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Urban Growth, Uninsured Risk, and the Rural Origins of Aggregate Volatility

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Abstract

The level of urbanization has increased by over 5 percentage points per decade outside the developed world since 1960. Rapid urbanization was accompanied by fast economic growth and job creation in most parts of the world. However, notably Africa (and Latin America after 1980) has had a different experience: while growth in GDP per capita slowed significantly or even reversed, the rate of urbanization continued its fast pace. This paper aims to explain this by introducing an aggregate risk differential between the countryside and the city. Uninsurable expected risk will lead to rural-urban migration as a form of ex-ante insurance if households are liquidity constrained in incomplete markets and cannot overcome adverse shocks. Macroeconomic volatility finds its origins in risk-prone natural resource production including agriculture and has a robust positive effect on urban growth, especially when economic growth is slow. The effect stands up to the transitional view on urbanization of economies shifting from an agricultural to an industrial base.

Key words: urbanization, risk, natural resources, volatility, rural-urban migration
JEL Classification: O1, R11, R23, R51, D81

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1 Introduction

The level of urbanization has increased by over 5 percentage points per decade outside the developed world since 1960. As a result, sometime this year the world will have more urban inhabitants than rural dwellers. Rapid urbanization was accompanied by fast economic growth in most parts of the world. However, notably Africa (and Latin America after 1980) has had a different experience (Fay, Opal, 2000) as is shown in Figure 1. While growth in GDP per capita slowed significantly or even reversed, the rate of urbanization continued its normal fast pace. Table 1 ranks regions by the growth differential between national and urban population. Given the low GDP per capita growth in Sub-Saharan Africa it is surprising that it comes on top in terms of urbanization speed. Without growth to create jobs or higher wages in cities (such as in East Asia) it seems puzzling that so many rural dweller choose to become urban dwellers. Most people end up in slums which do not necessarily offer better living conditions than rural areas for a given income (UN-Habitat, 2006). The long time period and crowding should lower the expected income gain from moving to the city. Big city lights are not always bright. It seems that the continued migration flows in some parts of the world are larger and more persistent than the classic Harris-Todaro (1970) model can explain. An illustration is given by Equatorial Guinea, a Sub-Saharan African country. Between 1990 and 1995 its urban population grew 12% faster than the national population, yet GDP per capita and manufacturing value added were declining by respectively -9% and -7% per year on average.

Apart from being pulled to the city by a higher income promise people may also be pushed from the rural area. If living conditions worsen in the countryside because sources of income decline (by natural causes such as rainfall or conflicts for example) then people will move to cities even if urban economic growth is absent, because it is the only place to go with at least some chance of improvement. Even if rural life exhibits good as well as bad years then people are still pushed off the land and to the city in bad years, unless they have the financial means to smooth consumption and 'ride out the bad times'. The more volatile shocks are, the more likely it is that sufficiently bad years occur that wipe out savings. Natural resource production and the exogenous prices they fetch on the world market show very volatile behavior (Deaton, 1999). Financial services to insure against shocks are relatively absent in rural areas (Collier, Gunning, 1999). Return migration in good years is limited by population growth, but also because good years offer more urban employment. Sub-Saharan Africa was the most volatile region during the past 45 years and also very resource dependent, as Table 1 shows.[2] Our example of Equatorial Guinea did not suffer from war or conflict in the 1990s, but output growth volatility in the agricultural sector (62% of all value added) was a worrying 27% and the standard deviation of yearly GDP per capita growth rates a similarly high 24%! The negative agricultural growth shock of -29% in 1993 (while World food export prices had been declining for three years) may well have pushed farmers to cities to find alternative income sources, if they could not use financial instruments to wait for next year's positive shock of +44%. Risk was evidently high.

This paper will try to explain urbanization occurring even under negative growth, by including another feature of many developing countries: their dependence on natural resource production and consequent shocks to GDP growth. Figure 2 shows the dependence of four regions on resource exports over time. Notably Africa and Latin America are very resource dependent.

Recent work has explained the different African experience by using rainfall data (Barrios et al., 2006) and shown that low rain fall (low agricultural productivity) is associated with a higher contemporary level of urbanization. Fay and Opal (2000) and Davis and Henderson (2003) identify government policy resulting in 'urban bias' and artificially high urban wages as an important cause for high levels of urbanization, in combination with urban poverty. Other explanations are ethnic tensions, democracy (more regional autonomy, so less urban bias), less than average agricultural yield (which is related to rainfall),

[2] See appendix A for data sources.

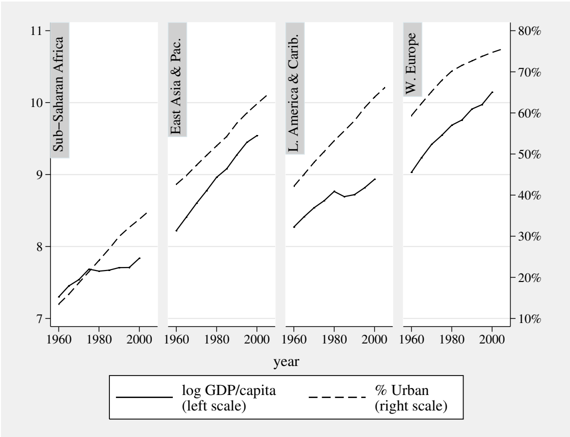

Fig. 1. Growth and urbanization

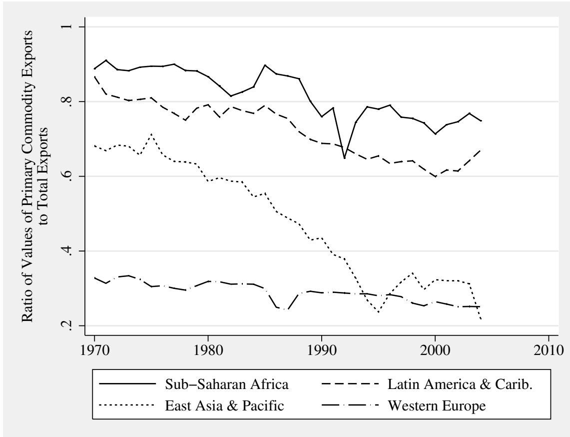

Fig. 2. Resource dependence

Table 1
Economic and Urban Growth by Region (yearly %, 1960-2005)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP/capita growth		% Population growth			Nat. resource exp. value/GDP	% Urban	
	mean	sd	urban	total	(3)-(4)	mean	1960	2005
Sub-Saharan Africa	0.85	6.93	5.25	2.54	2.71	17.37	13.50	36.25
South Asia	2.40	2.70	3.97	2.12	1.85	5.05	13.00	23.92
Eastern Europe & Central Asia	2.98	4.54	2.84	1.30	1.53	3.83	32.85	60.50
East Asia & Pacific	3.39	4.13	3.31	1.84	1.48	16.04	42.62	64.31
Middle East & North Africa	1.78	5.75	3.96	2.84	1.12	11.48	42.27	65.17
Latin America & Caribbean	1.44	4.11	3.10	2.00	1.10	13.96	42.16	66.10
Western Europe	2.78	2.52	1.22	0.57	0.65	7.54	59.35	75.53
North America	2.28	1.88	1.53	1.17	0.36	5.82	69.55	80.45

Note: Ordered on column 5. Means (or standard deviations) are calculated as the within-region cross-country unweighed average (or standard deviation) of country-time-period average growth rates (or standard deviations).

and changes in the 5-year average ratio of producer prices of wheat, rice, and maize to the country's CPI (which is often used as a proxy for rural to urban terms of trade), and to the world prices. We will add to this literature by focusing on volatility in output (standard deviation of GDP per capita growth), and volatility in the value of natural resources. We believe that the uncertainty associated with shocks around 5-year means is more important than average changes themselves. We will show that these shocks originate mostly from rural (resource) sectors rather than urban (manufacturing) sectors and that the resource sector tends to be more risky. Figure 2 shows cumulative density functions for four resources, and general price indices for industrial countries and the world. The x-axis shows the size of yearly standard deviations in % monthly price index changes. It is clear that a country with a high dependence on for example food products faces much more volatile prices than the average industrial country which typically trades in manufactures. Moreover, food prices are almost as volatile as oil prices. This prompted large price stabilization schemes in the 1970s which had many pitfalls and adverse side effects as studied in Newbery and Stiglitz (1981). Figure 2 plots the same resource price indices over time in levels. There are clearly very volatile periods and periods in which the price is much more stable. The volatility of output shocks is primarily caused by volatility in non-urban sectors, such as the natural resource sector. We will furthermore primarily focus on the speed of urbanization rather than the level and hypothesize that urban growth is faster in more volatile periods, especially if average growth is low. Shocks around a low or negative growth rate are probably worse than shocks around a high and positive growth rate.

