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The impact of domestic and international commodity price volatility on agricultural income instability in Ghana, Vietnam and Peru

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ABSTRACT

The extent to which commodity price volatility affects the income of producing households and their vulnerability to poverty and food insecurity depends on household diversification patterns and the degree of their exposure to markets. This paper focuses on estimating agricultural income uncertainties for a number of different household types in Ghana, Vietnam and Peru. Following a theoretical framework that leads to explicit formulae for household income variance, we combine information from household data sets and commodity price time series in order to estimate income uncertainty that emanates from price and production volatility under different scenarios of exposure to the international and the domestic markets shocks. Our results indicate that market and non market uncertainties significantly affect the variability of income of households in these countries, and especially households that are specialized in few commodities. However, it turns out that, under current policies, almost all of their income variability is due to domestic factors, with international prices not contributing much at least in the short run. Wider exposure to international markets would increase the income variability of producers that have been subjected to domestic market stabilization policies in Ghana and Vietnam, while it would decrease it in the case of Peru.

RESUME

La mesure dans laquelle l'instabilité des prix des produits affecte les revenus des ménages de producteurs et leur vulnérabilité à la pauvreté et à l'insécurité alimentaire dépend des schémas de diversification de l'activité des ménages et de leur dépendance à l'égard des marchés. Cet article évalue les incertitudes qui entourent les revenus agricoles pour plusieurs types différents de ménages au Ghana, au Viet Nam et au Pérou. Après une étude théorique qui débouche sur des formules explicites d'évaluation des variations des revenus des ménages, des séries de données sur les ménages et des séries chronologiques de prix des produits sont combinées pour estimer l'incertitude qui entoure les revenus par suite de l'instabilité des prix et de la production dans différents scénarios de vulnérabilité aux chocs sur les marchés internationaux et nationaux. Les résultats montrent que les incertitudes provenant des marchés et d'autres causes affectent de manière significative la variabilité des revenus des ménages dans ces pays, surtout dans le cas des ménages qui sont spécialisés dans un petit nombre de produits. Il s'avère néanmoins que, sur la base des politiques actuelles, la variabilité de leurs revenus est imputable presque intégralement à des facteurs internes, les prix internationaux n'y contribuant guère, tout au moins à court terme. Une exposition accrue aux marchés internationaux accroîtrait la variabilité des revenus des producteurs touchés par les politiques de stabilisation des marchés intérieurs au Ghana et au Viet Nam, mais la réduirait dans le cas du Pérou.

RESUMEN

La medida en la que la volatilidad de los precios de los productos básicos afecta los ingresos de los hogares productivos y su vulnerabilidad a la pobreza e inseguridad alimentaria depende de los modelos de diversificación de los hogares y de su grado de colocación en los mercados. Este artículo se centra en la estimación de las incertidumbres de los ingresos agrícolas para un cierto número de diferentes tipos hogares en Ghana, Viet Nam y Perú. A continuación del marco teórico que conduce a fórmulas explícitas para la variación en el ingreso por núcleo familiar, se combina la información de conjuntos de datos de los hogares y de conjuntos de precios históricos de los productos básicos con el objeto de estimar la incertidumbre en los ingresos que deriva de la volatilidad de los precios y la producción bajo diversos escenarios de posicionamiento ante “shocks” en los mercados internos e internacionales. Nuestros resultados indican que las incertidumbres del mercado y ajenas al mercado afectan significativamente la variabilidad de los ingresos en los hogares de esos países, en particular en los hogares especializados en unos pocos productos básicos. Sin embargo, resulta que, en virtud de las políticas actuales, casi toda la variabilidad de sus ingresos se debe a factores internos, sin que contribuyan los precios internacionales, al menos en el corto plazo. Una cobertura más amplia de los mercados internacionales incrementaría la variabilidad de los ingresos de los productores que han estado sujetos a políticas de estabilización de los mercados internos en Ghana y Viet Nam, mientras que en el caso de Perú se habría producido una reducción.

CONTENTS

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1 INTRODUCTION

Discussions and analyses of agricultural trade liberalization have focused for the most part on the issue of changes in the level of average prices faced by producers and consumers of agricultural products under different liberalizing scenarios. However, a rather neglected issue, at least in analytical studies, is the extent to which trade liberalization may affect the instability faced by agricultural producers. More specifically, does increased exposure to international agricultural markets increase the instability of income of agricultural producers? Does it increase or decrease the welfare of households? These are questions frequently asked by developing country policy makers and advocates, and figure in discussions concerning trade liberalization. The purpose of this paper is to investigate the issue of income instability of agricultural producers arising from domestic and international causes, and to explore the question of whether increased exposure to international markets will make farmers' incomes more or less unstable.

Agricultural producers are exposed to a variety of income uncertainties, both market related, such as price variations, and non-market related, such as unstable weather patterns. They are also exposed to a variety of idiosyncratic shocks that affect their income, such as illnesses. Such uncertainties induce substantial income risks that can be particularly detrimental to small and/or poor producers in developing countries. In particular it has been shown that income instability in the presence of liquidity constraints and inadequate assets, which features rather prominent in many developing countries, can create poverty traps (Zimmerman and Carter, 2003).

Farmers in developing countries have developed several ways for dealing with the various risks they face. These involve risk management strategies, namely actions taken ahead of the resolution of any uncertainty to improve the *ex ante* exposure of the household to various risks, as well as risk coping strategies, namely rules adopted *ex ante* to help the household to deal *ex post* with any undesirable consequences. Risk management strategies include, among others, crop diversification, income diversification through off-farm work and sharecropping. Such *ex ante* strategies usually sacrifice higher expected income for a more stable income stream. Risk coping strategies may include the availability of short term consumption credit, mutual family or village based reciprocal giving arrangements, and other arrangements. (for a recent survey of these practices see Dercon, 2004).

A significant share of the income variations of rural producers in developing countries seems to be due to idiosyncratic shocks, namely shocks peculiar to a household (Morduch, 1995, Townsend, 1995, Carter, 1997). Such risks can be insured through formal or informal pooling of a large number of such shocks, such as through village reciprocity relations, which are present in many developing countries, or the formal private or public insurance schemes that exist in many developed countries. Covariate shocks, however, namely those that affect all households in a given community or region, such as weather or price shocks, cannot be insured by pooling them within a small or even larger region. It is the need to insure farmers against such covariate shocks that has induced the governments of most developed countries to institute various price or income support schemes, under the perception that the private insurance industry would not be able to provide adequate coverage at reasonable cost.

The absence of such arrangements in developing countries is what induces rural households to develop self insurance, or what has been termed "consumption smoothing strategies" to deal with covariate shocks. These strategies basically involve building "precautionary savings", in the form of liquid, or near liquid assets in good years, and depleting them in years of adverse covariate shocks (Deaton, 1991). There is conflicting evidence, however, on whether such strategies are effective at smoothing consumption (Rosenzweig and Binswanger, 1993; Rosenzweig and Wolpin, 1993; Fafchamps *et. al*, 1998; Dercon, 2004). The consensus, nevertheless, appears to be that despite the variety of smoothing strategies adopted by poor households in developing countries there is substantial residual consumption risk (Jalan and Ravallion, 1999).

While there has been considerable research devoted to the issue of world commodity market instability and its adverse growth consequences for developing countries (for some of the most recent analyses that review earlier studies as well, see Dehn, 2000 and Collier and Dehn, 2001), there has been much less research devoted to the domestic market instability facing many producers in developing countries.

Recently Bourguignon, Lambert and Suwa-Eisenmann (2004) showed that international agricultural trade instability implies different variances of domestic incomes for different groups of income earners. They did not, however, investigate the impact of increased exposure to international markets. However, partly because of non- or low tradability of many agricultural products and partly because of lack of transmission of world prices to domestic markets, the domestic agricultural product markets in many developing countries (DCs) are very unstable, not only from year to year, but also within each crop year. It is not clear how increased exposure to international markets will affect this market instability, and hence it is not clear whether trade liberalization will make the incomes of producers more, or less unstable. It is these issues that this paper sets out to explore.

The extent to which domestic markets are exposed to the international market may have important implications for domestic commodity price volatility. Domestic markets can be partly insulated by large marketing margins that arise due to high transaction costs. Poor infrastructure, transport and communication services give rise to large marketing margins due to high costs of delivering the locally produced commodity to the border for export, or the imported commodity to the domestic market for consumption. As a consequence, markets in developing countries may be insulated, resulting in a limited 'buffer' capacity, as the possibility that adverse shocks such as exogenous shifts in supply and demand can be adjusted through trade is limited. Often, in insulated markets small exogenous shocks may generate relatively large price fluctuations, thus resulting in significant increases in uncertainty. Market integration and trade, in a similar manner to commodity storage, may lead to a reduction in the volatility of domestic prices, given unanticipated shocks in domestic markets, thus reducing the burden of adjustment that is carried by producers and consumers.

The paper takes a microeconomic approach, in the sense that it explores potential changes in agricultural income instability and welfare from increased exposure to international markets of various representative groups of agriculture-dependent households in three diverse developing countries, namely Ghana, Peru and Vietnam. While none of these countries is in the WTO group of Least Developed Countries (LDCs), they are all classified as food insecure according to Diaz-Bonilla et al, (2000) and are commodity dependent in the sense that a large share of their exports consists of primary commodities, albeit not all agricultural.

