0.770)	0.758 (0.844)	1.085 (0.889)
R ²	0.279	0.394	0.399	0.291	0.282	0.427	0.169	0.231	0.243	0.172	0.199	0.284
N of observations	94	94	94	94	93	93	94	94	94	94	93	93

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 48A: Cross-section results, maize only

Error-correction model	Maize Pass-through estimates											
	Short-term Pass-through						Long-term Pass-through					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
LN(GDP per capita)	0.013 (0.021)	0.023 (0.020)	0.022 (0.021)	0.005 (0.022)	-0.008 (0.027)	-0.007 (0.028)	-0.126** (0.055)	-0.118** (0.054)	-0.124** (0.054)	-0.101* (0.058)	-0.168** (0.067)	-0.151* (0.078)
Period dummy (1991-2013)	0.279*** (0.058)	0.253*** (0.056)	0.258*** (0.057)	0.279*** (0.058)	0.247*** (0.060)	0.229*** (0.057)	0.493*** (0.155)	0.479*** (0.158)	0.490*** (0.166)	0.462*** (0.155)	0.452*** (0.165)	0.420*** (0.166)
Production / Supply		0.121*** (0.035)	0.074 (0.078)			0.090 (0.084)		-0.031 (0.094)	-0.156 (0.301)			-0.326 (0.346)
(Production / Supply) x Excess			0.007 (0.096)			-0.025 (0.103)			0.092 (0.311)			0.239 (0.338)
Excess production dummy			0.089 (0.143)			0.124 (0.146)			0.074 (0.322)			0.047 (0.324)
Weight in food consumption				-0.343* (0.198)		-0.359 (0.219)				0.972* (0.497)		1.149* (0.654)
Polity 2 index					0.007 (0.006)	0.007 (0.006)					0.014 (0.019)	0.015 (0.021)
Constant	0.030 (0.306)	-0.205 (0.307)	-0.174 (0.328)	0.169 (0.336)	0.333 (0.399)	0.252 (0.421)	2.174*** (0.809)	2.100*** (0.784)	2.229*** (0.787)	1.749* (0.894)	2.771*** (0.953)	2.608** (1.173)
R ²	0.185	0.232	0.243	0.188	0.198	0.261	0.090	0.080	0.084	0.097	0.103	0.111
N of observations	103	102	102	101	102	99	103	102	102	101	102	99

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 49A: Cross-section results, rice only

Error-correction model	Rice Pass-through estimates											
	Short-term Pass-through						Long-term Pass-through					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
LN(GDP per capita)	0.066*** (0.022)	0.063*** (0.021)	0.063*** (0.022)	0.052** (0.023)	0.046* (0.024)	0.027 (0.023)	-0.006 (0.068)	-0.005 (0.069)	-0.012 (0.074)	-0.072 (0.089)	-0.138 (0.084)	-0.208* (0.110)
Period dummy (1991-2013)	0.192*** (0.065)	0.182*** (0.066)	0.193*** (0.066)	0.201*** (0.065)	0.161** (0.069)	0.169** (0.070)	0.377 (0.234)	0.381 (0.237)	0.336 (0.255)	0.423* (0.231)	0.183 (0.265)	0.166 (0.282)
Production / Supply		0.031* (0.017)	-0.021 (0.108)			0.009 (0.112)		-0.012 (0.026)	0.109 (0.507)			0.209 (0.493)
(Production / Supply) x Excess			0.047 (0.111)			0.012 (0.114)			-0.083 (0.512)			-0.203 (0.501)
Excess production dummy			0.011 (0.087)			0.051 (0.086)			-0.206 (0.387)			-0.041 (0.399)
Weight in food consumption				-0.174 (0.180)		-0.207 (0.212)				-0.867 (0.665)		-0.829 (0.676)
Polity 2 index					0.006 (0.004)	0.007 (0.004)					0.039* (0.021)	0.044** (0.022)
Constant	-0.794** (0.318)	-0.779** (0.311)	-0.771** (0.338)	-0.572* (0.337)	-0.496 (0.352)	-0.237 (0.354)	0.489 (0.978)	0.483 (0.987)	0.620 (1.186)	1.594 (1.379)	2.461* (1.244)	3.566** (1.735)
R ²	0.280	0.303	0.308	0.290	0.280	0.321	0.027	0.028	0.039	0.047	0.070	0.094
N of observations	79	79	79	79	78	78	79	79	79	79	78	78

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

APPENDIX 14: ROBUSTNESS CHECKS - 3

The tables below display regression results parallel to those displayed in Table 9: instead of ECMs, First-Difference models (with up to three lags) were used to estimate the pass-through (the dependent variable).

Table 50A: Cross-section results, Pass-through estimated with static first-difference

First-difference no lag	Full sample of available pass-through estimates						
	Short-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.050*** (0.010)	0.046*** (0.010)	0.047*** (0.010)	0.048*** (0.010)	0.044*** (0.013)	0.038*** (0.013)	-0.162 (0.169)
Wheat dummy	0.026 (0.037)	0.051 (0.036)	0.057 (0.037)	0.033 (0.037)	0.028 (0.037)	0.075* (0.038)	0.030 (0.042)
Maize dummy	0.029 (0.035)	0.055 (0.035)	0.057 (0.036)	0.019 (0.035)	0.029 (0.036)	0.040 (0.036)	0.032 (0.033)
Period dummy (1991-2013)	0.212*** (0.033)	0.200*** (0.032)	0.199*** (0.033)	0.211*** (0.033)	0.203*** (0.036)	0.193*** (0.034)	0.279*** (0.085)
Production / Supply		0.071** (0.029)	0.105** (0.044)			0.122*** (0.046)	
(Production / Supply) x Excess			-0.056 (0.054)			-0.078 (0.056)	
Excess production dummy			0.101* (0.060)			0.125** (0.062)	
Weight in food consumption				-0.091 (0.085)		-0.176* (0.092)	
Polity 2 index					0.002 (0.003)	0.002 (0.003)	
Country dummies							YES
Constant	-0.582*** (0.147)	-0.596*** (0.139)	-0.645*** (0.147)	-0.531*** (0.153)	-0.495** (0.192)	-0.489** (0.191)	2.424 (2.480)
R ²	0.272	0.331	0.341	0.271	0.273	0.345	
N of observations	281	280	280	279	277	274	281
Number of countries							75
Observations per country							3.750

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 51A: Cross-section results, Pass-through estimated with first-difference (one lag)

First-difference 1 lag	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.052*** (0.010)	0.047*** (0.010)	0.048*** (0.010)	0.048*** (0.010)	0.043*** (0.013)	0.035*** (0.013)	-0.172 (0.162)	0.037*** (0.013)	0.033** (0.013)	0.034*** (0.013)	0.040*** (0.013)	0.035** (0.017)	0.034* (0.018)	-0.092 (0.199)
Wheat dummy	0.013 (0.037)	0.037 (0.036)	0.044 (0.037)	0.024 (0.038)	0.016 (0.037)	0.068* (0.038)	0.009 (0.039)	0.081* (0.047)	0.104** (0.046)	0.112** (0.046)	0.072 (0.048)	0.082* (0.047)	0.107** (0.050)	0.111* (0.059)
Maize dummy	0.041 (0.036)	0.066* (0.036)	0.069* (0.037)	0.026 (0.035)	0.040 (0.036)	0.046 (0.036)	0.042 (0.035)	0.016 (0.043)	0.041 (0.043)	0.042 (0.043)	0.025 (0.043)	0.014 (0.043)	0.042 (0.044)	0.024 (0.041)
Period dummy (1991-2013)	0.213*** (0.033)	0.202*** (0.032)	0.201*** (0.033)	0.214*** (0.033)	0.201*** (0.036)	0.194*** (0.034)	0.287*** (0.081)	0.286*** (0.041)	0.274*** (0.040)	0.272*** (0.041)	0.277*** (0.041)	0.282*** (0.044)	0.264*** (0.043)	0.324*** (0.117)
Production / Supply		0.070** (0.029)	0.099** (0.043)			0.125*** (0.045)			0.068** (0.032)	0.127* (0.066)			0.109 (0.071)	
(Production / Supply) x Excess			-0.053 (0.052)			-0.085 (0.054)				-0.083 (0.073)			-0.063 (0.079)	
Excess production dummy			0.106* (0.059)			0.140** (0.060)				0.113 (0.072)			0.095 (0.076)	
Weight in food consumption				-0.151* (0.088)		-0.244** (0.095)				0.130 (0.124)			0.059 (0.139)	
Polity 2 index					0.003 (0.003)	0.003 (0.003)						0.001 (0.004)	0.001 (0.004)	
Country dummies							YES							YES
Constant	-0.611*** (0.148)	-0.624*** (0.140)	-0.671*** (0.146)	-0.526*** (0.154)	-0.488** (0.192)	-0.453** (0.191)	2.578 (2.372)	-0.341* (0.194)	-0.356* (0.189)	-0.425** (0.191)	-0.409** (0.203)	-0.315 (0.258)	-0.416 (0.260)	1.383 (2.922)
R ²	0.273	0.330	0.341	0.275	0.274	0.351		0.235	0.269	0.277	0.234	0.241	0.276	
N of observations	281	280	280	279	277	274	281	281	280	280	279	277	274	281
Number of countries							75							75
Observations per country							3.750							3.750

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 52A: Cross-section results, Pass-through estimated with first-difference (two lags)

First-difference 2 lags	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.053*** (0.010)	0.050*** (0.010)	0.051*** (0.010)	0.047*** (0.010)	0.044*** (0.013)	0.036*** (0.013)	-0.164 (0.170)	0.027* (0.015)	0.024 (0.015)	0.025 (0.015)	0.029* (0.016)	0.021 (0.017)	0.023 (0.017)	-0.232 (0.251)
Wheat dummy	0.019 (0.037)	0.041 (0.037)	0.046 (0.037)	0.037 (0.039)	0.019 (0.038)	0.074* (0.040)	0.020 (0.033)	0.083* (0.049)	0.101** (0.049)	0.105** (0.048)	0.077 (0.052)	0.083* (0.049)	0.097* (0.053)	0.128*** (0.047)
Maize dummy	0.040 (0.038)	0.063* (0.038)	0.065* (0.039)	0.018 (0.036)	0.036 (0.038)	0.033 (0.037)	0.040 (0.037)	-0.012 (0.051)	0.006 (0.052)	0.006 (0.053)	0.001 (0.052)	-0.020 (0.050)	0.004 (0.052)	-0.004 (0.047)
Period dummy (1991-2013)	0.196*** (0.032)	0.185*** (0.032)	0.185*** (0.032)	0.199*** (0.033)	0.182*** (0.035)	0.178*** (0.034)	0.272*** (0.080)	0.253*** (0.043)	0.244*** (0.043)	0.242*** (0.043)	0.247*** (0.043)	0.241*** (0.044)	0.229*** (0.045)	0.358*** (0.123)
Production / Supply		0.063** (0.025)	0.090** (0.042)			0.129*** (0.046)			0.052** (0.023)	0.104 (0.070)			0.096 (0.075)	
(Production / Supply) x Excess			-0.043 (0.050)			-0.090* (0.053)				-0.060 (0.074)			-0.051 (0.080)	
Excess production dummy			0.073 (0.058)			0.116** (0.058)				0.046 (0.076)			0.016 (0.080)	
Weight in food consumption				-0.250** (0.118)		-0.330** (0.131)					0.078 (0.167)		0.040 (0.182)	
Polity 2 index					0.004 (0.003)	0.003 (0.003)							0.004 (0.003)	0.003 (0.003)
Country dummies							YES							YES
Constant	-0.629*** (0.158)	-0.642*** (0.153)	-0.679*** (0.157)	-0.494*** (0.154)	-0.489** (0.196)	-0.431** (0.191)	2.494 (2.496)	-0.136 (0.225)	-0.147 (0.223)	-0.194 (0.223)	-0.189 (0.242)	-0.054 (0.249)	-0.165 (0.257)	3.569 (3.693)
R ²	0.257	0.303	0.308	0.270	0.267	0.335		0.168	0.185	0.187	0.167	0.193	0.207	
N of observations	281	280	280	279	277	274	281	281	280	280	279	277	274	281
Number of countries														75
Observations per country														3.750