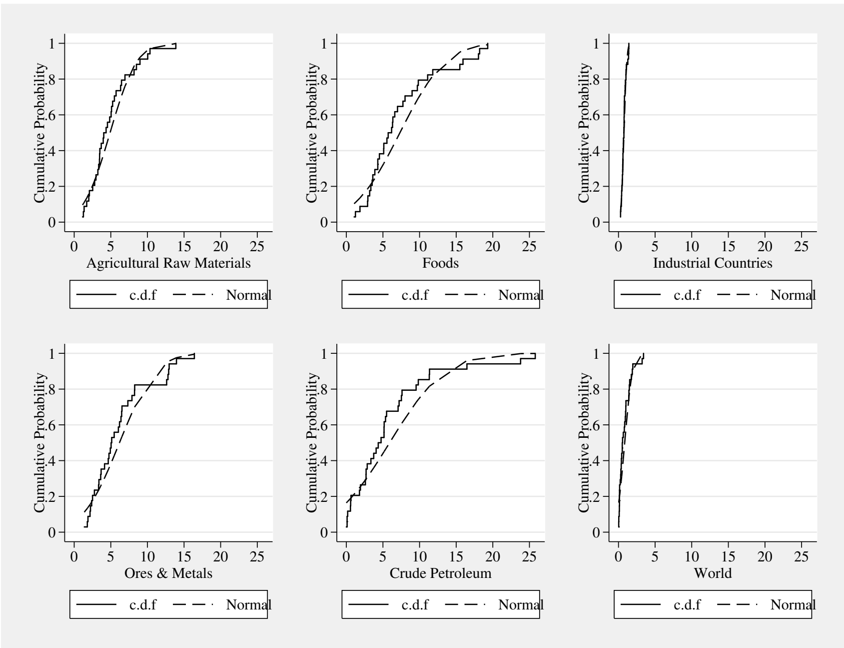

Fig. 3. Densities of Yearly Standard Deviation of Monthly Price Index Changes, 1970-2003

Uncertainty and risk as a motive to migrate (for some family members) was already noted by Stark and Levhari (1982). Daveri and Faini (1999) have estimated this motive for Italian migrants within Italy and internationally and conclude that risk is a significant determinant, driven by risk aversion. Dustmann (1997) similarly models the *duration* of migration as it is determined by risk at home and abroad and the (intertemporal) covariance of labor market shocks in addition to a wage differential. For example, a temporary migrant may diversify risk if the covariance of shocks is negative. We will try to link this

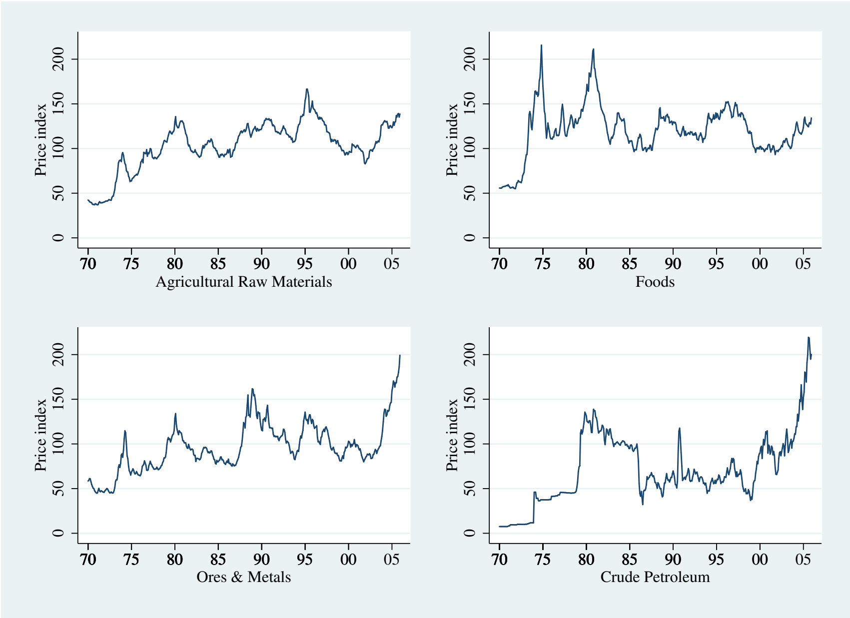

Fig. 4. Price index plots (monthly, labels at January of each year)

motive to a country's natural resource dependence and income risk in rural and urban sectors to explain fast rates of urban growth.

The next section describes the means by which households may cope with risk and how successful they are. Section 3 models households' migration behavior in response to shocks and section 4 discusses the estimation strategy. Sections 5 and 6 describe the results and assess their robustness, after which section 7 concludes.

2 Households and risk insurance

In industrialized countries households can deal with risk by buying financial services such as a savings and checking accounts, (unemployment) insurance, pensions, bonds, loans, etc., allowing them to smooth consumption over time. Most of these services are however beyond the reach of most people in developing countries, especially outside the urban environment where fever if any of these services are provided. Even inside cities a dual economy exists, the formal and the informal one, both in terms of labor and in terms of housing (see i.e. Temple, 2005). Slum dwellers will find it much harder to smooth consumption because they cannot provide collateral or a credit history. We are therefore in a situation of incomplete markets which affect not only households' (ex post) income, but also their (ex ante) behavior.

Insurance may partly be obtained by various informal means, as described in Besley (1995). We distinguish ex post risk sharing which usually happens at the village level among households. It takes the form of (cross-sectional) transfers which pool risk and income and provide insurance against idiosyncratic shocks but requires strong information and enforcement institutions within the community (Udry, 1990). However, the larger the covariance of shocks among households, the less scope there is for this form of insurance. Aggregate community shocks can not be insured against. Townsend (1994) and others [3] find that Pareto efficient risk pooling is often not achieved. Transfers across time may provide additional insurance, but Rosenzweig and Binswanger (1993) find that this is also limited because of credit constraints. Moreover, it leads households to choose less risky investment projects with a lower return with adverse effect on productive efficiency. [4] Accumulation of buffer stocks often in the form of bullocks may also be used to smooth consumption (Deaton, 1991), but this may also affect production if these assets are used in production (Rosenzweig and Wolpin, 1993) and is thus a sub-optimal insurance method.

Households can also cope with risk by changing their behavior in such a way that they minimize the chance of bad shocks hitting them in anticipation of risk. This is referred to as ex ante insurance and takes the form of conservative investment decisions, such as postponing adoption of new risky technology, crop diversification, crops of lower yields but faster growth cycles, diversifying family members among different income activities or sharecropping. It is also related to remittances and risk diversification by means of assigning family members to work in a different area, country or sector such as in Stark and Lucas (1988), although we do not believe that this alone can account for the high speed

[3] See Bardhan and Udry, 1999.

[4] Risk usually commands a higher return because otherwise the project would never be started, but in a rural development country setting risk might be high even with low return if social and financial constraints limit the ability to change predetermined investments, such as being born on a family (subsistence) farm.

of urbanization. The relative importance of ex ante risk insurance is shown by Elbers et al. (2005). They use micro data to quantify the ex post and ex ante effects of risk on capital accumulation and find that two-thirds of the detrimental effect of risk is due to the ex ante type which influences households behavioral decisions.

Since we focus on aggregate shocks which are uninsurable by the local informal ex post methods we assume that ex ante risk insurance is an important response to, for example, world resource price shocks. We hypothesize that migration is the link between risk and urban growth because it is the ex ante response to aggregate rural income risk.

3 Model of ex-ante risk insurance

The theoretical reason to look at volatility as an explanation for urbanization is derived as follows. Representative workers are either employed in an urban manufacturing sector M, the urban informal sector I or in the rural resource sector R.[5] The resource sector may produce agriculture, mining or plantation products such as coffee, and is assumed to be the only source of income and employment outside the city. The national composition of output in these sectors is also translated into output growth volatility (its standard deviation). We will show that output volatility originates to an important extend from shocks to the exogenous world prices for exports including manufactures and natural resources, the latter of which are more volatile. The more total GDP depends on resource export earnings, the higher will also be the covariance between GDP growth shocks and resource prices. Shocks are larger and more frequent in the rural resource sector than in the urban manufacturing sector.[6] Furthermore, the urban sector typically has better access to financial services to insure against shocks, while the rural agricultural sector is additionally affected by weather

[5] The 'sector' of subsistence farming is not explicitly modeled because it is affected mostly by weather shocks, more than it is affected by price shocks.