We estimate household income variances, and coefficients of variation, as well as welfare changes, under a variety of assumptions, applying a theoretical framework which is an extension of the one developed by Sarris (2002). The framework combines information from both cross section household data and time series on prices and yields and leads to explicit analytical formulae for estimating household income variance and welfare. The framework is applied to the World Bank's Living Standards Measurement Survey (LSMS) data on Ghana, Vietnam and Peru. Under the assumption that producing households do not change their long run production and income diversification patterns, household income variance and welfare changes are estimated in terms of price and yield uncertainties, under the assumption that the households face domestic price uncertainties, and alternatively international price uncertainties.

The plan of the paper is the following. In section 2 we outline the conceptual framework of the study. Section 3 outlines the empirical framework. Section 4 discusses the data and the income structure of the various income classes in the three countries analyzed and presents the results of the analysis of income variability, and section 5 summarizes the main conclusions.

2 CONCEPTUAL FRAMEWORK

Consider a household that produces some agricultural commodities, and is also involved in several other income earning activities. The production-consumption-saving problem of the agricultural household in the context of risk can be formalized mathematically using standard intertemporal stochastic models and it is not the purpose here to review these (for detailed expositions see Fafchamps, 2003; Deaton, 1991, 1992; Zeldes, 1989; Williams and Wright, 1991; Kurosaki and Fafchamps, 2002).

The assumption that will be made here is that the welfare of the household can be approximated by the expected value of the indirect utility. This specification implicitly assumes that the household is in a

steady state condition, namely that the portfolio of its activities, as well as its risk coping strategies are stable. This framework is the one that has been utilized extensively in many discussions of risk as well as the benefits of commodity price stabilization schemes (Newbery and Stiglitz, 1981).

Consider the expected value of the indirect utility V at time t+1, given information up to and including time t Ω_t, $E\{V(P_{t+1}, I_{t+1})|\Omega_t\}$, where P is a vector of prices and I denotes the household expenditure. In the sequel the conditioning notation will be omitted, and whenever an expectation is indicated it will signify the conditional expectation, given information up to and including time t. In the same sense, the time subscripts will be dropped for ease of notation. It is important to think of price variability as conditional, because farmers base their decisions largely on conditional expectations of prices one production period ahead. Hence, the welfare measures computed will also utilize conditional distributions.

Consider a second order approximation of V, around the expected values of the random variables P, and I.

$$V(P,I) = V(\overline{P},\overline{I}) + \sum_i \frac{\partial V}{\partial P_i}(P_i - \overline{P_i}) + \frac{\partial V}{\partial I}(I - \overline{I}) +$$

$$\frac{1}{2}\left\{\sum_i\sum_j \frac{\partial^2 V}{\partial P_i \partial P_j}(P_i - \overline{P_i})(P_j - \overline{P_j}) + 2\sum_i \frac{\partial^2 V}{\partial I \partial P_i}(P_i - \overline{P_i})(I - \overline{I}) + \frac{\partial^2 V}{\partial^2 I}(I - \overline{I})^2\right\} \quad (1)$$

where a bar above a random variable denotes (conditional) expected value. If we take expected values of the above expression, then the two linear terms after the constant in the right hand side of (1) will disappear, and the remaining terms in the bracket will include terms that will involve the variances of prices and income, as well as the covariance between prices and expenditure.

Using the notation of Newbery and Stiglitz (1981), we denote by $V_{p_i}, V_I, V_{p_i p_j}, V_{Ip_i}, V_{II}$, the first and second order derivatives of the indirect utility above, with respect to prices and expenditure. Then using the formulas derived in Newbery and Stiglitz (1981, pp: 116 and 129-130) we can express the second order derivatives as follows:

$$V_{p_i p_j} = -\frac{1}{\overline{p_i}\,\overline{p_j}}\beta_i \overline{I} V_I[\varepsilon_{ij} + \beta_j(\rho - \eta_j)] \quad (2)$$

$$V_{Ip_i} = \frac{V_I}{\overline{p_i}}\beta_i(\rho - \eta_i) \quad (3)$$

$$V_{II} = -\frac{V_I}{\overline{I}}\rho \quad (4)$$

In the above equations, β_i denotes the household's budget share for good i, ε_{ij} denotes the price elasticity of demand for product i with respect to the price of product j (when $i=j$ the elasticity is just the own price elasticity of demand) ($\varepsilon_{ij} \equiv \frac{\overline{p_j}\partial q_i}{\overline{q_i}\partial p_j}$), η_i denotes the expenditure elasticity of demand for product i, and ρ denotes the coefficient of relative risk aversion (which as defined in (4) is a positive scalar, if it is assumed that the household is risk averse, implying that V_{II} is negative).

If we apply the formulas in (2)-(4) to (1), and if we normalize the welfare, by dividing by both mean expenditure and by the marginal utility of expenditure, we obtain an expression for the welfare of the household from its exposure to risk, expressed as a share of average expenditure as follows.

$$W^n \equiv \frac{E(V)}{\overline{IV}_I} = \frac{V(\overline{P},\overline{I})}{\overline{IV}_I} - \frac{1}{2}\sum_i\sum_j\left[\beta_i\varepsilon_{ij} + \beta_j(\rho-\eta_j)\right]\left[\frac{Cov(P_i,P_j)}{\overline{P}_i\overline{P}_j}\right]$$
$$+\sum_i \beta_i(\rho-\eta_i)\left[\frac{Cov(P_i,I)}{\overline{P}_i\overline{I}}\right] + \frac{1}{2}(-\rho)\left[CV^2(I)\right] \quad (5)$$

where CV denotes the coefficient of variation. Notice that as defined above all parts of the expression are unitless. Note also that all variances and covariances are conditional on information as of time *t*. It is clear from the above expression that the direction of a mean preserving change in the distributions of the random variables facing agricultural households is not at all obvious. It depends on the demand and risk parameters of the household, as well as the variance and covariances of prices and income. It is for instance possible that an increase in price instability maybe beneficial to the household, something that has been noted theoretically as early as the 1960s (Massell, 1969). Notice also that the expression takes into account both the structure of production as well as consumption. If, for instance, the household produces and consumes only one product, which is not subject to production uncertainty, and this constitutes its total income and expenditure, then it can be easily derived, assuming that only the price of this product is the source of uncertainly, that the terms in expression (5) that depend on the stochastic nature of prices and income, reduce to zero. This is to be expected, as in such a case price variations, which are the sole source of instability, will not affect the household.

Expression (5) indicates that the welfare of the household depends on the demand and risk characteristics of the household, as well as the exposure to the various risk inducing activities. In this paper we do not attempt to estimate the demand and risk characteristics of different groups of households. We rather concentrate only on the coefficients of variation of expenditure, as it is the main component of welfare in (5), especially if prices of the different expenditure categories are not strongly correlated with each other. If we do this, then (5) indicates that welfare of the household decreases as the coefficient of variation of its expenditure increases, and the decrease is proportional to the coefficient of relative risk aversion. The approximation also holds under some restrictive conditions (see Newbery and Stiglitz 1981, chapter 9).

Consider now the expressions for the variance of normalized expenditure (which is needed for the computation of the squared CV terms). The variations in total household expenditure result from variations in income, as well as savings and risk coping behaviour. It is well known that variations in income are smoothed out through these mechanisms, and hence the variation in expenditure is lower than the variation of income (Morduch, 1995). Empirically, a simple way to parameterize this is to assume that the expenditure deviations from their mean value are a multiple γ of the deviations of income *Y*, where consumption smoothing implies that $\gamma \leq 1$. With this parameterization, under the additional assumption that average expenditure is some fraction (different from γ) of average income, and as all variables are measured as deviations from their mean values, the right hand side of (5), after the first term, remains unaltered with the exception of constant multiplicative terms in the last two terms, if we substitute income *Y* for expenditure. Hence the basis for the subsequent analysis will be the coefficient of variation of household income.