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 53A: Cross-section results, Pass-through estimated with first-difference (three lags)

First-difference 3 lags	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.040*** (0.012)	0.036*** (0.012)	0.037*** (0.012)	0.034*** (0.012)	0.031* (0.017)	0.024 (0.016)	-0.016 (0.221)	0.010 (0.022)	0.007 (0.023)	0.010 (0.023)	0.013 (0.024)	0.002 (0.029)	0.009 (0.030)	0.211 (0.338)
Wheat dummy	0.037 (0.045)	0.059 (0.046)	0.063 (0.046)	0.055 (0.047)	0.036 (0.046)	0.086* (0.050)	0.057 (0.049)	0.152* (0.081)	0.166** (0.082)	0.170** (0.082)	0.147* (0.085)	0.157* (0.081)	0.166* (0.088)	0.233*** (0.088)
Maize dummy	0.009 (0.045)	0.032 (0.046)	0.031 (0.047)	-0.012 (0.044)	0.002 (0.045)	0.000 (0.045)	0.015 (0.045)	-0.018 (0.076)	-0.003 (0.077)	-0.009 (0.078)	-0.002 (0.073)	-0.026 (0.074)	-0.010 (0.073)	0.006 (0.064)
Period dummy (1991-2013)	0.232*** (0.036)	0.221*** (0.036)	0.219*** (0.036)	0.232*** (0.036)	0.218*** (0.041)	0.213*** (0.040)	0.245** (0.106)	0.380*** (0.059)	0.373*** (0.060)	0.367*** (0.061)	0.369*** (0.060)	0.363*** (0.065)	0.349*** (0.068)	0.287* (0.162)
Production / Supply		0.063** (0.026)	0.105* (0.060)			0.134** (0.065)			0.041 (0.032)	0.149 (0.117)			0.127 (0.124)	
(Production / Supply) x Excess			-0.051 (0.067)			-0.087 (0.072)				-0.105 (0.123)			-0.079 (0.132)	
Excess production dummy			0.044 (0.073)			0.079 (0.074)				0.010 (0.117)			-0.046 (0.124)	
Weight in food consumption				-0.250* (0.137)		-0.305** (0.154)					0.067 (0.254)		0.002 (0.268)	
Polity 2 index					0.004 (0.004)	0.003 (0.004)							0.006 (0.007)	0.004 (0.007)
Country dummies							YES							YES
Constant	-0.444** (0.187)	-0.456** (0.182)	-0.495*** (0.188)	-0.312 (0.192)	-0.304 (0.251)	-0.273 (0.251)	0.221 (3.243)	0.104 (0.339)	0.095 (0.340)	0.021 (0.344)	0.049 (0.371)	0.201 (0.438)	0.037 (0.455)	-3.184 (4.974)
R ²	0.192	0.225	0.226	0.200	0.199	0.242		0.132	0.136	0.140	0.129	0.151	0.154	
N of observations	281	280	280	279	277	274	281	281	280	280	279	277	274	281
Number of countries														75
Observations per country														3.750

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

APPENDIX 15: ROBUSTNESS CHECKS - 4

The tables below display regression results parallel to those displayed in Table 9: instead of pass-through estimated with ECMs on nominal dollar prices, the dependent variable is measured with (i) ECMs applied on nominal prices and including the nominal exchange rate; (ii) ECMs applied on real dollar prices (the international price is deflated by the US CPI, while the domestic producer prices are deflated by the domestic CPI); (iii) ECMs applied on real dollar prices, including the real exchange rate.

Table 54A: Cross-section results, ECM estimates over nominal prices with exchange rate

Entire sample of sub-period PT Error-correction model Nominal USD + Nominal exchange rate	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.038*** (0.012)	0.034*** (0.012)	0.034*** (0.012)	0.031** (0.013)	0.027 (0.017)	0.016 (0.017)	0.017 (0.189)	-0.031 (0.028)	-0.037 (0.029)	-0.038 (0.030)	-0.029 (0.030)	-0.063 (0.044)	-0.061 (0.045)	0.066 (0.233)
Wheat dummy	0.015 (0.046)	0.040 (0.044)	0.046 (0.045)	0.034 (0.046)	0.013 (0.046)	0.074 (0.046)	0.008 (0.047)	0.090 (0.114)	0.108 (0.119)	0.096 (0.120)	0.088 (0.117)	0.093 (0.115)	0.086 (0.125)	0.182 (0.131)
Maize dummy	0.063 (0.045)	0.092** (0.044)	0.097** (0.044)	0.041 (0.044)	0.060 (0.046)	0.066 (0.044)	0.053 (0.042)	0.007 (0.131)	0.019 (0.135)	0.016 (0.137)	0.021 (0.132)	-0.021 (0.131)	0.006 (0.136)	0.031 (0.145)
Period dummy (1991-2013)	0.222*** (0.039)	0.208*** (0.038)	0.209*** (0.038)	0.225*** (0.039)	0.208*** (0.039)	0.203*** (0.038)	0.210** (0.103)	0.101 (0.093)	0.099 (0.093)	0.101 (0.095)	0.094 (0.093)	0.071 (0.092)	0.071 (0.094)	0.056 (0.126)
Production / Supply		0.077** (0.031)	0.073 (0.061)			0.117* (0.064)			0.049 (0.035)	-0.028 (0.181)			-0.062 (0.189)	
(Production / Supply) x Excess			-0.021 (0.069)			-0.074 (0.072)				0.118 (0.192)			0.150 (0.202)	
Excess production dummy			0.105 (0.071)			0.160** (0.072)				-0.181 (0.177)			-0.209 (0.187)	
Weight in food consumption				-0.273** (0.113)		-0.359*** (0.123)					0.013 (0.297)		0.087 (0.331)	
Polity 2 index					0.004 (0.004)	0.003 (0.004)						0.012 (0.010)	0.010 (0.010)	
Country dummies							YES							YES
Constant	-0.364** (0.180)	-0.382** (0.172)	-0.404** (0.182)	-0.220 (0.187)	-0.196 (0.244)	-0.114 (0.247)	-0.246 (2.783)	1.037** (0.440)	1.070** (0.443)	1.167** (0.482)	1.009** (0.482)	1.500** (0.667)	1.502** (0.689)	-0.338 (3.406)
R ²	0.167	0.218	0.229	0.178	0.172	0.252		0.007	0.012	0.016	0.007	0.016	0.022	
N of observations	277	276	276	275	273	270	277	277	276	276	275	273	270	277
Number of countries														75
Observations per country							3.690							3.690

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 55A: Cross-section results, ECM estimates over real prices

Entire sample of sub-period PT Error-correction model Real USD	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.056*** (0.014)	0.051*** (0.014)	0.048*** (0.014)	0.054*** (0.014)	0.036** (0.017)	0.030* (0.016)	-0.196 (0.207)	0.027 (0.051)	0.034 (0.053)	0.027 (0.052)	0.034 (0.057)	0.038 (0.091)	0.031 (0.091)	0.769 (0.778)
Wheat dummy	-0.015 (0.050)	0.010 (0.049)	0.014 (0.050)	-0.004 (0.052)	-0.009 (0.050)	0.031 (0.052)	-0.002 (0.046)	0.115 (0.195)	0.097 (0.195)	0.112 (0.197)	0.092 (0.202)	0.112 (0.198)	0.108 (0.210)	0.422* (0.219)
Maize dummy	0.001 (0.051)	0.030 (0.050)	0.037 (0.050)	-0.001 (0.048)	0.002 (0.050)	0.029 (0.048)	-0.014 (0.043)	-0.079 (0.207)	-0.087 (0.210)	-0.071 (0.211)	-0.049 (0.208)	-0.079 (0.208)	-0.063 (0.212)	0.044 (0.203)
Period dummy (1991-2013)	0.143*** (0.045)	0.138*** (0.044)	0.143*** (0.044)	0.135*** (0.043)	0.121*** (0.046)	0.123*** (0.045)	0.259*** (0.099)	-0.514*** (0.158)	-0.521*** (0.160)	-0.509*** (0.162)	-0.506*** (0.159)	-0.501*** (0.190)	-0.496** (0.195)	-1.051** (0.468)
Production / Supply		0.067** (0.034)	0.060 (0.070)			0.043 (0.066)			-0.042 (0.063)	-0.007 (0.301)			0.031 (0.308)	
(Production / Supply) x Excess			-0.029 (0.076)			-0.017 (0.073)				-0.132 (0.315)			-0.168 (0.324)	
Excess production dummy			0.159** (0.079)			0.162** (0.074)				0.448 (0.279)			0.462 (0.292)	
Weight in food consumption				-0.152 (0.143)		-0.205 (0.143)					0.306 (0.537)		0.082 (0.563)	
Polity 2 index					0.007* (0.004)	0.005 (0.003)						-0.004 (0.022)	-0.001 (0.022)	
Bounds tax rate														
MFN tax rate														
Country dummies							YES							YES
Constant	-0.590*** (0.207)	-0.593*** (0.202)	-0.577*** (0.219)	-0.529*** (0.203)	-0.310 (0.248)	-0.275 (0.241)	2.993 (3.042)	0.715 (0.770)	0.658 (0.781)	0.650 (0.767)	0.558 (0.907)	0.553 (1.351)	0.550 (1.346)	-10.857 (11.416)
R ²	0.151	0.198	0.226	0.158	0.163	0.241		0.046	0.048	0.062	0.044	0.046	0.060	
N of observations	221	220	220	219	221	218	221	221	220	220	219	221	218	221
Number of countries														64
Observations per country							3.450							3.450

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

Table 56A: Cross-section results, ECM estimates over real prices with exchange rate