[6] Unfortunately, we will not be able to distinguish between urban and rural GDP growth and shocks, we only observe changes in aggregate GDP. We assume instead that manufactures are produced exclusively in cities and agriculture and resources outside cities.

shocks. It is therefore reasonable to assume that production and employment in the rural sector is inherently more risky than employment in the urban manufacturing sector even though its return is not necessarily higher. Some periods are more volatile than others and a country's development over time may change the dependence on resources and its ability to cope with external shocks. A time dimension is therefore also important. The goal of this model is to analyze the effect of a risk differential on workers' location choice.

A representative worker [7] faces a migration choice every period and simultaneously a choice between sectors. [8] Household face a liquidity constraint every period because we assume that financial markets are underdeveloped, especially in the rural and informal urban sectors. Lack of collateral or a credit history (and incomplete markets) prohibits borrowing such that in every period the value of assets A_t plus expected income y_t should be larger than consumption c_t and the optional cost of migration κ (which is positive only if a household decides to move, zero otherwise).

$$A_t + y_t - c_t - \kappa_t \geq 0 \tag{3.1}$$

Income y_t depends on the previous period 'portfolio' choice $z_{t-1} \in \{0, 1\}$ of the household which corresponds to a choice of sector and hence of location. [9] We call $z = 1$ rural and $z = 0$ urban. Because each location has a perfectly competitive sector people can always find employment in the city: either formal or informal. [10] We assume additionally that each sector faces a different degree of aggregate (multiplicative) income risk. Income is therefore a function of exogenous shocks taking place in the rural sector $\epsilon_t \sim N(1, \sigma_\epsilon^2)$ with unit mean and variance σ_ϵ^2 and in the urban sector $\eta_t \sim N(1, \sigma_\eta^2)$, with known joint

[7] We will not distinguish between migration of a single worker or of a household since we rely on aggregate data.

[8] This section builds heavily on a standard risk and insurance model with a precautionary savings motive (as in Mirrlees, 1965; Deaton, 1991), see Bardhan and Udry (1999). In these models households make choices between different investments with different risk and return. Here we add the possibility that location is a choice and that each location promises a different stream of income.

[9] We could also make this choice continuous. In that case the household chooses its distance to the nearest city and thus access to an external market with means of diversification, but this would not change our main results. See for example Brueckner and Zenou (1999) for an urbanization model with a land market.

[10] We abstract from any unemployment benefits.

density function $f(\epsilon, \eta)$. Income thus also depends on the previous-period location choice z_{t-1}: $y_t = y(z_{t-1}, \epsilon_t, \eta_t)$. Income is increasing in the size of the shocks: $\partial y_t / \partial \epsilon_t > 0$ if $z_{t-1} = 1$ and 0 otherwise and $\partial y_t / \partial \eta_t > 0$ if $z_{t-1} = 0$ and 0 otherwise.[11] Income is increasing in the choice of the rural sector in good rural times ($\partial^2 y_t / \partial \epsilon_t \partial z_{t-1} > 0$), but decreasing if the urban sector enjoys good times ($\partial^2 y_t / \partial \eta_t \partial z_{t-1} < 0$). It is therefore crucial to form expectations on the relative riskiness of both sectors to make a choice of location. We assume that the urban sector is less risky such that $\sigma_\eta^2 < \sigma_\epsilon^2$.

Households maximize a discounted flow of expected utility from consumption subject to their budget constraint, where r_t is the rate of return on assets:

$$\max_{c_t, z_{t+1}} E_t \sum_{\tau - t}^{T} \beta^{\tau - t} u(c_\tau) \tag{3.2}$$

$$s.t.\ A_{t+1} = (1 + r_t)(A_t + y_t - c_t - \kappa) \tag{3.3}$$

Households are risk averse so $u' > 0$, $u'' < 0$ and $\lim_{x \to 0} u'(x) = +\infty$. Households therefore aim to smooth consumption over time. The corresponding period t value function is given by:

$$\begin{aligned} V_t(A_t + y_t) = \max_{c_t} \{ & u(c_t) + \beta E_t V_{t+1}[(1 + r_t)(A_t + y_t - c_t - \kappa) \\ & + y(z_t, \epsilon_{t+1}, \eta_{t+1})] + \lambda_t (A_t + y_t - c_t - \kappa) \} \end{aligned} \tag{3.4}$$

where λ_t is the multiplier associated with the liquidity constraint. The current value of assets and income equals the maximum of current utility from consumption plus the discounted value of future assets and income. Maximization yields:

$$u'(c_t) = \beta E_t V'_{t+1}[(1 + r_t)(A_t + y_t - c_t - \kappa) + y(z_t, \epsilon_{t+1}, \eta_{t+1})] + \lambda_t \tag{3.5}$$

The household also chooses the location one period before as a form of ex-ante risk insur-

[11] Only if rural and urban shocks are uncorrelated. If they are imperfectly positively correlated then a rural shock might also affect urban income, but less so than an urban shock of equal magnitude.

ance. Using the envelop theorem we have:

$$E_{t-1}\frac{dV_t'(\cdot)}{dz_{t-1}} = E_{t-1}u'(c_t)\frac{\partial y}{\partial z_{t-1}} = 0 \tag{3.6}$$

$$\iff E_{t-1}[\beta(1+r)V_{t+1}'(\cdot) + \lambda_t]\frac{\partial y}{\partial z_{t-1}} = 0 \tag{3.7}$$

If the liquidity constraint 3.1 never binds ($\lambda_t = 0$), the location is chosen such that there is no incentive to move

$$E_{t-1}V_{t+1}'(\cdot)\frac{\partial y}{\partial z_{t-1}} = 0 \tag{3.8}$$

but if it does bind and $\lambda_t > 0$ households chose z_{t-1} such that (rewriting eq. 3.7)

$$E_{t-1}\beta(1+r)V_{t+1}'(\cdot)\frac{\partial y}{\partial z_{t-1}} = -E_{t-1}\lambda_t\frac{\partial y}{\partial z_{t-1}} \gtreqless 0 \tag{3.9}$$

The last inequality holds only when the liquidity constraint binds, which is when either shock is negative (meaning smaller than 1) but not equal to each other. We look at the short run effects of large shocks rather than the long run effects when shocks are expected to be at their mean of 1. Volatility is then interpreted as a higher chance of receiving a shock that is so large that all savings are diminished. Households will want to avoid being put in that situation. If the household lives and works in the city ($z_{t-1} = 0$) and the shock is sufficiently bad ($\eta_t << 1$) such that the liquidity constraint binds we have that $\partial y/\partial z_{t-1} > 0$. Households could improve utility by moving to the countryside if they expect the constraint to bind: $-E_{t-1}\lambda_t\frac{\partial y}{\partial z_{t-1}} < 0$. Conversely, if $z_{t-1} = 1$ (rural) and $\epsilon_t << 1$ (bad rural year) we have that $\partial y/\partial z_{t-1} < 0$ and thus that $-E_{t-1}\lambda_t\frac{\partial y}{\partial z_{t-1}} > 0$. In that case the urban sector would be better if households expect the constraint to bind. If both shocks are of equal size they cancel, and we are back in the situation of equation 3.8 where there is no incentive to move.

Three insights arise: the more likely it is that the liquidity constraint binds, the more likely households will be able to improve consumption and utility by migrating to the area where they expect shocks to be smaller. Secondly, since the variance of shocks to the rural sector was assumed to be larger than the variance of shocks to the urban sector, we have that rural households are more likely to suffer an adverse shock that is large enough to hit the liquidity constraint. They will migrate to the urban area. Without modern sector job growth this leads to an increase in the informal sector (for given wages) and a lower expected urban wage which is the balancing force. Thirdly, if both shocks are equal in size we have that $\partial y / \partial z_{t-1} = 0$. Then no improvement can be gained from migrating, even if households hit a liquidity constraint. This is the case if the covariance of both shocks equals 1.

In our three sector model we can write household income y_t as:

$$y_t(z_{t-1}, \epsilon_t, \eta_t) = z_{t-1} w_{R,t} \epsilon_t + (1 - z_{t-1})(e_t w_{M,t} + (1 - e_t) w_{I,t}) \eta_t \tag{3.10}$$

where the w_j ($j = R, M, I$) are sectoral wage rates and e_t is the share of urban labor employed in the modern sector, which are all taken as given by the household. The wage rate in the modern sector is higher than the wage in the informal sector. This may be due to for example minimum wage legislation, trade unions, efficiency wage or the need for specific human capital in the modern sector, but is not modeled explicitly. [12] Excess labor supply in the urban area is absorbed by the informal sector. The expected urban wage (second element in equation 3.10) is therefore the probability-weighted income of the informal and the modern sector.