3 EMPIRICAL FRAMEWORK

In order to implement the above theoretical framework, we need a more explicit expression for the coefficients of variation of income. In the sequel we shall consider as unstable only Y_a, namely the agricultural part of income, as this is the component on which we desire to focus the analysis. Let the share of agriculture[1] in total income be denoted by α, the average shares of each agricultural product *i* in agricultural income by s_i , the normalized quantity of product *i* produced by q_i (the normalization is

[1] This share in the subsequent empirical calculations will comprise only the part of agricultural income for which we have enough information to compute the stochastic variables.

made by dividing the amount Q produced in any period by the average value of production), and the normalized price of product *i* by p_i (which is defined as the price P of the product in a period divided by the average value of price). Then the normalized deviation of total income from its mean, under the assumption that the quantities produced by the household in period t are independent of the prices faced by the household in the same period[2], can be written as follows:

$$\hat{Y} \equiv \frac{Y - E(Y)}{E(Y)} = \alpha \frac{Y_a - E(Y_a)}{E(Y_a)} = \alpha \frac{\sum_i P_i Q_i - E(\sum_i P_i Q_i)}{E(\sum_i P_i Q_i)} = \alpha \frac{\sum_i P_i Q_i - \sum_i \overline{P_i Q_i}}{\sum_i \overline{P_i Q_i}} = \tag{6}$$

$$= \alpha \left[\sum_i s_i (\Delta p_i \Delta q_i + \Delta p_i + \Delta q_i) \right]$$

Given (6), the squared coefficient of variation of income can be written as follows.

$$CV^2(Y) = \alpha^2 \sum_i \sum_j s_i s_j E\left[(\Delta p_i \Delta q_i + \Delta p_i + \Delta q_i)(\Delta p_j \Delta q_j + \Delta p_j + \Delta q_j) \right] \tag{7}$$

If we assume normality of the various price and quantity terms, the only terms that will contribute to the expression in (7) are those that include an even number of terms in the products of the price and quantity terms. Hence (7) can be rewritten as follows.

$$CV^2(Y) = \alpha^2 \sum_i \sum_j s_i s_j E\left[\Delta p_i \Delta p_j \Delta q_i \Delta q_j + \Delta p_i \Delta p_j + \Delta p_i \Delta q_j + \Delta p_j \Delta q_i + \Delta q_i \Delta q_j \right] \tag{8}$$

Clearly the CV of income is just the square root of (8).

Consider now the relationship between the domestic and international prices of the various commodities. Given prices for a commodity in the domestic and international market P_{it}^d and P_{it}^w, the Law of One Price and the Enke-Samuelson-Takayama-Judge spatial price determination model (Enke,1951; Samuelson, 1953; Takayama and Judge, 1971 - for an extensive recent review of theory and applications see Fackler and Goodwin, 2001) postulate that at all points of time, allowing for transfer costs *c*, the relationship between the prices is as follows:

$$P_{it}^d = c + P_{it}^w \tag{9}$$

If a relationship, such as (9) between the two prices, held, the markets are said to be integrated. However, this extreme case may be unlikely to occur, especially in the short run. At the other end of the spectrum, if the probability distributions of the two prices were found to be independent, then one may say that there is no market integration and no price transmission. In general, given that the transaction costs present allow tradability, spatial arbitrage is expected to ensure that prices of a commodity will differ by an amount that is at most equal to the transfer costs, at least in the long run.

Empirical models of domestic price formation usually adhere to the following generic specification[3]:

$$p_{it}^d = \alpha_i + \zeta_i p_{it}^w + u_{it} \tag{10}$$

where p_{it}^d and p_{it}^w denote the domestic and international price of commodity *i* respectively and u_{it} is an error term. Equation (10) implies that, given tradability and allowing for transfer costs, commodity prices in the domestic market are determined by international market prices, at least in the long run.

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[2] This assumption, of course, is only an approximation, but it holds for most products where production decisions must be made several months in advance of actual production and sale. It is made for simplicity as otherwise the formulas would become too unwieldy.

[3] From here on we shall use lower case letters for normalized prices, as the parameter ζ in (10) can also incorporate any multiplicative effects in the price transmission equation, arising from normalization.

Seasonality can be introduced into the model by appending a set of dummy variables. The parameter ζ_i is sometimes interpreted as the elasticity of transmission of world price to domestic price, when prices are converted in logarithms, and can be thought of as a measure of the extent to which international price signals pass-through to the domestic market. An elasticity equal to one implies that the domestic market is perfectly integrated with the international market, with the domestic price of the product being determined basically in the international market. Nevertheless, the interpretation of ζ_i, and the quantification of the relationship between the domestic and international prices will depend on the statistical methodology applied for estimation, rather than the underlying theoretical concept itself (Balcombe and Morrison, 2002; Rapsomanikis *et al.*, 2004).

Denote by σ_i the coefficient of variation of production of the i^{th} crop produced by the household, by κ_{ij} the correlation coefficient between the production of the i^{th} crop and the j^{th} other crop produced by the household, by v_i^w the coefficient of variation of the world price of the i^{th} product, by ρ_{ij} the correlation coefficient of world prices of the i^{th} and j^{th} products (if they are tradable), by v_i the coefficient of variation of the random component u_{it} of the domestic price of the i^{th} product, and by ψ_{ij} the correlation coefficient between the random components u_{it} of the domestic prices of the i^{th} and j^{th} products.

Given (10) the various terms in (8) can be evaluated as follows

$$E(\Delta p_i \Delta p_j \Delta q_i \Delta q_j) = (\zeta_i \zeta_j \rho_{ij} v_i^w v_j^w + \psi_{ij} v_i v_j)\kappa_{ij}\sigma_i\sigma_j \tag{11}$$

$$E(\Delta p_i \Delta p_j) = \zeta_i \zeta_j \rho_{ij} v_i^w v_j^w + \psi_{ij} v_i v_j \tag{12}$$

$$E(\Delta p_i \Delta q_j) = 0 \tag{13}$$

$$E(\Delta q_i \Delta q_j) = \kappa_{ij}\sigma_i\sigma_j \tag{14}$$

Notice that by setting the transmission coefficient ζ_i equal to zero in the above expressions, we obtain the components that are accounted for only by domestic factors, such as production, and not due to international price variability. Hence, if we subtract this component from the full expression of price and income variations, we obtain the part of domestic price and income variability that is due only to international variability. If, in turn, we set the transmission coefficient ζ_i equal to 1 and at the same time set the variance of the domestic error term u_{it} equal to zero, then we can simulate the situation where the domestic prices are equal to international prices, with the resulting expressions simulating the case where the household is faced only with international price variability.

In the empirical applications equation (10) is replaced by a reduced (or standard) Vector Autoregression (VAR) assuming that both domestic and international prices are stochastic in nature, have similar statistical properties[4] and are jointly determined:[5]

$$p_{it}^w = c_1 + \sum_{j=1}^{k} a_{11,j} p_{it-j}^w + \sum_{j=1}^{k} a_{12,j} p_{it-j}^d + \varepsilon_{it}^w \tag{15}$$

[4] The statistical properties of series can be summarized by the concept of stationarity. A stationary series has a constant mean and a constant finite covariance structure. Such a series does not vary systematically with time, but tends to revert to its mean value and to fluctuate around it within a more or less constant range. Alternatively, a non-stationary series has time dependent statistical properties. Non-stationary series may contain stochastic or deterministic trends. Variables that contain stochastic trends are called 'integrated' and exhibit systematic, but unpredictable variation, as compared to series that contain deterministic trends, which display predictable variation.

[5] The reduced VAR can be obtained simply by matrix inversion from the *primitive* form that includes also the contemporaneous influence of prices on each other.

$$p_{it}^{d} = c_2 + \sum_{j=1}^{k} a_{21,j} p_{it-j}^{d} + \sum_{j=1}^{k} a_{22,j} p_{it-j}^{w} + \varepsilon_{it}^{d} \tag{16}$$

where the α's are parameters and the ε's are white noise error terms.

The errors ε_{it}^{d} and ε_{it}^{w} are, in general, contemporaneously correlated, and thus, in conjunction with the parameters α_{ij} provide a basis for the estimation of *h*-step ahead means and variances of the prices, conditional on the VAR relationships.[6] Within this framework, under the implicit assumption that economic agents form expectations according to the VAR relationships, the relative importance of shocks to the domestic and international prices, as well as their overall impact on the domestic price can be analyzed. VARs provide the statistical framework for testing the existence and direction of causality between international and domestic prices in the Granger-sense and thus introduce a causal ordering between the variables (Granger, 1969; 1988). Since shocks ε_{it}^{d} and ε_{it}^{w} are likely to be correlated, variation in the system is determined not only by the variance of each of the innovations, but also by the covariance. Ordering the prices in the VAR by means of a Granger causality test implies that the innovation of the first price, say p_{it}^{w}, is assumed to be independent and to determine that of the second price, say p_{it}^{d}. Thus, part of the shock in the domestic price is due to a shock in the international price, but not *vice versa*. Therefore, the relationship between the innovations can be expressed as follows:

$$\varepsilon_{it}^{d} = \zeta_i \varepsilon_{it}^{w} + \mu_{it} \tag{17}$$

with μ_{it} corresponding to the shock, or innovation in the domestic price that is not due to the innovations in the international prices, and is orthogonal to ε_{it}^{w}. Unlike the innovations of the standard form VAR in (15) and (16), μ_{it} and ε_{it}^{w} have means that are equal to zero and constant variances. In addition, the parameter ζ_i can be interpreted as a short run elasticity of the domestic price with respect to the international price. Under this framework, it is possible to decompose variation in the system into components that are due to variation in the innovations.

By substituting (17) into (16) conditional *h*-step ahead variances can be estimated through variance decomposition that requires the restating of equations (15) and (16) in their Vector Moving Average (VMA) form that expresses the prices as the weighted sum of past shocks to both domestic and international markets as follows:

$$\mathbf{p}_{it} = c + \sum_{j=0}^{\infty} \mathbf{\Theta}_j \mathbf{u}_{it-j} \tag{18}$$

where c is a vector of constants, $\mathbf{p}_{it} = \left(p_{it}^{w}, p_{it}^{d} \right)'$, $\mathbf{u}_{it} = \left[\varepsilon_{it}^{w} \quad \mu_{it} \right]'$ is a vector of orthogonal error terms with unit variance[7], and $\mathbf{\Theta}_j$ is a (2×2) matrix of parameters calculated from the autoregressive parameters α_{ij} and ζ_i.