Entire sample of sub-period PT Error-correction model Real USD + real exchange rate	Full sample of available pass-through estimates													
	Short-term Pass-through							Long-term Pass-through						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LN(GDP per capita)	0.056*** (0.015)	0.049*** (0.015)	0.046*** (0.015)	0.056*** (0.015)	0.035* (0.019)	0.026 (0.018)	-0.256 (0.202)	0.597*** (0.207)	0.613*** (0.227)	0.548** (0.214)	0.602*** (0.205)	0.642** (0.317)	0.590* (0.341)	-1.782 (2.617)
Wheat dummy	-0.014 (0.051)	0.017 (0.050)	0.024 (0.052)	-0.008 (0.053)	-0.007 (0.052)	0.038 (0.054)	-0.015 (0.045)	0.641 (0.897)	0.620 (0.938)	0.473 (0.929)	0.620 (0.884)	0.627 (0.916)	0.353 (0.931)	0.563 (0.945)
Maize dummy	0.002 (0.055)	0.036 (0.054)	0.044 (0.054)	0.006 (0.053)	0.003 (0.054)	0.040 (0.053)	-0.026 (0.048)	1.888* (1.139)	1.905* (1.144)	1.968* (1.183)	1.899 (1.192)	1.886 (1.146)	2.103 (1.303)	0.838 (0.902)
Period dummy (1991-2013)	0.202*** (0.048)	0.198*** (0.046)	0.204*** (0.047)	0.192*** (0.046)	0.178*** (0.049)	0.180*** (0.048)	0.349*** (0.096)	0.080 (0.721)	0.052 (0.727)	0.171 (0.725)	0.110 (0.726)	0.130 (0.776)	0.160 (0.794)	1.463 (1.947)
Production / Supply		0.082** (0.037)	0.095 (0.073)			0.070 (0.072)			-0.035 (0.252)	-2.200 (1.545)				-2.322 (1.784)
(Production / Supply) x Excess			-0.060 (0.078)			-0.040 (0.077)				2.390 (1.575)				2.546 (1.834)
Excess production dummy			0.219*** (0.080)			0.217*** (0.078)				-1.447 (1.373)				-1.619 (1.505)
Weight in food consumption				-0.082 (0.151)		-0.160 (0.152)					0.258 (1.833)			1.581 (2.351)
Polity 2 index					0.008* (0.004)	0.006 (0.004)							-0.015 (0.072)	-0.003 (0.080)
Bounds tax rate														
MFN tax rate														
Country dummies							YES							YES
Constant	-0.629*** (0.222)	-0.622*** (0.216)	-0.621*** (0.225)	-0.602*** (0.221)	-0.319 (0.273)	-0.299 (0.261)	3.847 (2.975)	-9.331*** (3.238)	-9.517*** (3.328)	-7.426*** (2.754)	-9.447*** (3.269)	-9.969** (4.654)	-8.227* (4.743)	26.093 (37.855)
R ²	0.174	0.231	0.271	0.176	0.186	0.281		0.047	0.048	0.060	0.047	0.048	0.060	
N of observations	221	220	220	219	221	218	221	221	220	220	219	221	218	221
Number of countries							64	LR-PT larger than 5 in absolute value were withdrawn from the sample						64
Observations per country							3.450							3.450

Robust standard errors indicated in parenthesis below the point estimates. * p<0.1, ** p<0.05, *** p<0.01

APPENDIX 16: PROCEDURE FOR CONSTRUCTING THE “ACI MAIN AIRPORT DATASET”

We detail below the selection procedure which allowed us to come up with the database we eventually used for the country-panel analysis.

First we identified the countries represented in the original ACI database by only one airport. Most of the time, those countries are either very small (Luxembourg, Malta, Qatar, Hong Kong...) or in early stages of development. It is therefore not surprising that they should only have one airport. Yet in some cases, the airport reported in the database is surprising (see for instance Iraq which is not represented by Baghdad international airport, but rather by Erbil’s).

**Table 57A: List of countries with only one available airport
(in the grid, the blue squares represent the years for which we have traffic information)**

COUNTRY	CITY	AIRPORT	IATA code	#Obs	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
AFR = 23 countries																								
Angola	Luanda	I.A. 4 de Fevereiro	LAD	7																				
Benin	Cotonou	I.A. Cotonou	COO	18																				
Burundi	Bujumbura	I.A. Bujumbura	BJM	19																				
Comoros	Moroni	I.A. Moroni	HAH	20																				
Congo (Dem Rep)	Kinshasa	A. Kinshasa/Ndjili	FIH	17																				
Cote D'Ivoire	Abidjan	A. Felix Houphouet Boigny	ABJ	19																				
Djibouti	Djibouti	I.A. Djibouti-Ambouli	JIB	12																				
Eq. Guinea	Malabo	Malabo I.A.	SSG	3																				
Eritrea	Asmara	Asmara I.A.	ASM	20																				
Gambia	Banjul	Banjul I.A.	BJL	20																				
Ghana	Accra	Kotoka I.A.	ACC	17																				
Guinea	Conakry	A. Conakry G'Bessia	CKY	20																				
Liberia	Monrovia	Roberts I.A.	ROB	10																				
Malawi	Lilongwe	Lilongwe I.A.	LLW	18																				
Mali	Bamako	I.A. Bamako-Sénou	BKO	16																				
Mauritius	Plaine Magnien	SSR I.A.	MRU	20																				
Mayotte	Dzaoudzi	Dzaoudzi Pamandzi I.A.	DZA	3																				
Rwanda	Kigali	Kigali I.A.	KGL	19																				
Seychelles	Victoria	Seychelles I.A.	SEZ	5																				
Sudan	Khartoum	Khartoum I.A.	KRT	7																				
Swaziland	Manzini	Matsapha I.A.	MTS	5																				
Togo	Lome	A. Lomé-Tokoïn	LFW	20																				
Uganda	Entebbe	Entebbe I.A.	EBB	20																				
ASP = 17 countries																								
Am. Samoa	Pago Pago	Pago Pago I.A.	PPG	8																				
Bangladesh	Dhaka	Shahjalal I.A.	DAC	12																				
Brunei	Bandar Seri Begawan	Brunei I.A.	BWN	14																				
Guam	Hagatña	Guam I.A.	GUM	14																				
Hong Kong, China	Hong Kong	Hong Kong I.A.	HKG	20																				
Macau, China	Macau	Macau I.A.	MFM	18																				
Maldives	Malé	Male' Ibrahim Nasir I.A.	MLE	17																				
Marshall Isl.	Majuro	Majuro I.A.	MAJ	4																				
Micronesia	Pohnpei	Pohnpei I.A.	PNI	11																				
Mongolia	Ulaanbaatar	Chinggis Khaan I.A.	ULN	10																				
Nepal	Kathmandu	Tribhuvan I.A.	KTM	15																				
Papua NewG.	Port Moresby	Port Moresby I.A.	POM	2																				
Singapore	Singapore	Singapore Changi A.	SIN	20																				
Sri Lanka	Colombo	Bandaranaike I.A.	CMB	20																				
Tonga	Nuku'Alofa	Fua'amotu I.A.	TBU	11																				
Vanuatu	Port Vila	Port Vila (Bauerfield) I.A.	VLI	10																				
Wallis & Fortuna	Hihifo	Wallis Hihifo A.	WLS	2																				
EUR = 12 countries																								
Albania	Tirana	Tirana I.A. Nene Tereza	TIA	12																				
Armenia	Yerevan	Zvartnots I.A.	EVN	13																				
Belarus	Minsk	Minsk N.A.	MSQ	15																				
Estonia	Tallinn	Tallinn A.	TLL	20																				
Gibraltar	Gibraltar	Gibraltar A.	GIB	4																				
Hungary	Budapest	Budapest Ferihegy I.A.	BUD	20																				
Kosovo	Pristina	Pristina I.A.	PRN	11																				
Latvia	Riga	Riga I.A.	RIX	20																				
Luxembourg	Luxembourg	Luxembourg-Findel I.A.	LUX	20																				
Malta	Malta	Malta I.A.	MLA	20																				
Moldova	Chisinau	Chisinau A.	KIV	19																				
Monaco	Monaco	H. Monaco-Fontvielle	MCM	20																				

Continued next page

LAC = 17 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Antigua	St John'S	V. C. Bird I.A.	ANU	3																				
Bahamas	Nassau	Lynden Pindling I.A.	NAS	5																				
Barbados	Bridgetown	Grantley Adams I.A.	BGI	15																				
Belize	Belize City	Phillip S.W. Goldson I.A.	BZE	11																				
Bermuda	Bermuda	L.F. Wade I.A.	BDA	20																				
Costa Rica	San Jose	Juan Santamaria I.A.	SJO	11																				
Cuba	Havana	I.A. "José Martí"	HAV	12																				
El Salvador	San Salvador	I.A. El Salvador	SAL	19																				
French Guiana	Cayenne	A. Cayenne-Rochambeau	CAY	14																				
Grenada	St George's	Maurice Bishop I.A.	GND	16																				
Guadeloupe	Pointe-A-Pitre	A. Guadeloupe/Caraïbes	PTP	20																				
Guatemala	Guatemala City	A. La Aurora	GUA	2																				
Guyana	Georgetown	Cheddi Jagan I.A.	GEO	9																				
Haiti	Port-Au-Prince	I.A. Port-au-Prince	PAP	8																				
Martinique	Fort-De-France	A. Martinique-Le Lamentin	FDJ	20																				
Nicaragua	Managua	I.A. Managua	MGA	18																				
Panama	Panama City	I.A. Tocumen	PTY	13																				

MEA = 6 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Bahrain	Bahrain	Bahrain I.A.	BAH	20																				
Iraq	Erbil	Erbil I.A.	EBL	4																				
Kuwait	Kuwait	Kuwait I.A.	KWI	20																				
Lebanon	Beirut	Rafic Hariri I.A.	BEY	20																				
Oman	Muscat	Muscat I.A.	MCT	20																				
Qatar	Doha	Doha I.A.	DOH	12																				

Out of the 186 territories for which the ACI database provides data, 75 fell in the group of those represented by only one airport. We included these observations in the final database.

The next step consisted in identifying the largest city (in terms of passenger traffic) for the countries with multiple airports information, and we selected the corresponding airport (if there was only one airport for the largest city). This procedure enabled us to associate traffic data to 89 additional countries. NB: in general, but not always, the largest airport is also the one with the longest series.

Table 58A: List of countries with only one airport in the largest city (in the grid, the blue squares represent the years for which we have traffic information)

COUNTRY	CITY	AIRPORT	IATA code	# obs	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
AFR = 26 countries																								
Algeria	Algiers	A. Alger Houari Boumediène	ALG	20																				
Botswana	Gaborone	Sir Seretse Khama I.A.	GBE	16																				
Burkina Faso	Ouagadougou	A. Ouagadougou	OUA	15																				
Cameroon	Douala	I.A. Douala	DLA	19																				
Cape Verde	Ilha Do Sal	Amilcar Cabral I.A.	SID	20																				
Central Af. Rep.	Bangui	A. Bangui M'Poko	BGF	16																				
Chad	N'Djamena	N'Djamena A.	NDJ	2																				
Congo	Brazzaville	I.A. Brazzaville Maya-Maya	BZV	15																				
Egypt	Cairo	Cairo I.A.	CAI	20																				
Ethiopia	Addis Ababa	Addis Ababa Bole I.A.	ADD	19																				
Gabon	Libreville	I.A. Léon-Mba	LBV	20																				
Kenya	Nairobi	Jomo Kenyatta I.A.	NBO	19																				
La Reunion	Saint-Denis	A. la Réunion Roland Garros	RUN	20																				
Madagascar	Antananarivo	Antananarivo-Ivato A.	TNR	20																				
Mauritania	Nouakchott	A. Nouakchott	NKC	10																				
Morocco	Casablanca	A. Mohammed V	CMN	20																				
Mozambique	Maputo	Maputo I.A.	MPM	20																				
Niger	Niamey	A. Niamey	NIM	17																				
Nigeria	Lagos	Murtala Muhammed I.A.	LOS	12																				
Senegal	Dakar	I.A. Léopold Sédar Senghor	DKR	19																				
Sierra Leone	Freetown	Lungi I.A.	FNA	9																				
South Africa	Johannesburg	OR Tambo I.A.	JNB	20																				
Tanzania	Dar Es Salaam	Julius Nyerere I.A.	DAR	18																				
Tunisia	Tunis	I.A. Tunis Carthage	TUN	20																				
Zambia	Lusaka	Lusaka I.A.	LUN	20																				
Zimbabwe	Harare	Harare I.A.	HRE	13																				