With a non-binding liquidity constraint (3.8) becomes:

$$E_{t-1} V'_{t+1}(\cdot)(w_{R,t} \epsilon_t - (e_t w_{M,t} + (1 - e_t) w_{I,t}) \eta_t) = 0 \tag{3.11}$$

which is satisfied if the expected rural wage equals the expected urban wage and corresponds to a classic Harris-Todaro (1970) equilibrium migration equation. If however shocks are adverse enough to exhaust all assets such that the liquidity constraint binds, we have that:

$$\begin{aligned} E_{t-1} V'_{t+1}(\cdot)(w_{R,t} \epsilon_t - (e_t w_{M,t} + (1 - e_t) w_{I,t}) \eta_t) = \\ - E_{t-1} \lambda_t (w_{R,t} \epsilon_t - (e_t w_{M,t} + (1 - e_t) w_{I,t}) \eta_t) \gtreqless 0 \text{ if } \epsilon_t \lesseqgtr \eta_t \end{aligned} \tag{3.12}$$

[12] See for example Temple (2005) for an overview.

If $\epsilon_t < \eta_t$ and smaller than 1 it follows that the rural wage is smaller than the expected urban wage, corresponding to a negative marginal income to the location choice. The household could have improved income by decreasing z_{t-1}: moving to the urban sector. If however $\epsilon_t > \eta_t$ and $\eta_t < 1$, the reverse holds, and if both shocks are equally adverse we are back in the equilibrium setting. Within our assumption that the rural sector is more risky ($\sigma_\eta^2 < \sigma_\epsilon^2$) it follows that rural households are expected to face more severe shocks than urban households. Rural households can expect the liquidity constraint to bind in such volatile periods. The net direction of migration should therefore be from rural to urban areas. A crucial reason for this is the lack of financial instruments to insure against aggregate shocks (except some saving in the form of livestock for example). If such markets are available at all they will be more prevalent in urban areas (Collier, Gunning, 1999). Urban households will thus be better equipped to face downturns than their rural counterparts which reinforces the hypothesized direction of migration and hence urbanization. Urban growth due to migration should thus be positively influenced by volatility. Furthermore, the larger the urban informal sector, the lower urban growth because it depresses the expected urban wage. Positive wage growth in the urban modern sector will still induce faster urban growth.

The role of migration costs lies in the fact that risk aversion would induce a household to move independently from liquidity constraints. The premium a household would be willing to pay to get rid of risk depends on the functional form of utility, but is positive for risk averse households. Lower migration costs should induce more migration independently of shocks if they fall below the utility costs of risk. In long-run equilibrium when shocks are of mean size and no one has an incentive to move this means that the cost of migration is equal to the risk premium. We therefore include proxies such as the density of the road network, a decolonization dummy, and the polity index to capture changes in costs and migration restrictions in the regressions. Furthermore, if households have to sell off assets such as land to afford migration, they may be locked in when they arrive in cities (or slums) until they have accumulated enough assets again.

4 Estimating the effect of risk on urban growth

Our work builds on the work by Brueckner (1990) who specifies a monocentric-city model with rural-urban migration. He finds an important positive effect of the urban to rural income ratio on both urban population levels and growth rates but is limited to a cross-section of 24 developing countries, as are Becker and Morrison (1988). Moomaw and Shatter (1996) estimate a larger panel sample of countries. The most robust finding is that countries with a higher share of industry labor are more urbanized, supporting that view that urbanization takes place as a country transitions from an agricultural to an industrial base. If technological progress drives city growth through the industrial sector as simulated in Kelley and Williamson (1984) then urban income may continue to outpace rural income. Davis and Henderson (2003) estimate a 5 year panel from 1960 to 1995 and find that a shift out of agriculture to industry and the policies that affect this lead to urbanization. For example, planned economies such as China tend to restrict migration, and policy may affect the sectoral composition through for example import substitution programs.

The above mechanisms form plausible explanations for city growth but rely implicitly on economic growth of the urban manufacturing sector to generate a rural-urban income gap and sectoral transition. Why would some countries still urbanize if growth is absent? We add to the literature by focusing on risk and the hypothesized migration reaction of rural households and include macroeconomic volatility as an explanatory variable. We also extend the panel to 2005 and update the estimation techniques (see section 6).

As a starting point we take the specification in Davis and Henderson (2003) based on Brueckner (1990). In equilibrium the national urban population L^u_{it} for country i and year t (5-year intervals) is given by:

$$\ln L^u_{it} = \delta_0 \ln L_{it} + \delta_1 X_{it} + \gamma_i + e_{it} \tag{4.1}$$

where L is total population. The X_{it} include measures that should capture the country's state of development, rural-urban differences in public service provision, democracy and infrastructure which may affect migration costs, urban cost of living which is affected by local population and level of development, and ideally measures of the expected urban and rural wages. The γ_i capture fixed unobserved country characteristics and the e_{it} is the error term which may be autocorrelated within countries due to the high persistence of our variables.

However, we will not assume that countries are in equilibrium every 5 years and rather focus on changes. Our core message is that volatility is a strong destabilizing force which influences the speed of urbanization rather than the level. Volatile countries are not necessarily more or less urbanized, but volatile periods will induce more rural-urban migration. Our main specification is therefore given by:

$$\ln L^u_{i,t+1} - \ln L^u_{i,t} = \beta_0(\ln L_{i,t+1} - \ln L_{it}) + \beta_1 Z_{it} + \beta_3 \sigma_{it} + \gamma_i + e_{it} \tag{4.2}$$

where the Z_{it} contain the (ln) initial urbanization rate as a measure of the state of development (which is also highly collinear with initial (ln) GDP per capita), plus allows urbanization to influence itself if migration leads to more migration. $\beta_3\sigma_{it}$ denotes the effect of output per capita growth volatility and is our core variable of interest. We assume that households form expectations at the beginning of every period t on the volatility between t and t+1, and decide to move or not at time t. Average GDP per capita growth is included to capture the effects of economic development and the transition process (including changes to the urban-rural wage gap if growth, as is often assumed, originates in cities). An interaction term between volatility and average growth is added to see if the effects of risk are higher when growth is negative. Negative growth should make shocks worse for credit constraint households. In robustness tests we will also include an index of democracy and authoritarian rule (polity index), the state of infrastructure (road density), a dummy for independence because also colonialism limited migration, and change in average rainfall as a proxy for changes in agricultural productivity. Financial development (as proxied by domestic credit % GDP) captures the extend to which markets are complete and the degree to which households have access to financial services: the higher this number, the less likely it is that credit constraints ever bind, and the less volatility should affect urban growth. The panel structure of our data allows us to let all variables change over time and moreover to control for country fixed effects. We observe the level of urbanization and thus urban population growth only every 5 years, but are able to regress this on level country characteristics at the start of the period, and changes which happen during the 5 year period. See the appendix for detailed variable definitions and their sources.

A caveat is that we introduce a lagged dependent variable by regressing urban population growth on the initial level of urbanization.[13] Equation 4.2 can be rewritten as $\ln L^u_{t+1} = 1 * \ln L^u_t + \beta_1 \ln L^u - (\beta_1 + \beta_2) \ln L + \beta_2 \ln L_{t+1} + ... + \gamma_i + e_{it}$. Nickell (1981) showed that the coefficient β_1 is in this case measured with bias in both OLS and FE regressions if initial urban population is correlated with the country fixed effects. Estimators such as Arellano and Bond (1991) and Blundell and Bond (1998) should be able to solve for this bias by first differencing the system to get rid of the fixed effects and using lags as instruments. Davis and Henderson (2003) used these methods as a form of IV. Recent developments have made the estimators more reliable, see for example Windmeijer (2005) and Roodman (2006).

5 Estimating the effect of resource production on aggregate volatility

The drawback is that we have to rely on aggregate data to estimate the effect of volatility on urban growth. Although we would have liked to use shocks to rural versus urban GDP, no such data exists, so we have to extend the estimation with aggregate explanatory variables for aggregate output per capita shocks. We will show that volatility originates mostly in rural activities such as export of natural resources, including food, and in shocks to value added in the agricultural sector. We estimate the following equation

[13] This also occurs in Brueckner (1990) and Fay and Opal (2000) but is not addressed.

where we assume that resource production is a rural activity:

$$\sigma_{it}^{GDP/cap.} = \sigma_{it}^{resources} + R_{it} + \tilde{e}_{it} \tag{5.1}$$

where $\sigma_{it}^{GDP/cap.}$ is the 5-year standard deviation of output per capita growth rate regressed on $\sigma_{it}^{resources}$, the 5-year standard deviation of growth rates in natural resource export values, and R_{it}, a control matrix with initial dependence of GDP on resource exports at time t and possible other correlates with $\sigma_{it}^{GDP/cap.}$ such as rainfall shocks, financial development, a civil war dummy which happened all too often in many African countries, a measure of remoteness and openness to trade which allows export diversification to absorb sectoral shocks. Rainfall volatility allows us to distinguish between value added and export value shocks which incorporate price shocks, and nature shocks.