Equations (18) imply the following modification of (12), which is also the basis for the calculation of (11), in terms of the calculation of conditional *h*-step ahead covariance for the domestic price of the i^{th} product with that of the j^{th} product:

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[6] Hamilton (1994) and Lütkepohl (1993) provide a comprehensive presentation for Vector Autoregressions.

[7] Orthogonality and unit variance of the error terms of a VAR can be accomplished via Cholecki decomposition. The corresponding coefficient matrices Θ are adjusted accordingly.

$$E(\Delta p_i \Delta p_j) = \rho_{ij} \sum_{k=0}^{h-1} \Theta^i_{21,k} \Theta^j_{21,k} + \psi_{ij} \sum_{k=0}^{h-1} \Theta^i_{22,k} \Theta^j_{22,k} \equiv V^w_{t+h,t} + V^d_{t+h,t} \quad (19)$$

where $V^w_{t+h,t}$ and $V^d_{t+h,t}$ denote the parts of the covariance that are due to international and domestic shocks respectively, and the correlation coefficients ρ_{ij} and ψ_{ij} can be estimated from the residuals of the corresponding VAR equations for each product.

In view of the above discussion, we proceed in the implementation of the conceptual model in two stages. At the first stage we estimate conditional variances and covariances for each commodity on the basis of an estimate autoregressive model, or VAR depending on whether the commodity is internationally traded or not. In more detail, we proceed by assessing the statistical properties of the series, [8] specifying and estimating a VAR for the prices that have similar time series properties, testing for Granger causality and ordering the system and calculating twelve-month-ahead conditional variances and covariances through variance decomposition.

As a second step, these estimates are used, in conjunction with the specification of the production and income structure of the households, in order to estimate household income variances and coefficients of variation.

In order to evaluate the impact of the extent to which world market exposure affects household income volatility, we carry out the implementation of the model under two assumptions:

(i) household income variances are estimated with households being exposed to both domestic and international price volatility, taking into consideration the estimated price transmission coefficient;

(ii) household income variances are estimated with households being exposed to domestic price volatility only, and;

(iii) household income variances are estimated under a scenario of total exposure to international market prices, reflecting perfect market integration. The assumption implies that the prices that farmers are exposed to are measured in US dollars and converted into domestic currency by a fixed exchange rate, thus excluding the portion of variability that is induced through exchange rate variations.

4 THE DATA AND EMPIRICAL ANALYSIS

We specify the income and expenditure structure of the various farm households in the countries under examination by using the Living Standards Measurement Studies (LSMS) data surveys carried out by the World Bank and the respective national statistical institutions. [9] We restrict our analysis to households that have some agricultural activities and classify farm households by first dividing them according to geographical region in order to capture any agro-climatic conditions that may determine

[8] The assessment of the series' statistical properties is carried out by testing for non-stationarity by means of the Augmented Dickey-Fuller (Dickey and Fuller, 1979) and the Zt and Zρ tests by Phillips and Perron (1988).8 In the event that the unit root tests indicate that the price pairs do not have similar properties, or the estimated VARs8 and the Granger causality tests suggest that the domestic and international prices are not jointly determined, we utilize simple autoregressive models. A similar methodology is followed for the estimation of the conditional means and variances for yields, as well as for the domestic market prices of commodities which are not internationally traded (e.g. cocoyam in Ghana, or cassava in Ghana and Vietnam). As seasonality consists of a predictable component of the price series, we include monthly dummy variables in both Vector and single autoregressions in order to remove seasonal effects. Results of the non stationarity tests and the estimated autoregressions and vector autoregressions are available by the authors.

[9] Information on the LSMS data surveys can be found in http://www.internationalbank.org/html/prdph/lsms/index.htm.

crop production structure. The households are further classified according to their characterization as poor and non poor, utilizing general poverty thresholds set by studies undertaken by the World Bank and national statistical institutes. The sample is subsequently divided according to the share of income from all agricultural activities (households with share larger and smaller than 60 percent) and their share of agricultural income deriving from a main agricultural commodity depending on the country and the agro-climatic region. These classifications capture the extent to which households depend on agricultural activities and on the production of specific major commodities. For the households in each classification we estimate average income and the shares of income derived from production of agricultural commodities, from wages, from self-employment, rents and remittances. We also compute average total expenditure, and the expenditure shares for food, subdivided by food item.

For estimating the vector autoregressions and the conditional measures of price variability for each country, we use monthly data on domestic prices, compiled by the corresponding Ministries of Agriculture for the period 1992 to 2002. As it was not possible to obtain monthly domestic price data series for all commodities that are produced and described in the household classifications, we assume that agricultural income sources (such as fruits and vegetables) for which data is not available, present no uncertainties. All prices are in national currency per tonne and have been deflated utilizing a CPI provided by the IMF. Data on international prices have been collected by the International Financial Statistics (IMF, 2005), whilst conditional measures for yield variability have been estimated utilizing data from FAOSTAT.

4.1 Ghana

The results of the household classification analysis of the 1998/99 LSMS data on Ghana are shown in Table 1.[10] The sample of farm households represents 2.2 million farm households, out of a total of 4.1 million, which are divided into three regions, namely Forest, Coast and Savannah. These are further divided according to their income level as poor and non poor, utilizing a general poverty threshold of 900 000 cedis per capita per year.[11] The sample is further subdivided according to the contribution of agricultural activities in total income and according to the contribution of cocoa sales to agricultural income (households with share smaller than 30 percent, between 30 and 60 percent and larger than 60 percent).

Table 2 presents the conditional measures of the variability of agricultural prices faced by producers and the conditional CVs of international prices. These have been calculated by means of estimated single autoregressive models for the domestic price series of commodities that are not internationally traded (cocoyam, yam, cassava and millet), as well as for the domestic and international prices that have dissimilar statistical properties (bananas, maize and sorghum). As for the domestic and international prices of rice, on the basis of the unit root tests they were found to have similar statistical properties. The estimated VAR revealed that there was no significant relationship between the two prices with neither being Granger caused by the other. Consequently, producers in Ghana are exposed to domestic market shocks only, whilst international price shocks do not pass through to the domestic market. Table 3 presents the estimates of income variability measures. These conditional income CVs may underestimate the actual variability of income as they are estimated on the basis of the part of agricultural income for which data on commodity prices are available.[12] The estimates suggest that the agricultural income uncertainty farm households face is significant, with the agricultural income CV for most household classes ranging between 10 and 20 percent, whilst several households face CVs are estimated to be higher than 20 percent. As the portion of agricultural income that is included in the calculations in Table 3 is only part of the total income variation, the overall income variability of farm households due to agricultural shocks is smaller than what is indicated in Table 3, but not much less for those households with large share of agriculture in total income.

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[10] Further information on the Ghana LSMS 1998/99 data set can be found in http://www4.internationalbank.org/afr/poverty/pdf/docnav/02684.pdf

[11] The average exchange rate in Ghana for the period of the survey was 2 930.36 cedis per USD.

[12] The part of total income accounted by the portion of agricultural income for which we have enough information to compute the income variance is indicated in table 10.

Households that depend for a larger part of their agricultural income on the main export commodity, cocoa, seem to be exposed to larger agricultural income variability, despite the market intervention policies of the government parastatal Cocobod to stabilize producer prices, mainly due to high production variability. The per capita incomes of the household classes in Table 1, suggest that farm households characterized by a larger share of their agricultural income from cocoa have a larger income per capita. This would indicate that in Ghana farm households that are more specialized in cocoa farming are on average richer, but at the same time are more exposed to price and production risks. For predominantly agricultural households that depend on cocoa to a relatively lesser extent for their agricultural income, income volatility is still significant mainly due to the high variability in the domestic prices of maize and cassava. In the Coast region, poor predominantly agricultural households for which cocoa sales make up less than 30 percent of their agricultural income, are subject to relatively high uncertainty with a coefficient of variation that amounts to 12.9 percent, because cassava and maize production generate up to 68 percent of their agricultural income. In a similar manner, poor households in the Forest and Savannah regions that depend on roots and cereals are also subject to significant agricultural income fluctuations. The findings suggest that crop diversification strategies in Ghana, although important as a risk management strategy, may be relatively inadequate in shielding poor producers from large income fluctuations.

The measures of agricultural income variability that producers would face if they were exposed directly to international prices for all the internationally-traded commodities suggest that for the households that are highly dependent on cocoa, irrespective of whether they are poor or non-poor, exposure to full international prices would considerably increase the variability of their agricultural incomes, while for those households that depend the least on cocoa agricultural income variability would decrease. This result is largely the outcome of the fact that currently the domestic price of cocoa continues to be stabilized by Cocobod. Hence the abolition of this parastatal and full exposure to international prices is bound to have adverse effects on producers' overall income variability.