Continued next page

ASP = 18 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Australia	Sydney	Sydney I.A.	SYD	20																				
Cambodia	Siem Reap	Siem Reap I.A.	REP	13																				
Chinese Taipei	Taipei	Taiwan Taoyuan I.A.	TPE	20																				
Cook Islands	Rarotonga	Rarotonga I.A.	RAR	8																				
Fiji	Nadi	Nadi I.A.	NAN	20																				
French Polynesia	Papeete	A. Tahiti-Faa'a	PPT	19																				
India	New Delhi	Indira Gandhi I.A.	DEL	20																				
Kazakhstan	Astana	I.A. Astana	TSE	15																				
Korea (Rep)	Incheon	Incheon I.A.	ICN	14																				
Malaysia	Kuala Lumpur	KL I.A.	KUL	20																				
Myanmar	Yangon	Yangon I.A.	RGN	2																				
New Caledonia	Noumea	I.A. Noumea La Tontouta	NOU	20																				
New Zealand	Auckland	Auckland I.A.	AKL	20																				
Northern Mariana I.	Saipan	Saipan I.A.	SPN	15																				
Pakistan	Karachi	Jinnah I.A.	KHI	11																				
Samoa	Apia	Faleolo I.A.	APW	17																				
Uzbekistan	Tashkent	Tashkent I.A.	TAS	16																				
Vietnam	Ho Chi Minh City	Tan Son Nhat I.A.	SGN	12																				

EUR = 24 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Austria	Vienna	Vienna I.A.	VIE	20																				
Belgium	Brussels	Brussels I.A.	BRU	20																				
Bosnia & Herz.	Sarajevo	Sarajevo I.A.	SJJ	17																				
Bulgaria	Sofia	Sofia A.	SOF	20																				
Croatia	Zagreb	Zagreb A.	ZAG	20																				
Cyprus	Larnaca	Larnaca I.A.	LCA	20																				
Czech Rep.	Prague	Prague A.	PRG	20																				
Denmark	Copenhagen	Copenhagen I.A.	CPH	20																				
Finland	Helsinki	Helsinki-Vantaa A.	HEL	20																				
Georgia	Tbilisi	Tbilisi I.A.	TBS	13																				
Germany	Frankfurt	A. Frankfurt/Main	FRA	20																				
Greece	Athens	Athens I.A.	ATH	14																				
Iceland	Keflavik	Keflavik I.A.	KEF	19																				
Ireland	Dublin	Dublin A.	DUB	20																				
Lithuania	Vilnius	Vilnius I.A.	VNO	20																				
Macedonia	Skopje	Skopje Alexander the Great A.	SKP	20																				
Montenegro	Tivat	Tivat A.	TIV	12																				
Netherlands	Amsterdam	Amsterdam A.	AMS	20																				
Poland	Warsaw	Warsaw Frederic Chopin A.	WAW	20																				
Portugal	Lisbon	Lisbon A.	LIS	20																				
Serbia	Belgrade	Belgrade Nikola Tesla A.	BEG	20																				
Slovak Rep.	Bratislava	Bratislava A.	BTS	20																				
Slovenia	Ljubljana	Aerodrom Ljubljana I.A.	LIU	20																				
Switzerland	Zurich	A. Zürich	ZRH	20																				

LAC = 16 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Cayman I.	Grand Cayman	Owen Roberts I.A.	GCM	11																				
Chile	Santiago	I.A. Arturo Merino Benitez	SCL	19																				
Colombia	Bogota	I.A. El Dorado	BOG	14																				
Dominican Rep.	Punta Cana	I.A. Punta Cana	PUJ	19																				
Ecuador	Quito	Mariscal Sucre I.A.	UIO	20																				
Honduras	San Pedro Sula	I.A. Ramón Villeda Morales	SAP	19																				
Jamaica	Montego Bay	Sangster I.A.	MBJ	20																				
Mexico	Mexico City	I.A. México DF Lic Benito Juárez	MEX	20																				
Netherlands Antilles	Aruba	Reina Beatrix	AUA	20																				
Paraguay	Asuncion	I.A. Silvio Pettitrossi	ASU	12																				
Peru	Lima	I.A. Jorge Chávez	LIM	17																				
Saint Lucia	St Lucia	Hewanorra A.	UVF	19																				
Trinidad & Tobago	Port of Spain	Piarco I.A.	POS	20																				
Uruguay	Montevideo	I.A. Carrasco	MVD	13																				
Venezuela	Caracas	Simón Bolívar I.A. Maiquetia	CCS	20																				
Virgin I. (U.S.)	St Thomas	Cyril E King A.	STT	4																				

MEA = 4 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Israel	Tel-Aviv	Ben Gurion I.A.	TLV	20																				
Saudi Arabia	Jeddah	King Abdulaziz I.A.	JED	20																				
United Arab Emirates	Dubai	Dubai I.A.	DXB	20																				
Yemen	Sana'a	Sana'a I.A.	SAH	12																				

NAM = 1 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
USA	Atlanta GA	Hartsfield-Jackson Atlanta I.A.	ATL	20																				

We were left with 22 countries for which the largest city in terms of traffic had multiple airports. When, for a given city, the airports' series did not cover the same time span, we had to understand clearly why this was the case. Was it because the historical airport was being

supplemented by a new airport (in which case summing the series and considering the data before the opening of the new facility did have a sense)? Or was it because the airports did not report their data for several years (in which case the sum would create artificial jumps in the evaluation of traffic). In some cases, we were able to complement the data with publicly available figures (in light blue below). In other cases, the airport with missing values was small enough compared to the other airports of the city to simply drop it. In yet other cases, however, it was not possible to identify the cause of the missing values, nor find data to reconstruct the series, nor consider that the missing values were proper zeros (see for instance the case of Beijing Nanyuan airport, the reporting of which starts in 2010). We therefore chose to aggregate the airports data only on the common years, and drop the other observations (in red the dropped observations in the table below).

As dropping China would be problematic in terms of representativeness, we decided to apply a specific treatment to that country. In order to dilute the impact of the late entry of Nanyuan airport into the set, we summed the traffic information available for both Beijing and Shanghai. Indeed, the traffic in those two cities is of comparable magnitude (more than 80 million in 2013). The series for Hongqiao International Airport⁹¹ starts in 1995, and that for Pudong International Airport⁹² in 1999 (but this is the date of its inauguration). Consequently, China is represented, in the Main Airport ACI dataset by the aggregation of four airports (Beijing and Shanghai) from 1995 to 2013.

Table 59A: List of countries with multiple airports for the largest city (in the grid, the blue squares represent the years for which we have traffic information)

COUNTRY	CITY	AIRPORTS	IATA code	# obs	'94 '95 '96 '97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13
AFR = 1 countries					
Namibia	Windhoek	Eros A.	ERS	16	[grid]
		Hosea Kutako I.A.	WDH	18	[grid]
ASP = 5 countries					
China (PRC)	Beijing	Beijing Capital I.A.	PEK	20	[grid]
		Beijing Nanyuan	NAY	4	[grid]
Indonesia	Jakarta	Halim Perdanakusuma A.	HLP	20	[grid]
		Soekarno-Hatta I.A.	CGK	20	[grid]
Japan	Tokyo	Narita I.A.	NRT	20	[grid]
		Tokyo (Haneda) I.A.	HND	20	[grid]
Philippines	Manila	Clark I.A.	CRK	2_12	extended series + 1st value <0,5%
		Ninoy Aquino I.A.	MNL	20	[grid]
Thailand	Bangkok	Don Mueang I.A.	DMK	8	BKK opened in 2006... but total OK
		Suvarnabhumi I.A.	BKK	20	[grid]
EUR = 10 countries					
France	Paris	A. Paris-Charles de Gaulle	CDG	20	[grid]
		A. Paris-Orly	ORY	20	[grid]
Italy	Rome	A. Roma-Ciampino	CIA	20	[grid]
		A. Roma-Fiumicino	FCO	20	[grid]
Norway	Oslo	Fernebu A.	FBU	4	Closed in 1998, replaced by Oslo A. (but overlap pb)
		Oslo A.	OSL	17	[grid]
Romania	Bucharest	Bucharest Baneasa Aurel Blaicu I.A.	BBU	19	[grid]
		Henri Coanda I.A.	OTP	19	[grid]
Russian Fed.	Moscow	Bykovo A.	BKA	2	Very Small, and very little information
		Domodedovo I.A.	DME	17	[grid]
		Sheremetyevo I.A.	SVO	18	[grid]
		Vnukovo I.A.	VKO	20	[grid]

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⁹¹ Hongqiao International Airport (Shanghai): IATA code SHA

⁹² Pudong International Airport (Shanghai): IATA code PVG

Spain	Madrid	A. Barajas	MAD	20	
		A. Torrejon de Ardoz	TOJ	14	very small
Sweden	Stockholm	Stockholm-Arlanda A.	ARN	20	
		Stockholm-Bromma A.	BMA	20	
		Stockholm-Skavsta A.	NYO	8_17	
		Stockholm-Västerås A.	VST	8_17	
Turkey	Istanbul	Atatürk I.A.	IST	20	
		Sabiha Gökçen I.A.	SAW	13	Opened in 2003
Ukraine	Kiev	Borispol State I.A.	KBP	20	
		Kiev-Zhulhany I.A.	IEV	13	
UK	London	Gatwick A.	LGW	20	
		Heathrow A.	LHR	20	
		London City A.	LCY	20	
		London Luton A.	LTN	20	
		Stansted A.	STN	20	
LAC = 3 countries					
Argentina	Buenos Aires	I.A. Ezeiza	EZE	16	
		I.A. Don Torcuato Roberto Laplace	DOT	7	at most 0,25% of total
		A. Jorge Newberry	AEP	16	
Brazil	São Paulo	Campo de Marte A.	CBW	6	at most 0,5% of total
		Congonhas I.A.	CGH	13	
		Guarulhos I.A.	GRU	20	
Puerto Rico	San Juan	A. Isla Grande	SIG	2	Small, no information
		Luis Muñoz Marin I.A.	SJU	20	
MEA = 2 countries					
Iran	Tehran	Imam Khomeini I.A.	IKA	6	
		Mehrabad I.A.	THR	14	
Jordan	Amman	Marka I.A.	ADJ	3	
		Queen Alia I.A.	AMM	20	
NAM = 1 countries					
Canada	Toronto ON	Billy Bishop Toronto City A.	YTZ	12	<0,3% of total in 2002
		Toronto Pearson I.A.	YYZ	20	

APPENDIX 17: P-VALUES OF THE AUGMENTED DICKEY-FULLER TEST STATISTICS AT THE COUNTRY LEVEL (ACI – MAIN AIRPORTS DATABASE: 130 COUNTRIES IN THE SET, 12 THAT DO NOT PASS THE TEST)