We can never use the world price indices for resource exports directly because they consist of a basket of export products. The weights of each product does not correspond to the composition of our export variables for every country. We assume instead that supply is very inelastic and changes slowly because mines or plantations cannot be expanded in the short run. Shocks to changes in export value should then be interpreted as price shocks rather than quantity shocks.

Because resource exports are exported through ports, through cities, one could object and question whether much of the price movement actually affects the non-urban sector. Alternatively, we estimate the similar equation:

$$\sigma_{it}^{GDP/cap.} = \sigma_{it}^{sector\ growth} + R_{it} + \tilde{e}_{it} \tag{5.2}$$

where $\sigma_{it}^{sector\ growth}$ is the 5-year standard deviation of growth rates in various sectors. We assume that the manufacturing sector is a purely urban activity, while the agricultural sector (and the mining sector) are purely rural activities. We will show that shocks to the agricultural sector do affect aggregate volatility, while shocks to manufacturing have much less effect.

6 Panel evidence from 1960 to 2005

6.1 Urban growth and volatility

We start our estimation by performing simple OLS and FE regressions on our baseline equation 4.2 presented in Table B.1. For a sample of 108 countries from 1960 to 2005 we find that volatility significantly affects urban population growth, even after controlling for fixed (country) unobservable covariates, and the level of development as captured by initial urbanization [14] , average growth rate of GDP per capita and population growth during the same period. The errors are robust to heteroskedasticity and clustered by country because we find significant autocorrelation in the errors. [15]

In the third column we test for an interaction term between volatility and average GDP/capita growth. The size and significance of the resulting marginal effect of volatility cannot be read from the table because it depends on average growth and covariances. We represent the effect graphically in Figure B.1, which clearly shows that the marginal effect of volatility on urban growth is significant for negative average economic growth rates. This confirms our hypothesis that shocks to income have an important effect on rural-urban migration, especially when economic growth is slow or negative which is when liquidity constraints bind more often. A country such as Brazil for example, with average GDP per capita growth rate of only -0.5% per year between 1980 and 1985, could have had negative urban growth rate as jobs disappear. However, volatility during this period was 4.8% leading to fast urban growth of 5.6% over the period. In Niger during the same period urban growth was even 7.9%, although GDP per capita growth was declining at 3.4% per year! Volatility in this case was also 7.9%. This may explain continued urbanization even

[14] We experimented also with initial ln GDP/capita instead but this gave worse fits and was often insignificant in addition to being highly collinear with the initial level of urbanization.
[15] We deleted 4 outliers which had average GDP/capita growth rates of a staggering 18% *per year* or more during a 5 year interval (Haiti '65-'70, Ghana '65-'70, Equatorial Guinea '95-'05). The sample of countries included is listed in Table B.3. Small island nations did not bias the results.

without economic growth.

6.2 *Volatility, agriculture and natural resources*

Next we explore the source of macroeconomic volatility by looking at natural resource exports and fluctuations in sectoral value added growth rates. Note that this constrains our sample size and for example excludes the 1960s. The first two columns in Table B.2 regress 5 yearly observations of volatility on the standard deviation of resource export value growth rates, and in column 2 with controls for initial dependence. The agricultural effect seems much weaker than the effect of fuels and ores. However, when we add interactions between initial dependence and subsequent 5-year volatility we see that there is a strong effect of agricultural products. Countries with high volatility in food and agricultural materials export values have also more aggregate volatility if their GDP depends on these export earnings, making them more risky.

Columns 4 and 5 instead focus on three sectors: manufacturing, which we assumed is an urban activity, and agriculture (including plantations) and mining, which are large employers outside cities.[16] The last column shows that countries with relatively large agriculture and mining sectors are more volatile. Controlling for the relative importance of each sector in the economy we find that mainly fluctuation in the growth rate of value added of agriculture leads to aggregate shocks. The effect is twice as large as a shock to manufacturing sector growth. This confirms that rural sectors are more risky than urban sectors. It may well be that risk from rural production leads to aggregate risk which is positively associated with rural-urban migration. The export data explains less of the variation in aggregate volatility. It is likely the case that most natural resources are exported through ports in cities and exporting firms may have more access to external

[16] We also observe sector data for the categories transport, construction, retail, and 'other' which includes many services. However, only for the three used can we make a plausible distinction between urban and rural activities. The mining variable never works well, probably because it also includes utilities, which are urban rather than rural.

finance. Fluctuation in the value added of sectors may better reflect the inherent risk of these sectors and have larger effects on aggregate risk because it also includes producers for the local market.

The next section will test the robustness of these results and try to tackle the bias in the lagged dependent variable and endogeneity issues.

7 Endogeneity and robustness

7.1 Robustness: volatility and urban growth

There are strong reasons to believe that the regressions in Table B.1 suffer from omitted variable bias. First of all it might be that volatility really consists of shocks around a positive growth rate instead of reflecting positive as well as large negative shocks. One large positive shock might cause urban growth by itself and have less to do with risk. We therefore replace the volatility measure with one that is based on only those yearly periods where average growth was positive. [17] The higher this measure, the larger were the positive growth rates. It has no effect, while its converse, based on negative growth rates has a strong negative effect as expected. [18]

In the second column we add changes in average rainfall. Barrios et al (2006) found a strong correlation between rainfall and levels of urbanization, but we cannot confirm that it has any affect on urban growth. The polity index which is increasing in democratization and decreasing in authoritarian rule has no impact although Davis and Henderson (2003) did find political effects on primacy (the degree to which urban population is concentrated in one city). Infrastructure investments, which also decrease migration costs by unlocking

[17] This requires a minimum of two positive growth rates within each 5 year period.
[18] We reported only the positive measure because the negative measure is a much smaller sample requiring at least two negative growth rates within each 5 year period.

remote areas, as captured by the length of the road network as a share of country surface area, have a positive but insignificant effect. The independence dummy does show up significant: independence from colonial powers lifted old bans on migration and led to urban growth (Barrios et al., 2006). Including financial development improves the precision with which we measure the effect of volatility on urban growth but has no direct effect. Our main result that volatility affects urban growth is significant, even in this smaller sample and with all our robustness checks. [19]

Columns 3 to 6 explore heterogeneity in the effect of volatility on urban growth by dividing countries along the lines of their 1965 level of development, fuel and mining dependence and 1965 level of financial development. As expected, urban growth in OECD countries is not affected by volatility: they are too developed, even though the standard error reflects some heterogeneity within the OECD. [20] The 1965 level of development (as measured by quartile of GDP per capita) does not change the significant effect of volatility on urban growth. Fuel exporting countries also do not urbanize more than other countries in response to volatility, but mining dependent countries urbanize much faster than non-fuel and non-mining dependent countries in volatile times (measured by top decile of average dependence). Households in countries such as Zambia where up to 50% of GDP consists of copper exports appear to be much more vulnerable to risk outside cities: they migrate to urban centers. Finally, the least financially developed countries urbanize much faster than other countries in volatile periods, which is also consistent with lack of instruments for insurance. We always find an effect of volatility on urban growth, even after dividing countries along these lines.

[19] We did not include time dummies because this would assume shocks to urban growth common to all one-hundred countries which we consider to be unlikely.

[20] For example, an interaction between Mexico and volatility yields a positive but insignificant interaction term.

Endogeneity and lagged dependent variable bias

Table B.5 aims to tackle two problems at once. First we have to deal with the lagged dependent variable bias in the initial level of urbanization, by first differencing the equation to get rid of the fixed effect and using lagged levels as instruments. Table B.1 already predicted that the true value should be in between the OLS estimate which is biased upwards and the FE estimate which is biased downwards. This yields a range of -0.063 to -0.117 (Nickell, 1981). Secondly, we follow Davis and Henderson (2003) and use the difference GMM estimators (see further down) as an IV strategy.

There are several assumptions that have to be met before we can use lagged equations as valid instruments for current differenced equations. In Arellano and Bond (1991) [21] the errors should not be serially correlated of order 2 or more ($E[e_{is}e_{it}] = 0$ for $s \neq t$), we need predetermined initial conditions ($E[\ln L^u_{i1} e_{it}] = 0$ for $t = 2, ..., T$) and $E[\gamma_i] = E[e_{it}] = E[\gamma_i e_{it}] = 0$. [22] We use lagged initial urbanization as an instrument for current urbanization while assuming that passed levels have no direct effect on current growth rates. In effect we will use lags of order 3 or more meaning that variables dated 15 years earlier are used as instruments. A serious problem with this method is that β_0 might be close to zero. This means that the urban population changes relatively slowly from year to year and is thus very persistent. β_0 then contains little predictive information about next year's urban size and is too weak as an instruments for urbanization, even if it is exogenous. In finite samples this problem is even more severe and may bias the estimate of the lagged dependent variable's coefficient downward and even below the FE estimate. Blundell and Bond (1998) proposed to expand the instrument set by including additional moment

[21] We refer to this method as difference-GMM (DGMM).