4.2 Vietnam

Table 4 presents the results of the household classification for Vietnam, utilizing the 1997/98 LSMS data set.[13] The sample covers a weighted 13 million households representing 80 percent of all households in the country. These are divided into three regions, namely Urban and Northern Vietnam, Red River and North Coast, and South and Central Vietnam. The households are classified according to their income level as poor and non poor, utilizing a threshold of 19 590 000 dong of total household expenditure per capita per year,[14] and are further divided according to the contribution of agricultural activities to total income (households with contributions smaller and larger than 60 percent in total). The households are also classified according to the contribution of internationally tradable commodities to agricultural income (households with share smaller than 30 percent, between 30 and 60 percent and larger than 60 percent). In the Urban and Northern and Red River and North Coast regions households are divided according to the share of rice in agricultural income, whilst for the South and Central region households are classified according to their activities in the production of coffee. The production activities are categorized into rice, other cereals, (including maize, wheat, barley malt, millet and kaoliang), meat (includes pork, chicken and beef), fish, cassava, coffee, sugar, fruits, vegetables and other roots.

Table 5 presents the estimates of agricultural price variability to which producers are exposed and the shares of this variability that are accounted for by domestic and international shocks. The price variations that producers face are largely due to domestic factors, except for those producers who are largely dependent on coffee and rice. In addition, for all commodities except coffee, the US dollar denominated international prices are more, or equally, unstable compared to domestic prices. The decomposition of variability to components that are identified with domestic and international shocks was calculated by a series of single autoregression models and VARs. For the price pairs that were

[13]Further information on the Vietnam LSMS 1997/98 data set can be found in http://www.internationalbank.org/lsms/country/vn98/vn98bif.pdf.

[14] The average exchange rate pertinent to the survey period is 13 091 dong per US dollar.

found to have dissimilar statistical properties, namely prices for sugar and pork, we estimated single autoregressive models. For coffee, the estimated VAR parameters are statistically significant, revealing the correlations between the domestic and international prices, while the Granger causality test provides evidence that the international price causes the domestic price in Vietnam, in the Granger sense. The correlation coefficient between the VAR innovations is estimated to be approximately 0.49, indicating that shocks are to a large extent passed through from the international to the domestic market. The domestic and the international prices account for 80 and 20 percent of the domestic price forecast variance respectively, whilst variation in the domestic price can explain 38 percent of the variation in the international price.

The maize and beef domestic and international price VARs, in conjunction with the corresponding causality tests, suggest that the domestic price is not determined and Granger-caused by the international price. Consequently, for these commodities, the variance decomposition suggests that the proportion of the domestic price forecast variance that is attributed to variability in the international price is non-significant. For rice, the VAR estimated parameters suggest a rich dynamic structure. The Granger causality test provides sufficient evidence to suggest that the international price Granger-causes the domestic price. Decomposing the variance indicates that 29 percent of the variability of the domestic price for rice can be attributed to the international rice market.

Table 6 presents the estimates of conditional agricultural income variability for Vietnam. As expected the results suggest that the uncertainty households face varies according to production diversification, with households that produce a large share of rice and coffee, irrespective of their overall share of income from agriculture, being exposed to higher agricultural income volatility, relative to households that are characterized by a less specialized production pattern. Coffee producers in the South and Central region are subject to significant income variability. For producers whose share of coffee in total agricultural income is larger than 60 percent, irrespective of the share of agriculture in total income, the CV is around 50 percent, which is much higher than the CVs of all other household groups. By contrast, even the most highly specialized rice producers do not seem to incur a CV larger than 14 percent.

The results also indicate that almost all of the agricultural income variability that producers face is due to domestic factors. Even for the households that are highly dependent on coffee, it appears that most of their income variability is due to domestic factors. Such substantial income variation suggests that poor agricultural households may face serious food security problems *post* adverse coffee price shocks, due to limited resources employed for the production of food crops for in-household consumption.

The simulation of full exposure to international prices indicates that for almost all households in the Urban and Northern as well as the Red River and North Coast regions, perfect market integration would **increase** the CV of agricultural income. During the period under examination, Vietnam has implemented a series of policies aimed to maintain the domestic rice price at a certain level and to reduce its volatility, at least during this period. These policies included export management through a system of minimum export prices and quotas that were allocated to authorized export enterprises, both public and private. Minimum export prices were frequently revised in order to keep abreast of international prices. In 2001, export quantitative limits were removed. However, the new arrangements allow for the state trade enterprises to remain responsible for exports (FAO, 2001; 2002). Hence it is to be expected that substitution of these policies with full international market exposure would increase producers' income variability and this does obtain from the analysis. By contrast, the results indicate that the households in the South and Central regions who are highly specialized in coffee would experience a small decline in their overall CV, albeit without large international exposure. The remaining income variability would, nevertheless, still be substantial.

4.3 Peru

The household classifications for Peru are based on the 1994 LSMS data set and are presented in Table 7.[15] The sample consists of a weighted 1.9 million producing households representing 50

[15] Further information on the Peru LSMS 1994 data set can be found in http://www.internationalbank.org/lsms/country/pe94/docs/i-basica.pdf.

percent of all households in the country, divided into three regions namely Sierra, Coast and Selva. The households are classified according to their income level as poor and non poor, utilizing thresholds that vary across regions.[16] The sample is further divided according to the contribution of agricultural activities to total income (households with contributions smaller and larger than 60 percent in total) and according to the contribution of rice production to agricultural income (households with share smaller than 30 percent, between 30 and 60 percent and larger than 60 percent).

Table 8 presents the analysis of the variability of agricultural prices faced by producers and the shares of this variability that are accounted for by domestic and international shocks. It is notable that for commodities like coffee, wheat, and chicken the bulk of the domestic price variability is due to international factors. For the other commodities, the major part of the variability is due to domestic factors and the corresponding CVs of domestic prices do not follow a consistent pattern of instability *vis-à-vis* international prices.

In more detail, the VARs estimated for domestic and international beef prices, in conjunction with the Granger causality tests indicated that prices in the domestic and international market are related, albeit weakly, to the causality being manifested from the international to the domestic market. On similar lines, variance decomposition suggests that most of the variation in the domestic price is attributed to domestic shocks. For chicken, the estimated VAR parameters and the causality tests provide evidence that the domestic price is closely related to, and Granger-caused by, the international price. The undertaken variance decomposition indicated that, although domestic prices are highly volatile with a coefficient of variation equal to 0.41, most of this variation is attributable to the international price.

The domestic and international prices for bananas reveal that these prices are not jointly determined, suggesting that the international price for bananas may not be an appropriate proxy for explaining movements in the price for plantains in Peru. The VAR for the domestic and international prices for rice revealed that for the period under examination, price shocks in the international market are reflected in the domestic market and *vice versa*, although not to a full extent. The government in Peru intervenes in the market through tax restitutions for exports and a variable tariff imposed on rice imports. Imports of rice that originate in countries that are not members of the Andean Pact are subject to a 20 percent tariff plus a supplementary tax of 5 percent. In mid 2001, the country introduced a price band mechanism based on an external reference price and on a basic floor price, set twice a year in spite of the tariff that was in force. The implementation of these policies may have resulted in isolating the domestic market price from shocks in the international market, at least during the period covered by the sample.

Table 9 shows the results for Peru. In general, the results suggest that households with relatively less diversified production patterns face higher income uncertainty. In the Coast and Selva regions, the agricultural income CVs for predominantly agricultural households in which rice production constitutes more than 60 percent of their agricultural income, is estimated to be around 14-17 percent, which is considerably higher than the CV of farm households that obtain between 30 and 60 percent of their income from rice. In Sierra, the results appear to suggest that lower dependence on rice may not result in significant income risk reduction, as agricultural households that generate less than 30 percent of their agricultural income from the cultivation of rice are characterized by higher CVs relative to households with similar characteristics in the other regions.

The result that domestic price and quantity variations are the overwhelming determinant of producer incomes obtains here as well for all income classes.

The CVs that correspond to the scenario of complete exposure to international markets are reported in the last rows of Table 9. The results suggest that increasing exposure to international markets would lead to considerable reductions in all agricultural income CVs (except in one case in the Selva region). In general, for most household classifications, the reductions in the CVs would be by several

[16] Poverty thresholds in Peru vary across the 12 sub-regions that are examined in the LSMS data set and are calculated according to the cost of a basket of commodities. For the purposes of this research, region thresholds are estimated as weighted averages of the constituent sub regions. The average exchange rate for the period of the survey was 2.2 nuevo sol per US dollar.

percentage points. Such a finding suggests that domestic price policies that aim to stabilize rice prices may not have resulted in reducing agricultural income volatility. Predominantly agricultural households in the Selva region that generate less than 30 percent of their income from rice production would experience an increased income volatility of about 0.4 percentage points when exposed to international markets, possibly due to a higher share of income accruing through poultry and white meat production activities.

5 CONCLUSIONS

In this paper we attempt to provide answers to the questions of whether increased exposure to international markets reduces the volatility of domestic market prices and improves the welfare of agricultural commodity households. We develop a theoretical framework that leads to explicit formulae for household income variance on the basis of covariate shocks, such as commodity price and yield uncertainties. The empirical work focused on the estimation of household income uncertainties combining household micro classifications for a number of different household types in Ghana, Vietnam and Peru, and time series analysis. We estimated household class-specific income variability that emanates from market uncertainties, both price and production related, and used this empirical framework in order to conduct simulation experiments on the extent to which complete exposure, rather than partial or no exposure to international market signals affects commodity prices and thus agricultural income volatility.