Table 60A: p-values of the ADF test statistics at the country level

	# obs	ADF Passenger	ADF GDP
Algeria	20	0,725	0,797
Argentina	16	0,841	0,919
Armenia	13	0,227	0,311
Aruba	20	0,495	0,128
Australia	20	0,969	0,168
Austria	20	0,633	0,385
Bahrain	20	0,795	0,921
Barbados	14	0,737	0,156
Belarus	15	0,997	0,576
Belgium	20	0,377	0,188
Belize	11	0,922	0,979
Benin	10	0,016	0,783
Bosnia and Herzegovina	17	0,176	0,398
Brazil	13	0,792	0,861
Brunei Darussalam	14	0,476	0,429
Bulgaria	20	0,778	0,938
Burundi	17	0,362	0,942
Cabo Verde	20	0,520	0,249
Cambodia	13	0,897	0,547
Cameroon	18	0,005	0,996
Canada	20	0,530	0,278
Central African Rep.	14	0,761	0,968
Chile	19	0,978	0,977
China (PRC)	19	0,918	0,938
Colombia	12	0,044	0,779
Comoros	20	0,718	0,981
Congo	12	0,992	0,904
Congo (DRC)	16	0,204	0,953
Costa Rica	11	0,096	0,599
Côte d'Ivoire	19	0,188	0,971
Croatia	20	0,864	0,406
Cyprus	20	0,510	0,599
Czech Rep.	20	0,446	0,800
Denmark	20	0,760	0,145
Djibouti	12	0,522	0,957
Dominican Rep.	19	0,515	0,884
Ecuador	20	0,941	0,996
Egypt	20	0,028	0,663
El Salvador	17	0,019	0,702
Eritrea	20	0,054	0,161
Estonia	20	0,642	0,484
Ethiopia	19	0,998	0,998
Fiji	20	0,976	0,629
Finland	20	0,432	0,101
France	20	0,361	0,246
FYR of Macedonia	20	0,242	0,921
Gabon	20	0,163	0,933
Gambia	20	0,194	0,935
Germany	20	0,700	0,739
Ghana	17	0,996	0,999
Greece	12	-	0,428
Grenada	16	0,730	0,081
Guinea	20	0,110	0,142
Honduras	19	0,082	0,922
Hungary	20	0,353	0,437
Iceland	17	0,863	0,649
India	20	0,953	0,979
Indonesia	20	0,991	0,992
Ireland	20	0,319	0,094
Israel	20	0,943	0,950
Italy	20	0,475	0,290
Jamaica	20	0,110	0,610
Japan	20	0,792	0,700
Kazakhstan	15	0,885	0,032
Kenya	19	0,918	0,999
Kuwait	20	0,982	0,840
Latvia	20	0,865	0,467
Lebanon	20	0,941	0,987
Liberia	10	0,895	0,704
Lithuania	20	0,905	0,631
Luxembourg	20	0,918	0,300
Madagascar	20	0,129	0,805
Malawi	18	0,720	0,985
Malaysia	20	0,671	0,931
Maldives	17	0,825	0,803
Mali	15	0,687	0,001
Malta	20	0,985	0,036
Mauritius	20	0,105	0,421
Mexico	20	0,505	0,310
Morocco	20	0,794	0,990
Mozambique	20	0,894	0,013
Namibia	16	0,900	0,989
Nepal	15	0,940	0,989
Netherlands	20	0,193	0,153
New Zealand	20	0,866	0,748
Nicaragua	16	0,170	0,974
Niger	17	0,996	0,998
Nigeria	12	0,371	0,602
Norway	17	0,984	0,525
Oman	20	0,981	0,986
Pakistan	10	0,775	0,276
Panama	11	0,845	0,964
Peru	16	0,994	0,995
Philippines	20	0,999	0,997
Poland	20	0,954	0,701
Portugal	20	0,890	0,082
Qatar	12	0,367	0,358
Rep. of Korea	14	0,986	0,214
Rep. of Moldova	18	0,988	0,978
Romania	16	0,676	0,484
Russian Fed.	17	0,983	0,235
Rwanda	19	0,943	0,562
Saint Lucia	19	0,171	0,664
Samoa	16	0,344	0,004
Saudi Arabia	20	0,894	0,995
Senegal	19	0,541	0,338
Singapore	20	0,991	0,941
Slovakia	20	0,526	0,779
Slovenia	20	0,570	0,291
South Africa	20	0,003	0,878
Spain	20	0,270	0,222
Sri Lanka	20	0,952	0,998
Sweden	17	0,766	0,361
Switzerland	20	0,747	0,891
Thailand	20	0,978	0,976
Togo	20	0,978	0,993
Tonga	11	0,206	0,440
Trinidad and Tobago	20	0,412	0,268
Tunisia	20	0,273	0,076
Turkey	20	0,997	0,921
U.K.	20	0,184	0,328
U.S.A.	20	0,169	0,195
Uganda	20	0,972	0,819
United Arab Emirates	20	0,996	0,633
United Rep. of Tanzania	18	0,874	0,995
Uruguay	11	0,662	0,827
Uzbekistan	16	0,197	0,999
Vanuatu	10	0,929	0,075
Venezuela (Boliv. Rep.)	20	0,480	0,878
Zambia	20	0,955	1,000

APPENDIX 18: ERROR CORRECTION MODEL ESTIMATIONS WITH ICAO DATA OVER 1970-2013 ^{A) B) C)}

Table 61A: ECM estimates with ICAO data over the full period

ICAO full database (1970-2013)						
Country groupings	All	High Income OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Dependant variable = growth of traffic (Δ Log Traffic)						
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic ($-\phi$)	-0.124*** <i>(0.028)</i>	-0.174* <i>(0.074)</i>	-0.084 <i>(0.059)</i>	-0.113*** <i>(0.026)</i>	-0.138** <i>(0.042)</i>	-0.117*** <i>(0.021)</i>
Lagged Log GDP ($\phi\chi$)	0.146*** <i>(0.040)</i>	0.301* <i>(0.124)</i>	0.119 <i>(0.098)</i>	0.067 <i>(0.046)</i>	0.181* <i>(0.065)</i>	0.155*** <i>(0.027)</i>
Political Disorder (ω_1)	-0.361** <i>(0.117)</i>	-0.125 <i>(0.276)</i>	-0.787* <i>(0.320)</i>	0.171 <i>(0.406)</i>	-0.819 <i>(0.792)</i>	-0.503*** <i>(0.074)</i>
Terms of Trade (ω_2)	0.053 <i>(0.029)</i>	-0.025 <i>(0.055)</i>	0.065 <i>(0.056)</i>	0.083 <i>(0.042)</i>	0.017 <i>(0.041)</i>	-0.047 <i>(0.024)</i>
Growth of GDP (ψ_{Y0})	0.726*** <i>(0.197)</i>	1.213*** <i>(0.239)</i>	0.266 <i>(0.310)</i>	0.387** <i>(0.125)</i>	0.923 <i>(0.482)</i>	0.796** <i>(0.232)</i>
Long-run GDP-elasticity of air traffic (χ)	1.181*** <i>(0.115)</i>	1.725*** <i>(0.180)</i>	1.418*** <i>(0.390)</i>	0.591 <i>(0.305)</i>	1.314*** <i>(0.194)</i>	1.327*** <i>(0.159)</i>
Testing ($\chi - \psi_{Y0}$)=0	0.456* <i>(0.219)</i>	0.512 <i>(0.304)</i>	1.152* <i>(0.473)</i>	0.203 <i>(0.335)</i>	0.391 <i>(0.508)</i>	0.532 <i>(0.271)</i>
R ² (within)	0.091	0.133	0.049	0.058	0.278	0.083
Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic ($-\phi$)	-0.248*** <i>(0.046)</i>	-0.279*** <i>(0.045)</i>	-0.177** <i>(0.054)</i>	-0.159*** <i>(0.032)</i>	-0.228** <i>(0.051)</i>	-0.258*** <i>(0.023)</i>
Lagged Log GDP ($\phi\chi$)	0.325*** <i>(0.083)</i>	0.277** <i>(0.082)</i>	0.181 <i>(0.094)</i>	0.337** <i>(0.111)</i>	0.338* <i>(0.147)</i>	0.198 <i>(0.116)</i>
Political Disorder (ω_1)	-0.264 <i>(0.138)</i>	0.132 <i>(0.296)</i>	-0.992* <i>(0.363)</i>	0.406 <i>(0.558)</i>	-0.640 <i>(0.888)</i>	-0.330** <i>(0.113)</i>
Terms of Trade (ω_2)	0.015 <i>(0.026)</i>	0.031 <i>(0.044)</i>	0.081* <i>(0.036)</i>	0.027 <i>(0.052)</i>	0.009 <i>(0.052)</i>	-0.066* <i>(0.030)</i>
Growth of GDP (ψ_{Y0})	0.748*** <i>(0.201)</i>	1.111*** <i>(0.265)</i>	0.215 <i>(0.326)</i>	0.492*** <i>(0.129)</i>	0.903 <i>(0.469)</i>	0.801** <i>(0.221)</i>
Average time trend	-0.29%*** <i>(0.23%)</i>	0.58% <i>(0.39%)</i>	0.03% <i>(0.25%)</i>	-1.23%*** <i>(0.35%)</i>	-0.27% <i>(0.35%)</i>	0.89% <i>(0.55%)</i>
#neg. Trend // #pos. Trend	45 <0 // 61 ~ // 36 >0	1 <0 // 17 ~ // 10 >0	1 <0 // 16 ~ // 4 >0	20 <0 // 15 ~ // 1 >0	2 <0 // 7 ~ // 2 >0	2 <0 // 14 ~ // 9 >0
Long-run GDP-elasticity of air traffic (χ)	1.309*** <i>(0.258)</i>	0.993** <i>(0.338)</i>	1.026* <i>(0.483)</i>	2.121** <i>(0.735)</i>	1.481** <i>(0.482)</i>	0.769 <i>(0.454)</i>
Testing ($\chi - \psi_{Y0}$)=0	0.561** <i>(0.212)</i>	-0.118 <i>(0.345)</i>	0.810 <i>(0.537)</i>	1.629* <i>(0.708)</i>	0.579 <i>(0.423)</i>	-0.032 <i>(0.498)</i>
R ² (within)	0.188	0.215	0.159	0.152	0.353	0.163
Nb of obs.	4690	1041	783	1137	405	818
Nb of countries	142	28	21	36	11	25
Average Nb of obs.	33.03	37.18	37.29	31.58	36.82	32.72

Standard errors in brackets and italics, * $p > .1$, ** $p > .05$, *** $p > .01$

The ICAO database is restricted to those countries with at least 10 continuous years of observation, and with $I(1)$ GDP and traffic variables. In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).

APPENDIX 19 - PANEL SELECTION AND TREATMENT OF OUTLIERS

To the best of our knowledge, we are the first to build such a database for the French life insurance business. Unfortunately, the raw data was not rigorously maintained for certain fields and we chose to keep only the most reliable. Indeed, we observe a lot of mistakes or contradictory information that we are not able to correct as we identify no other source of data to conduct a cross-validation. The low quality issue concerns mainly small life insurers, mutual insurances and providence institutions which we therefore remove from our sample. The last two categories, however, sell few savings contracts. The data for medium and big insurers is clearly of a better quality. Another issue concerns the limited time depth, as we do not have access to reliable data prior to 1999. In such a context, the main purpose of this appendix consists in checking the reliability of the supervisory data-set and justifying the selected perimeter. We summarize below the treatments and filters we applied to the data.