[22] We do not require the initial conditions to be strictly exogenous which would require $E[\ln L^u_{i1} e_{it}] = 0$ $\forall t$. Strict exogeneity of all variables would result in a consistent within estimate for large N and T.

conditions: lagged first-differenced equations with the following additional assumption: [23]

$$E[\Delta \ln L^u_{i,t-1}, (\gamma_i + e_{it})] = 0 \text{ for } t = 3, ..., T. \quad (7.1)$$

All these assumptions can be tested with common Hansen/Sargan over-identification tests. Windmeijer (2005) provides corrected standard errors for the twostep version of system-GMM, which are otherwise too small. [24]

Columns 2 and 3 use difference GMM and show that both one and two step versions perform poorly: the lagged dependent coefficient is close or even below the FE estimate, although the two-step version improves precision of the volatility affect. [25] Column 4 is more successful in treating the weak instrument problem by expanding the instrument set. Both the Hansen and the Sargan tests are passed: one for the overall instrument set and one for the additional assumptions of SGMM. Since we found AR(2) in the errors we used the 3rd and 4th lag as instruments. These may be weaker instruments and have more trouble with predicting current volatility. Even so, the effect of volatility has become stronger and remains significant. Column 5 replaces the average aggregate growth rate with average growth rates in value added of agriculture and manufacturing as a control to test for the sector shift out of agriculture which is often the explanation for urbanization as in Davis and Henderson (2003). They both have the expected sign: growth of the manufacturing sector leads to urban growth and rural growth to urban decline, but they only slightly affect the volatility variable. Since these are unfortunately imperfect substitutes for rural and urban GDP they do predict urban growth imprecisely, in addition to restricting the sample which explains why many standard errors have increased.

[23] We refer to this method as system-GMM (SGMM).

[24] Both DGMM and SGMM have one- and two-step versions which refers to the method of estimating the weight matrix for GMM. One-step requires the assumption of homeskedastic e_{it} disturbances, but two-step estimation tends to deflate the standard errors. We use the identity matrix as an initial guess for the covariance matrix of idiosyncratic errors as in Blundell and Bond (1998). We always cluster the errors by country to allow for autocorrelation within countries and perform a small sample correction. See Bond (2002) for an overview.

[25] All estimations treat all regressors as endogenous but predetermined except changes in rainfall and the independence dummy.

Volatility has a significant and robust positive effect on urban growth even when instrumented with lagged values. An economy with more risk seems to induce larger flows of migration towards cities. It is in cities that there lies hope of improving living conditions because they offer a more diverse demand for labor. More importantly, risk and large shocks may well force households to give up on the countryside if such shocks exhaust their buffer savings. In the next section we show that aggregate shocks originate mostly from the agriculture sector and non-urban natural resource exports.

7.2 Robustness: explaining volatility

We turn to the origins of volatility and use a similar strategy as above except that we do not have to worry about a lagged dependent variable. We first look at natural resource export value and shocks therein. In Table B.6 we split resource exports into 4 categories and look at both dependence and shocks to (ln) changes in export receipts. Furthermore we control for other likely determinants of volatility, such as financial development. More financially developed countries have more means to deal with shocks through insurance, futures contracts, etc, and liquidity constraints are less often binding. Openness and access to waterways[26] allows diversification into less volatile sectors, cushioning the aggregate effect. Civil war and rainfall shocks are added as other suitable and exogenous candidates to explain aggregate volatility in income. The results are that shocks to fuel prices are most significantly important, but shocks to export receipts of food products have a much larger effect. Among the controls only openness matters in this short-run panel. There might be too little time variation in the other variables to yield significant effects. These variables allow however for a smaller sample and we explain less variance in volatility than with sectoral data, which we use next.

[26] The average distance in a country to the nearest coast or waterway is the most robust geographical determinant of aggregate per capita output volatility in Malik and Temple (2005).

Column 1 in Table B.7 provides a better fit of the variation in volatility (where the R2 is adjusted for the number of variables). We find a significant effect of shocks to value added growth in agriculture, even while controlling for initial agriculture dependence, the average growth rate and natural rain shocks. Column 2 furthermore controls for fixed unobserved country effects which do not affect the results much. We have also added shocks to changes in government spending, as this may be heavily influenced by export earning through taxation, even though it is essentially a choice variable. It has a large impact on aggregate volatility, but the direction of causality may be the other way around. Also shocks to the terms-of-trade exert a significant effect. Adding the mining sector in column 3 does not matter: it is mostly risk in agriculture, most clearly a rural activity, that leads to aggregate volatility. We now do find some evidence of civil war leading to aggregate volatility in this case. Columns 4 and 5 perform one and two-step versions of the difference-GMM estimator (Arellano-Bond, 1991) where the two-step version's standard errors are corrected or finite sample bias.[27] One-step assumes homoskedasticity of the errors and yields almost identical results compared to relaxing this assumption in column 5. Using a set of lagged level instruments for the equation in first differences shows the robustness of the effects of the shocks to government spending volatility, terms-of-trade shocks and agricultural value added growth shocks. The Hansen tests confirm exogeneity of the instruments. Unfortunately, this IV strategy limits the sample we can work with and as a consequence the standard errors have increased somewhat. System-GMM can use more information which indeed yields a better estimate in column 6.

We can conclude that the determinants of aggregate volatility originate in the agricultural sector even after controlling for a broad set of possible covariates. Shocks to the manufacturing sector have little effect on aggregate volatility. This shows that the rural sector is much more risky than the urban sector, lending support to our explanation that

[27] Using also system-GMM would not give us an edge in this case because we do not have to deal with a lagged dependent variable. In both estimations all regressors are treated as endogenous and predetermined except rainfall volatility and the civil war dummy.

such a risk differential induces rural-urban migration.

8 Conclusion

This paper addresses the fact that many countries urbanize surprisingly fast even though economic growth is slow or negative. Negative growth is unlikely to create urban jobs, it does not raise urban wages nor does it increase earlier migrants' flow of remittances, which could all be powerful urban-pull factors from the perspective of poor rural households. We solve this puzzle by acknowledging that push factors are at least as important, especially when the economic circumstances are such that households cannot cope with negative shocks to income. Periods of aggregate volatility turn out to be strong predictors of urban growth, especially when GDP per capita growth is negative. The source of volatility lies in rural activities such as agriculture and natural resource production which are much more risky sectors than urban manufacturing. World resource prices are highly volatile (which is more important than rainfall), and financial instruments such as credit to deal with aggregate risk are all but absent in the countryside. Aggregate risk may be more important than a sectoral shift from agriculture to manufacturing and the parallel transition to urbanization for countries with poor economic performance. Unable to save or insure effectively, households are forced to migrate to cities to avoid being hit by large negative shocks as an ex-ante response to expected risk, because large shocks may wipe out any buffer savings easily.

We realize that many countries with very large cities, and slums, view urbanization as a problem. If that is justified in itself then rural development of credit institutions could decrease migration pressure on cities. On the other hand, it might also be that agglomeration economies can bring opportunities to fast urbanizing countries if these centers can be made attractive enough for start-ups and foreign investment. Future research using micro data should shed more light on these issues.

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A Data Sources

Category	Variable	Definition	Source
Population	urban population growth	5 year (ln) change in total urban population, national definition	UN (2005)
	ln urban population share	ln (total urban population / total population)	idem
	av. national population growth rate	5 year average of yearly total population growth rates	WDI (2006)
GDP	volatility GDP/cap. growth	5 year standard deviation of yearly GDP per capita growth rates (PPP, 2000 USD)	PWT 6.2 from Heston et al. (2006)
	volatility of positive shocks	idem, for those periods with at least 2 positive growth rates and positive average growth (PPP, 2000 USD)	idem
	average GDP/capita growth	5 year average of yearly GDP per capita growth rates (PPP, 2000 USD, Laspeyres)	idem
Resources	% export value/GDP	F.o.b. value of exports as a percentage of GDP. **Fuels** corresponds to SITC section 3 (mineral fuels). **Ores and Metals**: SITC divisions 27, 28, and 68 (nonferrous metals). **Agricultural Raw Materials**: SITC section: 2 (crude materials except fuels) excluding divisions 22, 27 (crude fertilizers and minerals excluding coal, petroleum, and precious stones), and 28 (metalliferous ores and scrap). **Foods**: SITC sections: 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels). (constant USD)	WDI (2006)
	export growth volatility	5 year standard deviation of yearly (ln) changes by export group.	idem
	volatility of exp. growth	idem	idem
	exp. av. growth	5-year average yearly (ln) changes by export group	idem
	price indices	yearly standard deviation of monthly price changes	UNCTAD (2007)
Sectors	sector % total va	Value added (value of output less the value of intermediate consumption) of sector as a % of total value added. **Manufacturing**: section D Manufacturing. **Agriculture**: Section A Agriculture, hunting and forestry and Section B Fishing. **Mining**: Section C Mining and quarrying, Section E Electricity, gas and water supply. (all ISIC Rev 3.1)	United Nations Statistics Devision, (2007)
	av. growth sector va	5 year average of yearly growth rate of total value added per sector,	idem
	volatility of sector va growth	5 year volatility of yearly growth rate of total value added per sector.	idem
Geography	% change in average rainfall	Change in ln average 5 year rainfall from last 5 year period.	Mitchell et al. (2002)
	volatility of rainfall	5 year standard deviation of yearly rainfall data.	idem
	road density	Roads (km) / land (km2)	International Road Federation and WDI (2006)
	distance to coast or waterway (100km)	minimum distance in km, fixed effect	CID, General Measures of Geography, (1999)