One major result of the paper is that almost all of the agricultural income variability of producers seems to be due to domestic factors. While domestic prices for tradable commodities exhibit diverse patterns of price transmission from international prices, the impact of international prices on farmer income variability seems to be small, either because of small transmission, or because of small shares of farm income accounted for by the relevant price.

This empirical work provides mixed results concerning the impact on producer variability of total exposure to international prices. In general, the results suggest that, in the absence of effective price stabilization policies, in the countries under examination, increased exposure to international markets may result in a reduction in agricultural income volatility, as international markets may act as 'buffers' absorbing large domestic supply and demand shocks in domestic markets. However, with the exception of coffee producing households in Vietnam, any improvements in income variability brought about due to increased exposure to international markets are very small. Where price stabilization schemes are in place, as in the case of cocoa in Ghana, or rice in Vietnam, wider exposure to international markets may result in relatively higher income stream uncertainty, suggesting that domestic policies in these countries are effective in reducing uncertainty that emanates due to both domestic and international factors.

The extent to which households diversify their income sources and production patterns was found to affect income uncertainty. In general, as expected, households whose income depends largely on a single commodity face higher income volatility, as compared to households that adopt a more extensive diversification pattern. In Vietnam, for example, the results suggest that the household classes that predominantly depend on rice and coffee are subject to considerably higher agricultural income uncertainty, especially when opportunities for off-farm income do not exist. Similarly, in Peru households that depend on rice and cereals face higher uncertainties as compared to those that have a more diversified production pattern. Nevertheless, there are cases where both cash and food crops are subject to high price and yield volatility, as in the case of Ghana, suggesting that crop diversification strategies on their own or self-insurance may not be sufficient to shield producers from large income fluctuations. Thus, it is important that governments intervene in order to establish a mechanism through which commodity insurance can be provided.

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TABLES

Table 1. Household classification and characteristics in Ghana

Household type	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Region						**Coast**						
Estimated number of households	262 790	7 238	5 190	48 055	1 058	1 151	87 740	982	1 835	19 229		
Share of total households (%)	6.41	0.18	0.13	1.17	0.03	0.03	2.14	0.02	0.04	0.47	-	-
Total income per capita ('000 cedi)	812	1,339	1,669	550	514	804	2,683	1,290	8,399	1,575		
Share of agriculture in total income (%):	16.91	14.66	14.49	71.32	69.94	61.75	17.27	34.96	4.45	75.66	-	-
Share of agricultural income from (%):												
Cocoa	0.88	43.93	81.84	1.19	33.72	66.86	0.26	39.00	93.14	0.47		
Cereals	21.37	9.86	9.66	10.18	5.89	5.05	18.46	0.87	0.14	6.44	-	-
Meat	5.91	11.68	1.47	1.57	-	-	8.23	2.26	0.11	1.67	-	-
Roots	33.48	15.13	2.72	58.25	39.76	11.45	28.90	30.80	1.98	38.08		
Beverages	0.16	-	-	0.08	-	-	-	-	-	0.10	-	-
Fruits	1.50	1.92	0.26	0.69	0.86	0.37	1.12	3.09	0.21	1.87	-	-
Vegetables	13.84	16.02	2.74	11.05	16.48	10.73	14.07	20.52	3.86	17.04	-	-
Other agricultural commodities	22.85	1.47	1.31	16.99	3.29	5.54	28.95	3.46	0.57	34.33	-	-
Region						**Forest**						
Estimated number of households	503 790	51 169	31 785	149 464	26 710	8 935	192 334	16 632	11 746	86 874	19 283	6 108
Share of total households (%)	12.29	1.25	0.78	3.65	0.65	0.22	4.69	0.41	0.29	2.12	0.47	0.15
Total income per capita (000 cedi)	1 017	1 244	1 374	563	647	633	3 103	1 914	3 328	1 577	2 431	4 502
Share of agriculture in total income (%):	22.86	35.21	34.18	70.90	68.66	67.00	21.77	32.49	40.39	74.31	69.87	69.10
Share of agricultural income from (%):												
Cocoa	2.12	43.77	77.40	5.19	40.47	77.52	1.92	42.93	75.90	6.67	40.80	74.71
Cereals	28.31	10.75	5.09	17.60	5.44	2.94	27.33	5.94	3.31	8.74	5.81	2.36
Meat	6.03	2.82	1.33	2.60	1.49	0.58	5.45	3.64	0.55	4.22	0.82	0.88
Roots	36.48	20.69	8.83	43.57	29.39	8.50	36.50	27.58	10.80	44.64	20.65	12.54
Beverages	0.16	0.11	0.09	0.03	0.65	-	0.35	0.11	0.16	0.01	0.11	0.07
Fruits	1.51	1.03	0.57	1.37	0.84	0.81	1.24	1.98	0.27	1.84	1.70	0.11
Vegetables	18.25	17.33	5.58	25.20	18.81	8.73	21.21	15.09	6.84	28.49	26.18	8.63
Other agricultural commodities	7.15	3.49	1.11	4.42	2.91	0.92	6.00	2.73	2.16	5.38	3.94	0.69
Region						**Savannah**						
Estimated number of households	488 980	1 393		133 115	1 420	1 420	55 436			37 500	609	
Share of total households (%)	11.93	0.03	-	3.25	0.03	0.03	1.35	-	-	0.91	0.01	-
Total income per capita (000 cedi)	759	1 003		534	866	7 281	2 700			1 544	2,431	
Average share of agriculture in total income (%):	26.92	49.99		71.48	64.95	75.94	26.66			73.82	79.93	

Household type	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Share of agricultural income from (%):												
Cocoa	0.09	46.86	-	0.15	54.70	87.30	0.21	-	-	0.09	57.54	-
Cereals	38.69	8.90	-	30.68	9.60	1.86	27.57	-	-	20.16	1.67	-
Meat	13.47	1.32	-	10.79	4.93	1.59	10.19	-	-	8.58	-	-
Roots	14.03	28.10	-	25.43	19.87	7.15	31.40	-	-	40.50	27.71	-
Beverages	2.71	-	-	0.15	-	-	0.58	-	-	0.24	-	-
Fruits	0.34	-	-	0.52	-	-	0.33	-	-	0.86	0.76	-
Vegetables	10.91	3.30	-	17.61	6.61	0.95	10.16	-	-	17.94	10.99	-
Other agricultural commodities	19.76	11.52	-	14.67	4.28	1.15	19.55	-	-	11.63	1.33	-

Source: Authors' computations

Table 2. Ghana: Decomposed coefficients of variation of domestic prices (percent)*

	CV of Domestic prices accounted for by			World price Coefficients of Variation
	Domestic shocks	International shocks	Total	
Maize	21.24	0.00	21.24	18.4
Cassava	25.80	0.00	25.80	14.9
Plantains	36.06	0.00	36.06	
Cocoyam	17.33	0.00	17.33	
Yam	23.93	0.00	23.93	
Sorghum	24.81	0.00	24.81	16.6
Millet	13.58	0.00	13.58	16.6
Rice	13.30	0.00	13.30	11.5
Cocoa	8.35	0.00	8.35	20.2
Groundnuts	14.46	0.00	14.46	16.0

*Conditional coefficients of variation 12 months ahead.

Source. Authors' calculations.

Table 3. Coefficients of variation (CVs) of agricultural incomes in Ghana (percent)

Household type	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Region						**Coast**						
Actual agricultural income CVs due to price and production shocks	12.87	13.81	19.00	17.19	16.00	16.68	10.71	13.69	20.90	12.19	-	-
Agricultural income CVs due to domestic market and production shocks only	12.87	13.81	19.00	17.19	16.00	16.68	10.71	13.69	20.90	12.19	-	-
Simulated Agricultural income CVs due to world prices (in US) and production shocks	8.66	14.68	24.28	8.97	13.07	20.34	7.13	12.69	27.09	6.67	-	-
Region						**Forest**						
Actual agricultural income CVs due to price and production shocks	14.41	14.48	18.23	14.86	14.85	18.30	14.15	15.21	18.09	14.41	15.19	17.64
Agricultural income CVs due to domestic market and production shocks only	14.41	14.48	18.23	14.86	14.85	18.30	14.15	15.21	18.09	14.41	15.19	17.64
Simulated Agricultural income CVs due to world prices (in US) and production shocks	10.16	15.07	23.05	9.25	14.33	23.06	9.90	15.48	22.68	8.48	14.37	22.18
Region						**Savannah**						
Actual agricultural income CVs due to price and production shocks	10.00	15.22	-	10.62	15.23	20.15	12.78	-	-	14.73	14.94	-
Agricultural income CVs due to domestic market and production shocks only	10.00	15.22	-	10.62	15.23	20.15	12.78	-	-	14.73	14.94	-
Simulated Agricultural income CVs due to world prices (in US) and production shocks	9.23	16.54	-	9.17	17.60	25.81	10.79	-	-	11.88	17.84	-