At first, we extract all relevant information from the regulatory databases, selecting all undertakings with mathematical reserves larger than EUR 50 million for at least 5 years. We then scrutinize the data-set in order to identify atypical observations, correcting those that are obvious reporting mistakes from the undertakings and eliminating the extreme outliers for which we could find no explanation based on our expert opinion. Indeed, we analyze specifically each undertaking and try to explain their unusual data points by looking in the archives for known changes in management actions or major absorption operations. Most outlying companies are small, with highly targeted customers, and experience erratic financial incomes, probably due to the fact that they are not large enough to be able to diversify their risks efficiently.

We address the issue of mergers and acquisitions in our sample as these operations can induce serious changes in the financial situation of the affected entities. These events are relatively common in the French insurance market for the period under study, and precisely analyzing their effects on the profit sharing policy is a tricky problem. We could rely on the ACPR records that document these operations, however this information is very general and the concerned contracts and their amounts are not clearly identified. Being aware that large mergers and acquisitions can significantly bias the results, we decompose the entities before and after the operation and consider them as distinct undertakings. Indeed, we generally observe graphically large behavior changes for the absorbing companies in the following years.

After applying the size filters, correcting the reporting mistakes, and splitting the insurers that underwent mergers and acquisitions, we obtain a sample of 91 undertakings and 965 observations over the 1999-2013 period. We are left with only four “pure” mutual insurers (*Mutuelles*, ruled under the *Code de la Mutualité*), corresponding to 32 observations; and no providence institution (*Institution de Prévoyance*, ruled under the *Code de la Sécurité Sociale*). Note, however, that one subtlety of the French legislation is that there exist so called “mutual insurers” that are ruled by the *Code des Assurances* rather than by the *Code de la Mutualité* (the *Sociétés d’assurance mutuelle*, or mutual insurance corporations), which are often sub-branches of large insurance corporations.

We do have several undertakings of this type in our sample.

As could be seen with a mere histogram, the deviation of the asset returns from the OAT-10Y in our dataset is concentrated between $-500bps$ and $+500bps$, although a few observations reach extremely high spreads. When one looks more closely at the 22 observations outside this interval, one notices that 14 (and the furthest) correspond to the same two companies. Given their atypical behavior, we decide to drop these two insurers as we suspect errors in the reported data. The remaining 938 observations lie within the $[-803bps ; + 748bps]$ interval.

We then look at the distribution of the spread between the participation rate and the OAT10Y. The histogram of this variable is much more concentrated around 0 than the return on assets variable. Indeed, most observations lie between $-300bps$ and $+300bps$ (only 12 observations were outside this interval, five of which, and the highest, corresponding to one of the undertaking dropped previously).

In the end, we specifically scrutinize the variable coding for the stock of profit-participation reserve (PPB) relative to the mathematical reserves (MRs). This variable is considered at the beginning of year in order to avoid endogeneity with the participation rate: indeed, the stock of PPB at the end of the year depends on the amount of profit participation distributed (at the end of the year) for the entire elapsed year. One observation indicates a negative PPB. It relates to a merger operation, and we decide to drop it. On the other hand, we note that one observation reaches 47%. When looking at the evolution of the PPB ratio for the corresponding undertaking, one clearly sees that it is a reporting mistake as the observations that precede and follow it are almost constant, around 4%. We decide to drop this observation as well.

APPENDIX 20 - ADDITIONAL CONTROLS FOR THE STATIC MODEL

Building on Model 4, we try and add other potential explanatory candidates in order to see whether they can explain part of the remaining variance and check the stability of our coefficients to the introduction of these variables. We first look at the soundness variables (Models 5.a and 5.b) and at the size variable (Model 6). The results of the estimations are presented in Table 62.

The coefficients on the reference model's variables do not change much with the introduction of the additional terms, except for the one on asset returns which is reduced by an amount equivalent to the value of the coefficient on the newly introduced UCGL variable. We therefore merely decompose part of the variance previously attributed to the financial performance. Due to missing data, our sample is marginally reduced with the solvency ratio variable, although the coefficients of the baseline model are stable. While the coverage ratio is significant at the 10 % level in the FE specification, the impact is extremely small. The size variable (the natural logarithm of the mathematical reserves) does not alter the baseline model coefficients. The variable itself is only significant under the pooled-OLS specification, as there is not much variation for a given individual across time. The coefficient is positive, as expected, yet extremely small as it indicates that an increase in the MRs by 1 % is associated with an increase in the participation by *5bps*.

Table 62A: Estimating the static model with impact of the soundness and size variables.

	<i>Participation Rate Spread $\rho_{i,t}$</i>							
	Model 4		Model 5.a		Model 5.b		Model 6	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Asset Return – OAT-10Y	0.212*** (0.026)	0.148*** (0.025)	0.200*** (0.029)	0.116*** (0.027)	0.206*** (0.029)	0.138*** (0.027)	0.209*** (0.026)	0.147*** (0.025)
OAT-10Y	-0.259*** (0.027)	-0.341*** (0.027)	-0.253*** (0.028)	-0.331*** (0.027)	-0.257*** (0.028)	-0.338*** (0.028)	-0.246*** (0.027)	-0.347*** (0.030)
Surrender Rate	-0.030*** (0.007)	-0.053*** (0.010)	-0.029*** (0.008)	-0.052*** (0.009)	-0.029*** (0.008)	-0.053*** (0.010)	-0.031*** (0.007)	-0.052*** (0.010)
PPB Ratio (BoY)	0.016* (0.009)	0.067*** (0.022)	0.013 (0.009)	0.070*** (0.022)	0.011 (0.009)	0.067*** (0.023)	0.022** (0.009)	0.067*** (0.022)
UCGL ratio			0.008* (0.005)	0.018*** (0.005)				
Capital Ratio					0.00030* (0.00016)	0.00034* (0.00018)		
Log of the MRs							0.00052*** (0.00013)	-0.00019 (0.00055)
Constant	0.013*** (0.001)	0.016*** (0.001)	0.012*** (0.001)	0.015*** (0.001)	0.012*** (0.001)	0.015*** (0.001)	0.008*** (0.002)	0.018*** (0.005)
Nobs	936	936	934	934	915	915	936	936
F statistic	42	69	41	60	42	57	37	56
R^2	0.24	0.54	0.24	0.55	0.24	0.55	0.25	0.54
Adjusted R^2	0.24	0.49	0.24	0.50	0.24	0.49	0.25	0.49

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the static models, with both pooled-OLS and fixed effects (FE) specifications. Models 5.a and 5.b measure the additional effect of the soundness variables and Model 6 tests the contribution of the size effects. The constant corresponds to the mean of fixed effects for FE models. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Second, we study the effect of the introduction of several reserving variables (the *Provision pour risque d'exigibilité* – PRE, the *Provision pour dépréciation durable* – PDD and the *Réserve de capitalisation* – RC) on our reference model (Model 4). The results reported in Table 63

indicate clearly that PRE and PDD have no effect on the regression, whereas the RC comes out as statistically significantly correlated with the participation rate under the FE specification. The order of magnitude of the coefficient is small, about the same as the one on the PPB. The coefficients of the baseline model are not affected by the new variable.

In a last step, we consider in Table 64A two ALM variables in addition to the asset return variable: the asset structure (Model 8.a) and the capital gain ratio (Model 8.b).

It appears that more investment in equity generally implies a lower participation (both under OLS and FE specifications). This is rather surprising, as one would expect that more risk should be associated with higher yields over the long term. The coefficients of the baseline model are not affected much by the introduction of this asset allocation variable except, unsurprisingly and only marginally, the one for the return variable. The capital gains ratio has no significant impact on the model.

Table 63A: Estimating the static model with impact of the asset reserves variables.

	<i>Participation Rate Spread $\rho_{i,t}$</i>							
	Model 4		Model 7.a		Model 7.b		Model 7.c	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Asset Returns – OAT-10Y	0.212*** (0.026)	0.148*** (0.025)	0.211*** (0.028)	0.143*** (0.025)	0.212*** (0.027)	0.146*** (0.026)	0.208*** (0.026)	0.148*** (0.025)
OAT-10Y	-0.259*** (0.027)	-0.341*** (0.027)	-0.259*** (0.027)	-0.342*** (0.027)	-0.259*** (0.027)	-0.343*** (0.027)	-0.256*** (0.027)	-0.350*** (0.027)
Surrender Rate	-0.030*** (0.007)	-0.053*** (0.010)	-0.030*** (0.007)	-0.051*** (0.010)	-0.030*** (0.008)	-0.053*** (0.010)	-0.030*** (0.007)	-0.052*** (0.009)
PPB Ratio (BoY)	0.016* (0.009)	0.067*** (0.022)	0.016* (0.009)	0.067*** (0.022)	0.016* (0.009)	0.067*** (0.023)	0.014 (0.009)	0.066*** (0.022)
PRE Ratio			-0.020 (0.055)	-0.061 (0.051)				
PDD Ratio					-0.001 (0.024)	-0.013 (0.036)		
RC Ratio							-0.014 (0.018)	0.099** (0.043)
Constant	0.013*** (0.001)	0.016*** (0.001)	0.013*** (0.001)	0.017*** (0.001)	0.013*** (0.001)	0.017*** (0.001)	0.013*** (0.001)	0.015*** (0.001)
Nobs	936	936	936	936	936	936	935	935
F statistic	42	69	37	56	34	57	35	60
R^2	0.24	0.54	0.24	0.55	0.24	0.54	0.24	0.55
Adjusted R^2	0.24	0.49	0.23	0.50	0.23	0.49	0.23	0.50

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the static models, with both pooled-OLS and fixed effects (FE) specifications. Models 7.a-c measure the additional effect of the asset reserves variables. The constants correspond to the mean of fixed effects for FE models. *p<0.1; **p<0.05; ***p<0.01.

Table 64A: Estimating the static model with impact of the ALM variables.

	<i>Participation Rate Spread $\rho_{i,t}$</i>					
	Model 4		Model 8.a		Model 8.b	
	OLS	FE	OLS	FE	OLS	FE
Asset Return – OAT	0.212*** (0.026)	0.148*** (0.025)	0.215*** (0.028)	0.156*** (0.027)	0.218*** (0.026)	0.162*** (0.026)
OAT-10Y	-0.259*** (0.027)	-0.341*** (0.027)	-0.257*** (0.027)	-0.334*** (0.028)	-0.256*** (0.027)	-0.330*** (0.027)
Surrender Rate	-0.030*** (0.007)	-0.053*** (0.010)	-0.030*** (0.008)	-0.052*** (0.010)	-0.034*** (0.008)	-0.053*** (0.009)
PPB Ratio (BoY)	0.016* (0.009)	0.067*** (0.022)	0.016* (0.009)	0.067*** (0.023)	0.020** (0.009)	0.072*** (0.022)
Capital Gain Ratio			-0.011 (0.021)	-0.024 (0.021)		
Equity as % of Assets					-0.006** (0.003)	-0.011*** (0.004)
Constant	0.013*** (0.001)	0.016*** (0.001)	0.013*** (0.001)	0.016*** (0.001)	0.013*** (0.001)	0.017*** (0.001)
Nobs	936	936	936	936	934	934
F statistic	42	69	35	55	34	58
R^2	0.24	0.54	0.24	0.55	0.24	0.55
Adjusted R^2	0.24	0.49	0.23	0.50	0.24	0.50

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the static models, with both pooled-OLS and fixed effects (FE) specifications. Models 8.a and 8.b measure the additional effect of the ALM variables. The constants correspond to the mean of fixed effects for FE models. *p<0.1; **p<0.05; ***p<0.01.