Institutions	polity index	Index of autocracy (-10) to democracy (+10)	Marshall et al. (2007)
	independence index	dummy = 1 if a country is independent	CIA World Factbook (2007)
	financial development	Domestic credit to private sector (% of GDP)	WDI (2006)
	openness dummy	open to trade = 1	Wacziarg and Welch (2003)
Other	civil war dummy next 5 years	dummy =1 if a country is in civil war during any year of the 5 year period	Sambanis (2000)
	volatility of government spending	5 year standard deviation of yearly (ln) changes in government spending	PWT 6.2 from Heston et al. (2006)
	volatility in terms-of-trade	5 year standard deviation of yearly imports share of exports	WDI (2006)

B Regression tables

Table B.1
Urban growth and volatility, 1960-2005

Dependent variable:	(1: OLS)	(2: FE)	(3: FE)	sample means
5-year urban population growth				18.15%
volatility GDP/cap. growth	0.317**	0.254**	0.221*	3.93%
	(0.126)	(0.125)	(0.121)	
log urban population share	-0.063***	-0.117***	-0.117***	-1.08 = log(.34)
	(0.007)	(0.018)	(0.018)	
Average GDP/capita growth	0.309**	0.160	0.536***	1.76%
	(0.151)	(0.118)	(0.165)	
av. national population growth rate	1.168***	1.029***	1.031***	9.96%
	(0.074)	(0.083)	(0.078)	
constant	-0.021**	-0.061***	-0.064***	
	(0.009)	(0.021)	(0.020)	
volatility * average GDP/cap. growth			-5.308**	
			(2.318)	
Observations	861	861	861	
Adj. R2	0.64	0.43	0.45	
countries	108	108	108	

Robust and country-clustered standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

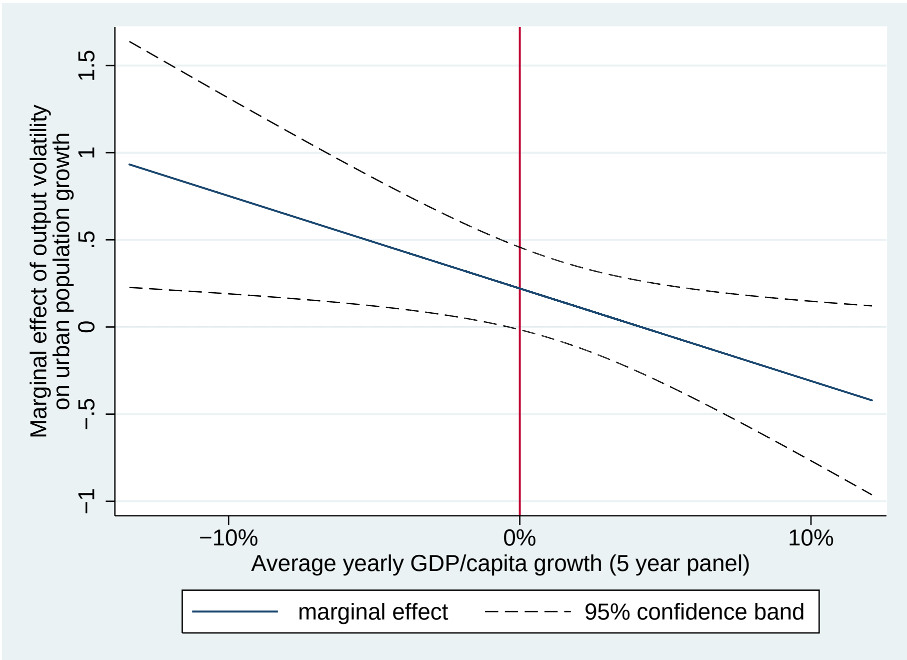

Fig. B.1. Marginal effect of volatility on urban population growth for given average growth rates, 1960-2005

Table B.2
Volatility and natural resources (exports and national value added)

Dependent variable:	(1: OLS)	(2: OLS)	(3: OLS)	(4: OLS)	(5: OLS)
5-year volatility of GDP/capita growth		(exports)		(sectors)	
volatility of fuel and ores exp. growth	0.094*	0.107*	0.110*		
	(0.055)	(0.054)	(0.056)		
volatility of food and agr. exp. growth	0.496**	0.295	0.161		
	(0.217)	(0.206)	(0.156)		
% fuel and ore export value/GPD		0.063***	0.079***		
		(0.017)	(0.028)		
% food and agr. export value/GPD		0.034	-0.023		
		(0.024)	(0.027)		
fuel and ore volatility * dependence			-1.066		
			(1.339)		
food and agr. volatility * dependence			6.180***		
			(2.292)		
volatility of agri. va growth				0.073***	0.082***
				(0.020)	(0.019)
volatility of mining va growth				0.016	0.009
				(0.010)	(0.008)
volatility of manuf. va growth				0.073***	0.041**
				(0.026)	(0.020)
agriculture % total va					0.062***
					(0.013)
mining % total va					0.086***
					(0.018)
manuf. % total va					-0.004
					(0.016)
constant	0.025***	0.019***	0.021***	0.014***	0.000
	(0.003)	(0.002)	(0.002)	(0.003)	(0.005)
Observations	632	593	593	731	731
Adj. R2	0.05	0.09	0.10	0.17	0.27
countries	99	99	99	105	105

Robust and country-clustered standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table B.3
Countries included in the sample of Table B.1

Algeria	Congo, Dem. Rep.	Haiti	Mauritius	Senegal
Argentina	Congo, Rep.	Honduras	Mexico	Singapore
Australia	Costa Rica	Hong Kong, China	Morocco	South Africa
Austria	Cote d'Ivoire	Iceland	Mozambique	Spain
Bangladesh	Cyprus	India	Namibia	Sri Lanka
Barbados	Denmark	Indonesia	Nepal	Sweden
Belgium	Dominican Republic	Iran, Islamic Rep.	Netherlands	Switzerland
Benin	Ecuador	Ireland	New Zealand	Syrian Arab Republic
Bolivia	Egypt, Arab Rep.	Israel	Nicaragua	Tanzania
Botswana	El Salvador	Italy	Niger	Thailand
Brazil	Equatorial Guinea	Jamaica	Nigeria	Togo
Burkina Faso	Ethiopia	Japan	Norway	Trinidad and Tobago
Burundi	Fiji	Jordan	Pakistan	Turkey
Cameroon	Finland	Kenya	Panama	Uganda
Canada	France	Korea, Rep.	Papua New Guinea	United Kingdom
Cape Verde	Gabon	Lesotho	Paraguay	United States
Central African Republic	Gambia, The	Luxembourg	Peru	Uruguay
Chad	Ghana	Madagascar	Philippines	Venezuela, RB
Chile	Greece	Malawi	Portugal	Zambia
China	Guatemala	Malaysia	Puerto Rico	Zimbabwe
Colombia	Guinea	Mali	Romania	
Comoros	Guinea-Bissau	Mauritania	Rwanda	