Source. Computed by authors

Table 4. Household classification and characteristics in Vietnam

	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Region						**Urban and Northern**						
Estimated number of households	164 061	193 203	77 569	316 921	684 132	125 460	1 264 246	179 788	179 154	356 599	223 382	76 235
Share of total households (%)	1.02	1.20	0.48	1.96	4.24	0.78	7.84	1.11	1.11	2.21	1.39	0.47
Total income per capita (dong)	2 662	2 293	1 905	1 546	1 173	745	8 115	5 201	8 121	2 672	1 638	1 886
Share of agriculture in total income (%)	24.97	38.07	30.16	91.98	91.34	94.85	9.90	29.04	13.32	88.14	90.45	93.37
Share of agricultural income from (%):												
Rice	10.77	43.94	74.01	17.29	44.10	69.28	2.16	46.00	85.07	11.81	41.05	77.69
Cereals other than rice	0.74	2.38	0.75	4.57	3.59	2.41	1.66	0.55	0.14	1.58	0.97	0.55
Meat	27.09	31.88	11.59	34.08	27.47	16.16	27.69	30.84	6.84	35.00	32.16	15.79
Fish	13.63	4.15	2.38	6.80	3.68	1.88	6.68	3.65	0.91	7.57	3.15	0.65
Cassava	2.31	1.08	1.15	1.91	1.76	1.14	0.34	0.10	0.01	0.63	0.43	0.01
Coffee	0.00	0.00	0.00	0.21	0.00	0.00	1.58	0.00	0.03	0.81	0.00	0.00
Sugar	2.37	1.28	1.85	12.49	1.20	0.00	10.28	1.78	1.37	9.79	1.18	0.53
Fruits	12.24	3.45	1.35	5.17	4.35	1.48	16.66	3.27	2.39	15.84	4.76	1.37
Vegetables	10.08	4.40	2.15	8.44	4.71	2.05	4.21	3.14	0.60	6.41	5.90	2.15
Roots other than cassava	0.60	0.86	0.39	1.19	0.54	0.26	0.36	1.01	0.07	0.26	0.59	0.13
Other agriculture	20.16	6.57	4.37	7.85	8.60	5.33	28.37	9.67	2.57	10.29	9.80	1.11
Region						**Red River and North Coast**						
Estimated number of households	184 308	298 393	234 811	173 966	622 875	369 433	536 795	546 296	282 737	356 527	613 870	169 116
Share of total households (%)	1.14	1.85	1.46	1.08	3.86	2.29	3.33	3.39	1.75	2.21	3.81	1.05
Total income per capita (dong)	2 394	1 894	1 602	1 377	1 116	766	5 175	6 300	4 779	2 574	1 636	1 317
Share of agriculture in total income (%)	22.49	36.17	31.42	91.01	89.59	89.31	19.32	16.51	15.37	81.88	86.15	88.11
Share of agricultural income from (%):												
Rice	11.54	45.92	76.52	21.10	43.98	75.70	13.17	43.53	73.89	18.36	43.43	72.25
Cereals other than rice	1.91	0.58	0.28	0.63	0.75	0.28	0.54	0.29	0.29	0.49	0.36	0.18
Meat	44.77	32.41	12.55	42.88	32.09	13.24	47.16	36.42	14.42	41.73	33.69	16.10
Fish	9.15	3.50	1.94	4.72	4.43	2.11	3.44	4.22	1.91	6.54	5.69	2.74
Cassava	1.57	0.32	0.28	2.13	1.22	0.78	0.08	0.14	0.24	0.34	0.57	0.03
Coffee	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00
Sugar	1.01	0.76	0.57	2.24	0.66	0.20	1.40	0.73	0.62	1.36	0.58	0.01
Fruits	4.78	4.39	2.21	3.81	2.83	1.78	9.64	4.22	2.46	7.04	3.86	2.39
Vegetables	3.42	3.14	1.88	6.52	4.73	2.40	9.76	3.92	2.10	11.46	4.75	2.57
Roots other than cassava	2.24	1.43	0.61	1.28	1.17	0.78	0.54	0.46	0.63	0.55	0.81	0.64
Other agriculture	19.60	7.56	3.14	14.69	8.15	2.74	14.27	6.06	3.45	12.10	6.26	3.10

	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of coffee in agricultural income			Share of coffee in agricultural income			Share of coffee in agricultural income			Share of coffee in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Region						South and Central						
Estimated number of households	412 373	1 168	5 633	1 171 145	26 151	32 370	1 211 060	11 555	24 905	1 559 728	39 217	102 592
Share of total households (%)	2.56	0.01	0.03	7.26	0.16	0.20	7.51	0.07	0.15	9.67	0.24	0.64
Total income per capita (dong)	2 437	4 758	2 896	1 155	1 508	1 676	5 727	5 278	6 448	2 778	2 691	5 445
Share of agriculture in total income (%)	22.00	17.12	35.08	92.47	93.52	95.20	16.96	31.55	24.93	90.80	84.97	92.80
Share of agricultural income from (%):												
Rice	37.40	0.00	2.55	44.77	20.43	3.46	36.63	16.71	0.18	44.31	8.35	1.56
Cereals other than rice	0.95	0.00	0.27	2.61	4.68	1.44	1.47	0.13	0.01	0.69	2.23	0.88
Meat	11.82	2.19	15.16	16.22	15.78	3.52	21.69	19.63	4.71	16.53	16.57	4.91
Fish	19.40	0.00	0.00	6.53	0.97	0.02	6.04	0.00	0.00	6.31	0.07	0.09
Cassava	0.66	0.00	0.01	2.71	0.61	0.15	0.51	0.01	0.00	0.39	0.57	0.20
Coffee	0.06	31.80	80.29	0.13	43.38	86.02	0.25	42.99	89.23	0.26	44.56	87.28
Sugar	0.95	0.00	0.09	3.69	1.37	0.02	3.42	0.00	0.00	3.33	0.84	0.00
Fruits	10.07	6.05	0.43	8.27	2.30	0.52	10.65	0.20	1.37	9.83	3.11	0.36
Vegetables	7.31	0.00	0.31	6.20	2.88	0.34	4.95	2.25	2.22	6.14	4.11	0.15
Roots other than cassava	0.26	0.00	0.47	0.27	0.02	0.14	0.17	0.06	0.02	0.12	0.23	0.00
Other agriculture	11.12	59.96	0.42	8.60	7.58	4.37	14.22	18.02	2.26	12.09	19.36	4.57

Source. Computed by authors.

Table 5. Vietnam: Decomposed coefficients of variation of domestic prices (percent)*

	CV of Domestic prices accounted for by			World price Coefficients of Variation
	Domestic shocks	**International shocks**	**Total**	
Coffee	51.01	12.68	63.69	45.6
Maize	6.10	0.09	6.20	18.4
Sugar beet	12.53	0.42	12.95	25.0
Rice	7.74	3.11	10.85	11.5
Beef	2.62	0.01	2.63	9.8
Pork	7.54	0.10	7.64	18.7

*Conditional coefficients of variation 12 months ahead

Source. Computed by authors.

Table 6. Coefficients of variation (CVs) of agricultural incomes in Vietnam (percent)

Household type	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Urban and Northern												
Actual agricultural income CVs due to price and production shocks	3.56	8.09	10.64	5.58	7.73	10.38	3.71	8.07	12.00	5.05	7.49	11.53
Agricultural income CVs due to domestic market and production shocks only	3.56	8.09	10.64	5.58	7.73	10.38	3.71	8.07	12.00	5.05	7.49	11.53
Simulated agricultural income CVs due to world prices (in US) and production shocks	4.91	9.74	12.39	7.23	9.13	12.11	5.40	9.67	14.02	6.88	9.04	13.44
	Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income		
Red River and North Coast												
Actual agricultural income CVs due to price and production shocks	4.92	8.19	11.09	5.79	7.80	11.04	5.43	8.47	10.78	5.53	8.02	10.68
Agricultural income CVs due to domestic market and production shocks only	4.92	8.19	11.09	5.79	7.80	11.04	5.43	8.47	10.78	5.53	8.02	10.68
Simulated Agricultural income CVs due to world prices (in US) and production shocks	6.97	9.87	12.93	7.71	9.38	12.88	7.80	10.52	12.56	7.53	9.80	12.47
	Share of coffee in agricultural income			Share of coffee in agricultural income			Share of coffee in agricultural income			Share of coffee in agricultural income		
South and Central												
Actual agricultural income CVs due to price and production shocks	5.77	19.32	48.92	7.12	27.67	52.45	6.36	26.88	54.28	7.03	27.78	53.19
Agricultural income CVs due to domestic market and production shocks only	5.77	19.21	48.66	7.12	27.54	52.16	6.36	26.74	53.99	7.03	27.64	52.90
Simulated Agricultural income CVs due to world prices (in US) and production shocks	6.71	18.25	46.26	8.22	26.32	49.55	7.50	25.51	51.31	8.13	26.42	50.28