APPENDIX 21 - ROBUSTNESS CHECKS

In order to check the consistency of our estimates, we run the model over two sub-periods of 7 years to assess the time stability of the coefficients. Note that 2006 belongs to the two sub-periods. The results are fairly encouraging as the point estimates are rather stable across the both sub-periods.

Table 65A: Time stability of the static model (Model 4).

	<i>Participation Rate Spread $\rho_{i,t}$</i>					
	Model 4 - Entire period		Model 4 - [1999, 2006]		Model 4 - [2006, 2013]	
	OLS	FE	OLS	FE	OLS	FE
Asset Return – OAT-10Y	0.212*** (0.026)	0.148*** (0.025)	0.220*** (0.037)	0.122*** (0.030)	0.156*** (0.032)	0.072** (0.036)
OAT-10Y	-0.259*** (0.027)	-0.341*** (0.027)	-0.212*** (0.053)	-0.338*** (0.041)	-0.434*** (0.047)	-0.532*** (0.048)
Surrender rate	-0.030*** (0.007)	-0.053*** (0.010)	-0.051*** (0.010)	-0.069*** (0.013)	-0.003 (0.010)	-0.016 (0.012)
PPB ratio (BoY)	0.016* (0.009)	0.067*** (0.022)	0.013 (0.012)	0.096** (0.043)	0.011 (0.015)	0.090** (0.042)
Constant	0.013*** (0.001)	0.016*** (0.001)	0.012*** (0.002)	0.017*** (0.002)	0.017*** (0.002)	0.020*** (0.002)
Nobs	936	936	492	492	511	511
F statistic	42	69	16	26	51	69
R^2	0.24	0.54	0.22	0.63	0.30	0.64
Adjusted R^2	0.24	0.49	0.22	0.55	0.29	0.57

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the static models, with both pooled-OLS and fixed effects (FE) specifications. We test the time stability of the estimated coefficients on two sub-periods ([1999,2006] and [2006,2013]). The constants correspond to the mean of fixed effects for FE models. *p<0.1; **p<0.05; ***p<0.01.

Indeed, as can be seen in Table 65, in both the OLS and fixed-effects specifications with static target rate, the signs and orders of magnitude are preserved from one sub-period to the other. More precisely, it appears that the coefficient on the financial performance relative to the French government bond stays positive and statistically significant, yet decreases in magnitude from one sub-period to the other (from 0.12 to 0.07 under FE). Good financial performance seems to translate less and less into a better participation rate. The coefficient on the OAT-10Y remains negative and large. The continuous decrease of the government bonds rates over the period could explain the increase in the absolute value of the coefficient, as it becomes more complicated to serve less than the OAT-10Y while staying above the legal 0 bound. As the OAT-10Y gets close to zero, the mean of participation spread can only increase. The coefficient for the surrender rate—negative and statistically significant in the first period—becomes insignificant in the second. The coefficient on the stock of PPB stays consistently around 0.9.

We extracted the content of the fixed-effects to see whether they were coherent from one period to the other. A simple OLS regression of the coefficients for the first period on the coefficients for the second yields a point estimate of 0.98 significant at the 1% confidence level

and an adjusted R^2 of 0.52: this tends to confirm that the fixed effects do capture idiosyncratic characteristics which are stable over time.

These robustness checks seem to confirm the main findings of the paper concerning the static model. We obtain similar results with the dynamic model (see Table 66).

Table 66A: Time stability of the dynamic model (Model 4’).

	<i>Participation Rate Spread $\rho_{i,t}$</i>								
	Model 4' - Entire period			Model 4' - [1999-2006]			Model 4' - [2006-2013]		
	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM	OLS	FE	2 steps Syst-GMM
Lag [Participation – OAT-10Y]	0.444*** (0.041)	0.182*** (0.050)	0.182*** (0.048)	0.421*** (0.063)	0.036 (0.090)	0.099 (0.088)	0.438*** (0.045)	0.128** (0.055)	0.071 (0.050)
Asset return – OAT-10Y	0.129*** (0.021)	0.125*** (0.027)	0.146*** (0.028)	0.119*** (0.032)	0.089** (0.036)	0.143*** (0.054)	0.107*** (0.024)	0.104*** (0.030)	0.151*** (0.027)
OAT-10Y	-0.254*** (0.023)	-0.331*** (0.025)	-0.300*** (0.03)	-0.274*** (0.052)	-0.385*** (0.043)	-0.322*** (0.055)	-0.350*** (0.034)	-0.446*** (0.035)	-0.411*** (0.046)
Surrender rate	-0.020*** (0.007)	-0.040*** (0.010)	-0.023** (0.010)	-0.033*** (0.010)	-0.064*** (0.011)	-0.052*** (0.012)	-0.008 (0.008)	-0.014 (0.012)	-0.009 (0.012)
PPB Ratio (BoY)	0.023** (0.010)	0.071*** (0.024)	0.035** (0.015)	0.024* (0.013)	0.116** (0.046)	0.056** (0.026)	0.015 (0.018)	0.064* (0.038)	0.021 (0.014)
Constant	0.011*** (0.001)	0.015*** (0.001)	0.013*** (0.001)	0.013*** (0.002)	0.019*** (0.002)	0.016*** (0.003)	0.013*** (0.001)	0.017*** (0.001)	0.016*** (0.002)
Nobs	842	842	842	411	411	411	495	495	495
F statistic	73	65	.	24	22	.	67	56	.
R ²	0.45	0.6	.	0.41	0.64	.	0.49	0.67	.
Adjusted R ²	0.45	0.55	.	0.4	0.56	.	0.48	0.6	.
Arellano-Bond AR(1) p-value	.	.	0.00	.	.	0.00	.	.	0.00
Wald-Chi ² p-value	.	.	0.00	.	.	0.00	.	.	0.00
Sargan test p-value	.	.	0.00	.	.	0.00	.	.	0.00
Hansen test p-value	.	.	0.89	.	.	0.03	.	.	0.78

Note: This table contains the estimated parameters and their robust standard errors in parentheses (White) for the dynamic models, with pooled-OLS, fixed effects (FE) and two steps system-GMM specifications. We test the time stability of the estimated coefficients on two sub-periods ([1999,2006] and [2006,2013]). The constants correspond to the mean of fixed effects for FE models.*p<0.1; **p<0.05; ***p<0.01.

This appendix presents an empirical clustering analysis for insurers in our data. The schemes are detected empirically through an analysis of the respective variations of the financial margin and participation rates with respect to the asset returns spreads. The categories are then reused as inputs for the selected model of the previous chapter for cross-validation of both classification and estimation.

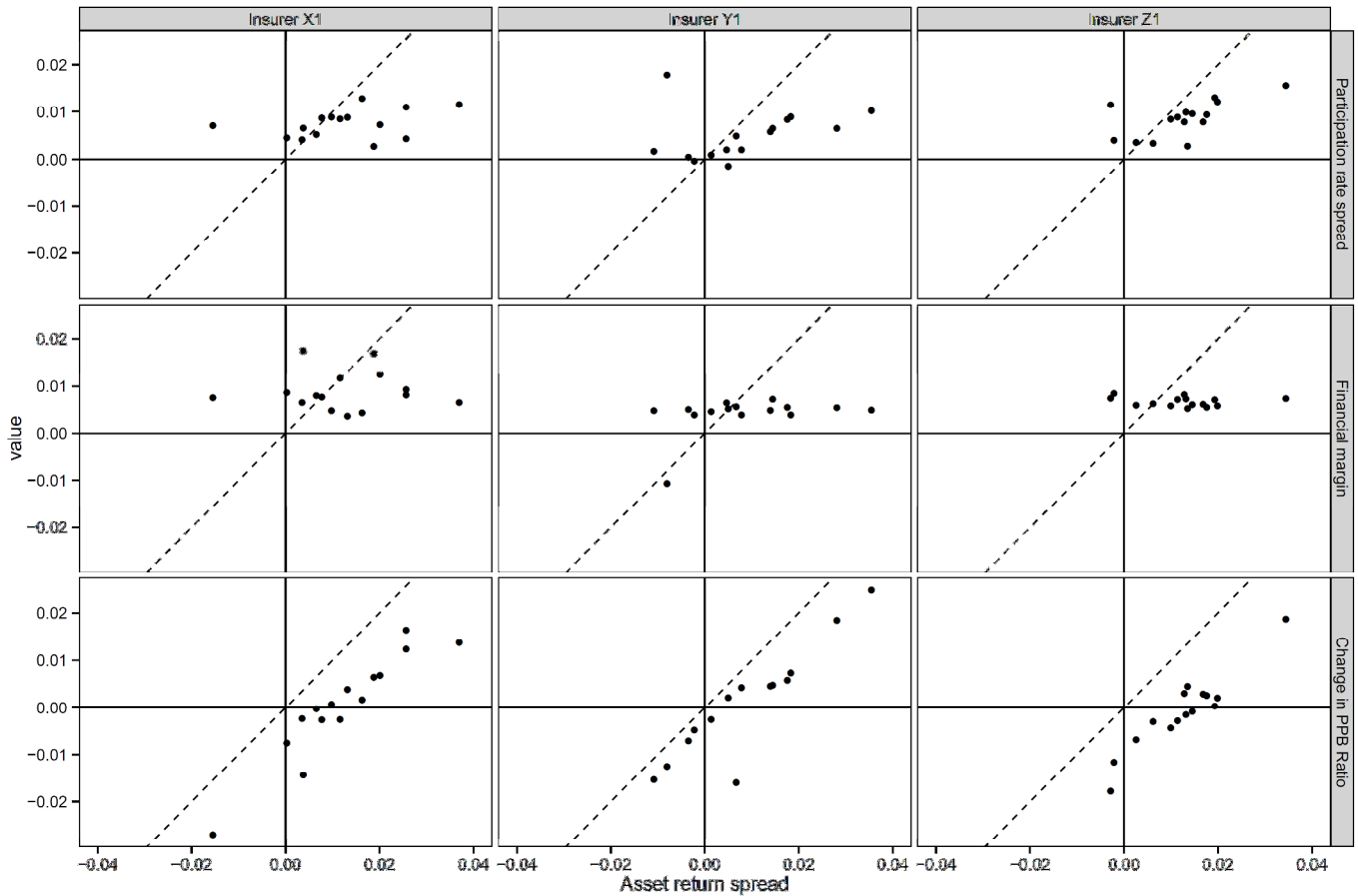
Graph 20A, Graph 21A and Graph 22A exhibit three different behavioral patterns for a sample of anonymized insurers. The three undertakings presented in Graph 20A (Type 1) are characterized by an extremely smooth financial margin (second row), and a participation very close to the OAT-10Y (first row). The PPB varies in parallel with the assets performances (third row), but the observations are slightly below the 45° line. All this seems to indicate that the behavioral rule of these undertakings is 1) take the targeted financial margin; 2) serve the OAT-10Y; 3) store the rest of the assets' return in the PPB for later participation. Note however that over the 15 years under study, the PPB was not much released, which can raise questions about the enforcement of the legal obligation not to retain the PPB for more than 8 years⁹³. In contrast, for the three insurers of Graph 21A (Type 2), the participation rate is largely driven by the assets' performance: indeed, in the first row, it appears that the observations parallel the 45° line. This does not mean however that the policy is necessarily at the advantage of the policyholder, despite the overall good financial performances of these undertakings: the parallel behavior of the participation is sometimes considerably below the assets' returns and even below the OAT-10Y (see for instance X2 and Y2). The financial margins (second row) are fairly stable, as well as the PPB. All this seems to indicate that the behavioral rule of these undertakings is: 1) take the targeted financial margin; 2) conserve the PPB; 3) serve what is left to the policyholders, even if below the OAT-10Y.