Table B.4
Robustness, urban growth, volatility and heterogeneous effects

Dependent variable: **5-year urban pop. growth**	(1: FE)	(2: FE)	(3: FE)	(4: FE)	(5: FE)	(6: FE)
volatility of positive shocks	0.159					
	(0.192)					
volatility GDP/cap. growth		0.477**	0.512**	0.287**	0.246**	0.344***
		(0.206)	(0.211)	(0.125)	(0.122)	(0.115)
OECD countries * volatility			-0.600**			
			(0.266)			
min 1965 quart. GDP/cap. * volatility				0.364		
				(0.323)		
top 1965 quart. GDP/cap. * volatility				0.142		
				(0.123)		
top dec. av. fuel exp. * volatility					-0.241	
					(0.256)	
top dec. av. ores exp. * volatility					0.730***	
					(0.262)	
min 1965 quart. fin.dev. * volatility						0.681**
						(0.334)
top 1965 quart. fin.dev. * volatility						-0.317
						(0.198)
log urban population share	-0.117***	-0.150***	-0.148***	-0.150***	-0.151***	-0.145***
	(0.019)	(0.028)	(0.029)	(0.028)	(0.028)	(0.029)
Average GDP/capita growth	0.022	0.428***	0.423***	0.417***	0.399***	0.432***
	(0.123)	(0.138)	(0.137)	(0.136)	(0.133)	(0.132)
av. national population growth rate	1.037***	1.146***	1.151***	1.195***	1.193***	1.284***
	(0.091)	(0.082)	(0.084)	(0.117)	(0.114)	(0.150)
financial development		0.008	0.006	0.010	0.008	0.007
		(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
% change average rainfall		-0.006	-0.008	-0.008	-0.003	-0.003
		(0.014)	(0.014)	(0.015)	(0.016)	(0.015)
polity index		0.000	0.000	0.000	0.000	0.000
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
road density		0.022	0.019	0.022	0.019	0.022
		(0.024)	(0.023)	(0.023)	(0.023)	(0.022)
independence index		0.026***	0.027***	0.027***	0.028***	0.028***
		(0.007)	(0.007)	(0.007)	(0.006)	(0.007)
constant	-0.052**	-0.148***	-0.143***	-0.153***	-0.151***	-0.158***
	(0.020)	(0.027)	(0.027)	(0.026)	(0.023)	(0.025)
Observations	796	522	522	522	522	522
countries	108	100	100	100	100	100
Adj. R2	0.41	0.55	0.55	0.55	0.56	0.56

Robust and country-clustered standard errors in parentheses. *'65 quart.* = quartile range in 1965; *dec. av.* = decile range in 1965 of variable's long term average export share of GDP.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table B.5
Robustness, urban growth and volatility

Dependent variable:	(1: FE)	(2: DGMM)	(3: DGMM)	(4: SGMM)	(5: SGMM)
5-year urban pop. growth		one-step	two-step	two-step	two-step
volatility GDP/cap. growth	0.477**	0.441**	0.400**	0.529**	0.549*
	(0.206)	(0.220)	(0.200)	(0.209)	(0.284)
log urban population share	-0.150***	-0.165***	-0.144***	-0.075***	-0.101***
	(0.028)	(0.039)	(0.043)	(0.024)	(0.025)
Average GDP/capita growth	0.428***	0.223	0.238	0.246*	
	(0.138)	(0.158)	(0.168)	(0.134)	
av. national population growth rate	1.146***	1.088***	1.168***	1.266***	1.233***
	(0.082)	(0.177)	(0.129)	(0.202)	(0.155)
financial development	0.008	-0.016	-0.010	-0.011	0.003
	(0.011)	(0.023)	(0.028)	(0.020)	(0.016)
% change average rainfall	-0.006	0.008	0.001	0.002	0.011
	(0.014)	(0.011)	(0.010)	(0.011)	(0.012)
polity index	0.000	0.001	0.001	0.001	0.002
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
road density	0.022	0.056	0.024	0.011	0.015
	(0.024)	(0.054)	(0.051)	(0.014)	(0.009)
independence index	0.026***	0.001	-0.003	0.009	0.014
	(0.007)	(0.011)	(0.011)	(0.007)	(0.009)
av. growth agriculture va					-0.023
					(0.071)
av. growth manuf. va					0.047
					(0.074)
constant	-0.148***			-0.062*	-0.095**
	(0.027)			(0.037)	(0.038)
Observations	522	419	419	522	462
countries	100	92	92	100	98
Adj. R2	0.55				
Hansen overid. test p-value		0.7643	0.7643	0.5193	0.6356
Diff-Sargan overid. test p-value				0.306	0.370

Robust and country-clustered standard errors in parentheses.
Two-step GMM regressions include Windmeijer (2005) corrected s.e.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table B.6
Robustness, volatility and natural resource exports (value share of GDP)

5-year volatility of GDP/capita growth	(1: OLS)	(2: OLS)	(3: OLS)
volatility of food and agr. exp. growth	0.348		
	(0.217)		
food export growth volatility		0.489**	0.776*
		(0.238)	(0.400)
agr. r.m. export growth volatility		-0.103	-0.075
		(0.086)	(0.126)
volatility of fuel and ores exp. growth	0.071		
	(0.065)		
fuel export growth volatility		0.060***	0.065**
		(0.021)	(0.027)
ores export growth volatility		0.036	-0.046
		(0.045)	(0.063)
% fuel and ore export value/GPD	0.063***		
	(0.020)		
% fuel export value/GDP		0.060***	0.058***
		(0.015)	(0.012)
% ore and metal export value/GDP		0.087*	0.066
		(0.046)	(0.057)
% food and agr. export value/GPD	0.032		
	(0.023)		
% food export value/GDP		0.064**	0.047
		(0.031)	(0.035)
% agricultural r.m. export value/GDP		-0.055*	-0.008
		(0.029)	(0.031)
financial development	-0.007*		-0.004
	(0.003)		(0.004)
openness dummy	-0.010***		-0.009***
	(0.003)		(0.003)
distance to coast or waterway (100km)	0.000		0.000
	(0.000)		(0.000)
civil war dummy next 5 years	-0.000		-0.000
	(0.004)		(0.004)
volatility of rainfall	-0.000		-0.000
	(0.000)		(0.000)
constant	0.029***	0.017***	0.025***
	(0.004)	(0.002)	(0.005)
Observations	470	581	461
Adj. R2	0.17	0.13	0.21
countries	88	99	88

Robust and country-clustered standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table B.7
Robustness, volatility and natural resources (national value added)

Dependent variable:	(1: OLS)	(2: FE)	(3: FE)	(4: DGMM)	(5: DGMM)	(6: SGMM)
5-year volatility GDP/cap. growth				one-step	two-step	two-step
agriculture % total va	-0.023	-0.048	-0.045	0.060	0.057	0.028
	(0.015)	(0.029)	(0.036)	(0.062)	(0.073)	(0.034)
volatility of agri. va growth	0.042**	0.046**	0.050**	0.051*	0.046*	0.080**
	(0.020)	(0.021)	(0.021)	(0.026)	(0.027)	(0.033)
av. growth agriculture va	0.003	-0.014	-0.027	0.052	0.039	-0.020
	(0.023)	(0.023)	(0.024)	(0.059)	(0.064)	(0.048)
manuf. % total va	-0.038*	0.038	0.053	-0.025	-0.020	-0.002
	(0.020)	(0.030)	(0.035)	(0.095)	(0.111)	(0.050)
volatility of manuf. va growth	0.021	0.007	0.008	0.015	0.024	0.014
	(0.019)	(0.020)	(0.020)	(0.024)	(0.020)	(0.026)
av. growth manuf. va	0.014	0.046*	0.038	-0.044	-0.029	0.045
	(0.023)	(0.023)	(0.026)	(0.059)	(0.058)	(0.047)
financial development	-0.001	0.003	0.006	0.015	0.013	0.011
	(0.003)	(0.005)	(0.006)	(0.017)	(0.018)	(0.011)
openness dummy	-0.001	0.001	0.001	-0.001	-0.001	-0.003
	(0.003)	(0.004)	(0.004)	(0.008)	(0.009)	(0.005)
civil war dummy next 5 years	0.005	0.009	0.009*	0.005	0.004	0.005
	(0.004)	(0.005)	(0.005)	(0.007)	(0.009)	(0.010)
volatility of rainfall	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
volatility of government spending	0.208***	0.196***	0.197***	0.194***	0.195***	0.212***
	(0.039)	(0.048)	(0.048)	(0.057)	(0.063)	(0.047)
volatility in terms of trade	0.035**	0.050***	0.051***	0.049**	0.051**	0.016
	(0.015)	(0.014)	(0.014)	(0.021)	(0.021)	(0.023)
distance to coast or waterway	0.001*	0.000	0.000			0.000
	(0.000)	(0.000)	(0.000)			(0.001)
constant	0.016**	0.007	-0.002			-0.006
	(0.007)	(0.010)	(0.015)			(0.015)
mining % total va			0.060			
			(0.040)			
volatility of mining va growth			-0.006			
			(0.008)			
av. growth mining va			0.026			
			(0.021)			
Observations	538	538	528	442	442	538
Adj. R2	0.47	0.38	0.39			
countries	95	95	93	94	94	95
Hansen overid. test p-value				0.4668	0.4668	0.5782
Diff-Sargan overid. test p-value						0.201

Robust and country-clustered standard errors in parentheses in all regressions.
Two-step D-GMM includes Windmeijer (2005) corrected s.e.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$