Source. Computed by authors

Table 7. Household classification and characteristics in Peru

	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
	Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income			Share of rice in agricultural income		
Region						**Coast**						
Estimated number of households	136 109	3 886	5 505	18 674	1 481	6 085	315 603	9 855	5 344	31 843	2 222	12 170
Share of total households (%)	3.07	0.09	0.12	0.42	0.03	0.14	7.13	0.22	0.12	0.72	0.05	0.27
Total income per capita (nuevo sol)	996	1 095	1 037	482	305	815	4 237	3 300	3 334	4 090	2 181	3 416
Share of agriculture in total income (%)	13.48	11.06	11.67	87.01	90.79	81.97	11.34	16.38	30.82	83.26	76.42	93.33
Share of agricultural income from (percent):												
Rice	0.54	42.78	83.37	2.13	41.72	93.60	4.01	42.32	89.77	0.80	53.03	85.22
Cereals	7.60	0.00	0.00	28.40	22.29	0.25	6.04	3.31	0.50	31.88	19.12	3.95
Meat	22.89	20.87	2.04	17.30	12.89	3.82	13.99	7.40	5.84	12.03	11.75	2.69
Roots	4.80	4.13	0.00	3.70	9.23	0.16	5.38	0.77	0.00	4.29	0.00	1.94
Beverages (coffee/cocoa)	0.63	0.21	0.28	2.21	0.00	0.12	1.84	3.11	0.00	0.09	0.14	0.00
Fruits	5.93	0.00	0.00	3.90	5.93	0.00	8.15	0.13	0.05	4.54	8.22	0.00
Vegetables	10.31	0.00	1.43	23.91	0.38	0.28	6.33	4.38	0.11	23.55	0.00	5.04
Other agriculture	47.31	32.01	12.88	18.46	7.55	1.76	54.25	38.59	3.74	22.81	7.74	1.16
Region						**Sierra**						
Estimated number of households	212 039	2 637	1 195	261 885	1 195	1 195	332 162	8 158	1 195	205 907	2 391	10 759
Share of total households (%)	4.79	0.06	0.03	5.91	0.03	0.03	7.50	0.18	0.03	4.65	0.05	0.24
Total income per capita (nuevo sol)	622	824	116	467	102	676	4 897	2 801	1 207	2 172	1 647	1 947
Share of agriculture in total income (%)	27.65	18.26	36.81	86.47	100.00	93.92	21.16	14.93	43.61	86.77	93.11	89.91
Share of agricultural income from (percent):												
Rice	0.98	37.94	77.29	0.20	38.33	71.00	3.15	36.27	97.86	0.72	52.89	79.66
Cereals	27.26	0.52	18.58	30.36	3.29	0.00	23.03	13.22	0.00	34.36	23.66	1.32
Meat	17.06	1.22	4.13	21.50	9.86	5.35	18.80	0.58	0.00	16.36	6.85	7.23
Roots	20.35	0.00	0.00	23.86	9.11	0.00	12.73	0.00	0.00	23.00	1.19	2.57
Beverages (coffee/cocoa)	1.32	0.91	0.00	0.34	0.00	0.00	0.54	3.09	0.00	0.31	0.00	0.00
Fruits	3.64	0.00	0.00	0.36	39.42	0.00	2.53	5.19	2.14	1.44	0.00	0.07
Vegetables	8.74	3.96	0.00	7.35	0.00	0.00	5.33	1.65	0.00	6.93	6.10	1.86
Other agriculture	20.65	55.45	0.00	16.02	0.00	23.66	33.90	40.01	0.00	16.89	9.32	7.29
Region						**Selva**						
Estimated number of households	69 458	3 364	8 827	61 341	6 835	6 835	120 961	6 128	6 085	51 850	8 228	6 171
Share of total households (%)	1.57	0.08	0.20	1.39	0.15	0.15	2.73	0.14	0.14	1.17	0.19	0.14
Total income per capita (nuevo sol)	681	593	573	618	514	457	3 270	3 411	2 629	2 436	1 407	1 690

	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Share of agriculture in total income (%)	24.47	41.69	39.34	86.79	77.91	84.45	20.53	27.18	35.08	86.47	94.19	85.15
Rice	2.33	47.80	81.63	4.73	43.32	77.66	3.94	48.22	75.35	2.86	42.29	78.12
Cereals	6.49	2.17	2.49	6.68	2.45	0.62	6.28	2.96	4.00	5.35	3.75	1.95
Meat	25.22	11.40	8.53	13.28	11.41	7.57	14.32	7.63	1.49	11.78	15.18	3.84
Roots	9.63	5.84	2.03	17.90	11.87	3.56	8.88	14.23	2.03	12.59	12.37	7.62
Beverages (coffee/cocoa)	1.50	0.62	0.18	8.93	2.29	1.16	4.12	1.76	0.56	14.49	2.70	0.09
Fruits	17.28	4.58	0.68	25.67	13.91	4.20	13.63	10.68	0.17	34.00	11.88	0.72
Vegetables	8.73	2.45	0.23	8.91	1.47	2.39	6.19	0.63	0.61	8.52	4.85	4.66
Other agriculture	28.82	25.15	4.20	13.90	13.28	2.84	42.64	13.90	15.79	10.42	6.97	3.00

Source. Computed by authors.

Table 8. Peru: Decomposed coefficients of variation of domestic prices (percent)*

	CV of Domestic prices accounted for by			World price Coefficients of Variation
	Domestic shocks	International shocks	Total	
Coffee	10.85	64.65	75.51	45.6
Maize	19.94	0.00	19.94	18.4
Wheat	6.71	11.74	18.44	17.7
Rice	16.20	11.57	27.77	11.5
Beef	16.71	0.00	16.71	9.8
Pork	8.31	0.00	8.31	18.7
Chicken	7.04	34.27	41.31	10.6
Plantains	16.46	0.00	16.46	14.9

*Conditional coefficients of variation 12 months ahead

Source. Computed by authors.

Table 9. Coefficients of variation (CVs) of agricultural incomes in Ghana (percent)

	Poor						Non Poor					
	Share of agriculture in household income						Share of agriculture in household income					
	< 60%			>60%			< 60%			>60%		
	Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income			Share of cocoa in agricultural income		
	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Coast												
Actual agricultural income CVs due to price and production shocks	12.87	13.81	19.00	17.19	16.00	16.68	10.71	13.69	20.90	12.19	-	-
Agricultural income CVs due to domestic market and production shocks only	12.87	13.81	19.00	17.19	16.00	16.68	10.71	13.69	20.90	12.19	-	-
Simulated Agricultural income CVs due to world prices (in US) and production shocks	8.66	14.68	24.28	8.97	13.07	20.34	7.13	12.69	27.09	6.67	-	-
Forest												
Actual agricultural income CVs due to price and production shocks	14.41	14.48	18.23	14.86	14.85	18.30	14.15	15.21	18.09	14.41	15.19	17.64
Agricultural income CVs due to domestic market and production shocks only	14.41	14.48	18.23	14.86	14.85	18.30	14.15	15.21	18.09	14.41	15.19	17.64
Simulated Agricultural income CVs due to world prices (in US) and production shocks	10.16	15.07	23.05	9.25	14.33	23.06	9.90	15.48	22.68	8.48	14.37	22.18
Savannah												
Actual agricultural income CVs due to price and production shocks	10.00	15.22	-	10.62	15.23	20.15	12.78	-	-	14.73	14.94	-
Agricultural income CVs due to domestic market and production shocks only	10.00	15.22	-	10.62	15.23	20.15	12.78	-	-	14.73	14.94	-
Simulated Agricultural income CVs due to world prices (in US) and production shocks	9.23	16.54	-	9.17	17.60	25.81	10.79	-	-	11.88	17.84	-

Source. Computed by authors

Table 10. Shares of included agricultural income in total household income

Poor						Non Poor					
Share of agriculture in household income						Share of agriculture in household income					
< 60%			>60%			< 60%			>60%		
Share of main commodity in agricultural income			Share of main commodity in agricultural income			Share of main commodity in agricultural income			Share of main commodity in agricultural income		
<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%	<30%	30-60 %	>60%
Ghana Coast											
0.115	0.122	0.137	0.542	0.616	0.574	0.100	0.319	0.044	0.471		
Ghana Forest											
0.184	0.312	0.324	0.601	0.622	0.643	0.173	0.291	0.390	0.621	0.625	0.666
Ghana Savannah											
0.182	0.419		0.504	0.569	0.731	0.199			0.539	0.727	
Vietnam Urban and Northern											
0.093	0.282	0.254	0.588	0.655	0.794	0.034	0.209	0.121	0.474	0.625	0.864
Vietnam Red River and North Coast											
0.130	0.300	0.290	0.593	0.676	0.797	0.139	0.256	0.221	0.470	0.647	0.770
Vietnam South and Central											
0.124	0.054	0.339	0.623	0.789	0.888	0.137	0.296	0.268	0.568	0.632	0.875
Peru Coast											
0.041	0.065	0.083	0.468	0.824	0.794	0.026	0.064	0.322	0.444	0.630	0.821
Peru Sierra											
0.135	0.075	0.368	0.590	0.606	0.717	0.068	0.066	0.427	0.595	0.798	0.810
Peru Selva											
0.113	0.263	0.355	0.541	0.582	0.754	0.068	0.148	0.222	0.589	0.738	0.785

Source. Computed by authors

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