For others, with a more “mutual insurance” type, the bad financial performances are absorbed through a lower financial margin, and the participation rates are maintained close to the OAT-10Y. The three insurers presented in Graph 22A (Type 3 – two out of three happen to be ruled by the *Code de la Mutualité*) display an extremely smooth participation around the OAT-10Y (first row) despite rather poor financial performances (returns often lower than the government bonds rates) and a PPB that does not vary much (third row). One can actually see in the second row that all bad financial performances are absorbed by the financial margins, which become negative when the assets yield less than the OAT-10Y. Together, these considerations seem to indicate that the behavioral rule of these undertakings is 1) serve the OAT-10Y to the policyholders; 2) conserve the PPB; 3) absorb the poor performances with negative financial margins.

⁹³ Over the past, there have been concerns about the PPB management. For example, the highest French public-Law court, the Conseil d'État (“CE”) confirmed several times ACPR's decision that PPB should not be monitored nor mitigated (see CE, 5 May 2010, n° 307089 or CE, 30 March 2007, n° 277991). Those rulings indicate that insurance companies might have already tried to implement such schemes. Note however that in the case of liabilities' portfolio transfer, CE ruled that companies do have leeway to reallocate the PPB, except for ring-fenced funds (see CE, 24 November 1989, n° 92619 or n° 92621).

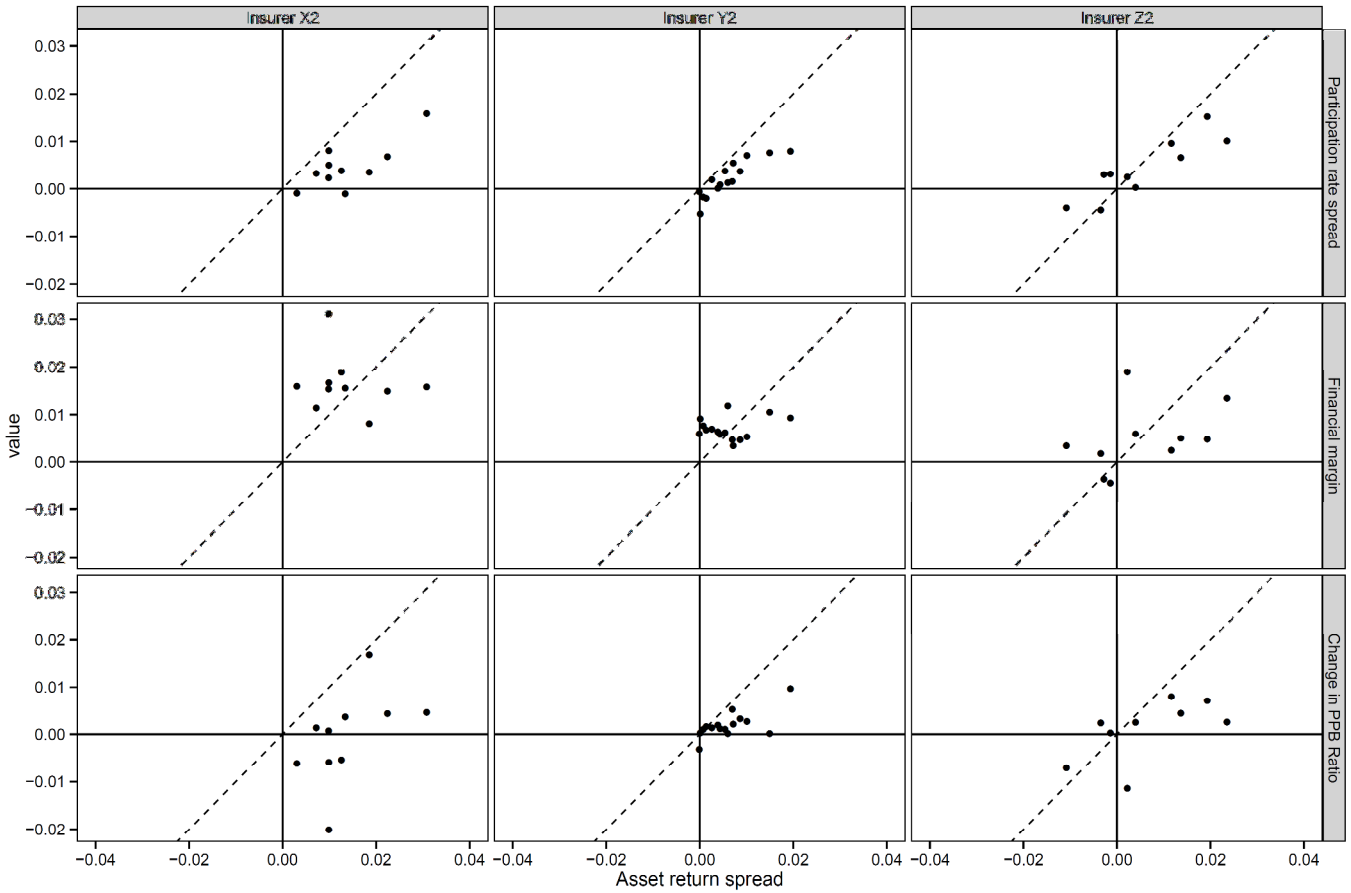
The definition of “standard patterns” is natural for our analysis, but the small average number of observations per company makes the categorization difficult or very dependent on an expert’s classification.

Graph 20A: Type 1 pattern



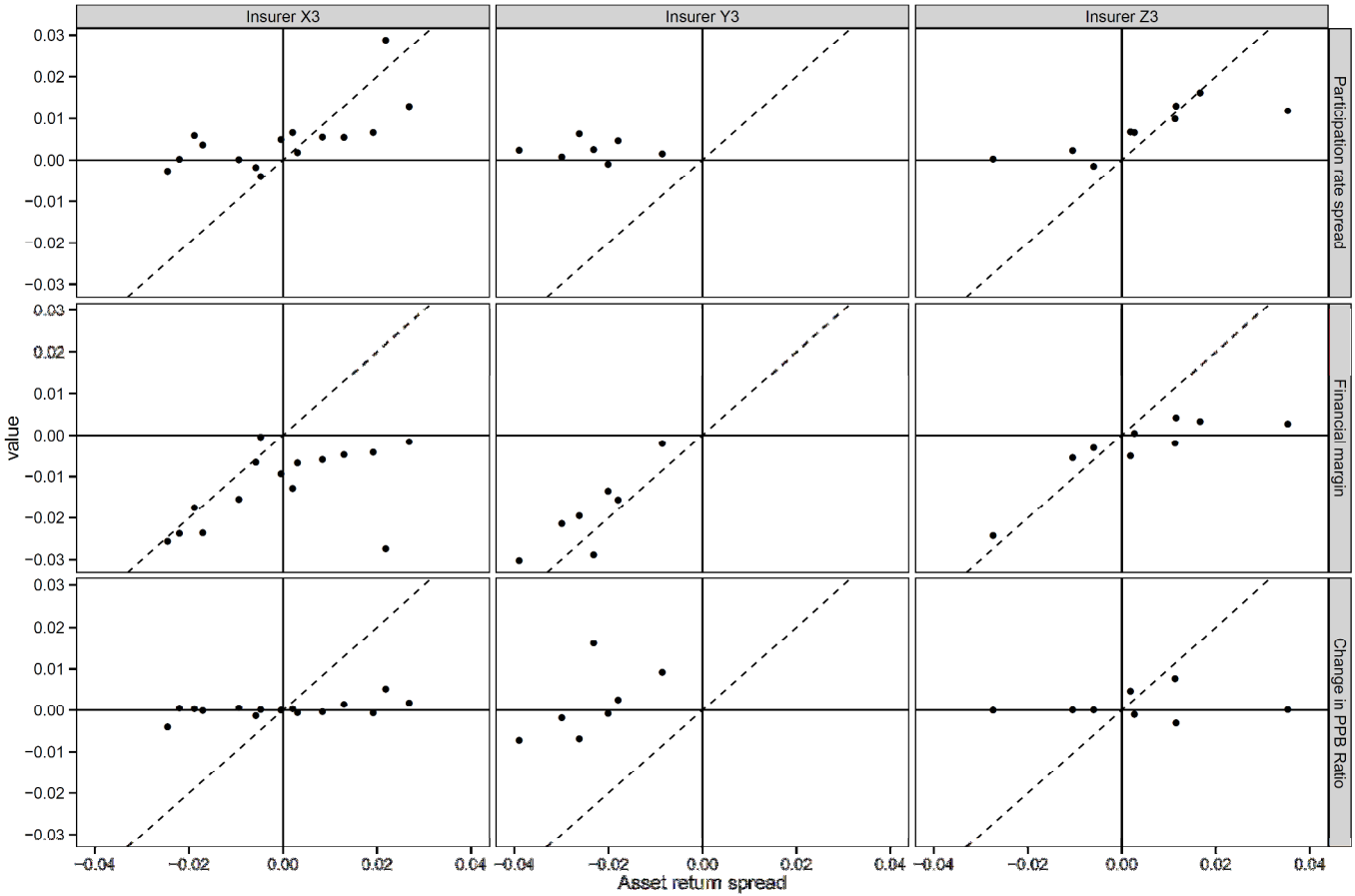
Note: Each column corresponds to a distinct undertaking and each observation (dot) to a given year. All X-axes represent the difference between the assets’ returns and the OAT-10Y rate. Thus, an abscissa of 0.02 means that the assets yielded 2 percentage points (200bps) more than the OAT-10Y. In the first row, the ordinate is the difference between the participation served and the OAT-10Y. For the second row, it represents the financial margin, and in the third, it corresponds to the relative change in the PPB. In each graph, the 45° line is materialized with dashes.

Graph 21A: Type 2 pattern



Note: Each column corresponds to a distinct undertaking and each observation (dot) to a given year. All X-axes represent the difference between the assets' returns and the OAT-10Y rate. Thus, an abscissa of 0.02 means that the assets yielded 2 percentage points (200bps) more than the OAT-10Y. In the first row, the ordinate is the difference between the participation served and the OAT-10Y. For the second row, it represents the financial margin, and in the third, it corresponds to the relative change in the PPB. In each graph, the 45° line is materialized with dashes.

Graph 22A: Type 3 pattern



Note: Each column corresponds to a distinct undertaking and each observation (dot) to a given year. All X-axes represent the difference between the assets' returns and the OAT-10Y rate. Thus, an abscissa of 0.02 means that the assets yielded 2 percentage points (200bps) more than the OAT-10Y. In the first row, the ordinate is the difference between the participation served and the OAT-10Y. For the second row, it represents the financial margin, and in the third, it corresponds to the relative change in the PPB. In each graph, the 45° line is materialized with dashes.