Demographic Dividends in Africa:
Reconciling the Evidence with a Mixed Decomposition Approach

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ABSTRACT

The demographic dividend offers a strong theoretical argument for the effects of fertility transitions on economic development. Yet, empirical consensus on the magnitude of dividends remains limited by 1) the diversity in methods and frameworks used and 2) a scarcity of detailed data. We address these limitations in two ways. One is by conceptually distinguishing between the 'mechanical' versus 'substantive' components of the dividend. A second is through methodological integration of two analytic traditions –regression and accounting methods. Because regressions capture substantive influences while accounting methods capture mechanical influences, their integration -in the form of a mixed decomposition- gives a fuller picture. The method can be applied under rich data environments but also in more limited data environments. Its application to African settings circa 1980-2010 suggests the that for most countries where fertility fell a mechanical dividend that accounted for anywhere between 12% and 38% of the country's economic growth.

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INTRODUCTION

The thesis of a 'demographic dividend' has enriched population theory with a plausible rationale for why population change might affect economic growth (Bloom, Canning and Sevilla 2002). The argument seems fairly compelling: as birth rates fall (and before life expectancy subsequently rise), countries undergo a temporary period of low age-dependency that favors savings, investment and, ultimately, economic growth. Yet this thesis is beset by a lack a firm consensus on the evidence, notably whether the dividend is automatic, large, or how it depends on contextual conditions (Lam 2013; Lutz 2004). Importantly, these disparate findings often muddle policy advice to countries hoping to bank on their fertility transitions.

The question then, is whether the divergent findings represent a lack of scientific clarity on the impact of the dividend, or if, instead, they are the result of conceptual and methodological differences that may not be formally recognized. We make the argument for the latter. Conceptually, analyses of the dividend have not worked from a common and clear conceptual script spelling out the chain of processes leading from fertility change to economic growth. Some studies thus analyze the dividend in reduced-form, directly linking fertility and economic outcomes; others consider pathways in greater detail but do so recursively (Eloundou-Enyegue and Giroux 2012); more detailed investigations consider the feedbacks (Canning 2014; Moreland et al. 2014) or even the interplay between age structure and other social processes (PRB 2014). These and other perspectives further vary in their implicit assumptions about patterns of fertility decline, age-dependency, behavioral mechanisms, possible feedbacks, ripple effects, or redundancy with education effects (see Bongaarts 2006, Basu 2012, Mason and Lee 2005, Canning 2004; PRB 2014, and Lutz 2014, respectively).

Compounding these conceptual differences are methodological differences as well: dividend studies have employed a variety of approaches from causal regression, simulation, demographic projections, or national accounting (see Schultz 2005, Weil 2012, Moreland 200x, Mason and Lee 2005, respectively). Unless these differences between methods are clarified, findings are hard to reconcile. This paper attempts such reconciliation. Conceptually, we propose distinguishing between the 'mechanical' and 'substantive' components of a dividend. In clear, changes in dependency ratios affect economic outcomes via (1) a purely mechanical/ compositional effect (i.e., a simple shift in the percent of people found in the productive ages) and (2) a 'substantive/behavioral' effect stemming from the effects of age structure on economic behavior. The mechanical effect is automatic and easiest to estimate, and it gives a lower-bound estimate of the national dividend. We er to it as the 'm-dividend.' The second component is more contingent and harder to estimate reliably. It is erred to as the 's-dividend.' The total dividend is the sum of its mechanical and substantive effects.

Methodologically, and building on the conceptual distinction between mechanical vs. substantive components, we propose a mixed decomposition approach. This integrative strategy combines the strengths of regression and decomposition. So far, these two methodological traditions have been used separately to study the dividend, and they have different foci and strengths. Regression-based approaches are best at estimating substantive effects while decomposition approaches are best at capturing compositional influences. Their combination yields a fuller picture of the dividend.

The proposed mixed decomposition applies most easily in data-rich environments, where analysts have detailed *historical* information on age-profiles of economic behavior such as being sought in the global NTA project (NTA 2014). However, because most low-income countries lack this information, we suggest cruder alternatives using less detailed but more readily available statistics (World Bank 2014; Lee and Barro 2014). We apply the method to 24 African countries to document the magnitude and makeup of dividends. These empirical analyses are designed to answer two questions:

1. How much did national changes in age structure contribute to economic growth?
2. How large is the 'm-dividend' compared to the 's-dividend'?

Beyond answering these narrow empirical questions, the paper's review address broader debates currently waged about the dividend, namely whether it is automatic, large, and sustained. It also sheds lights on how one can reconcile seeming empirical discrepancies resulting from studies following different methodological orientations. The rest of the paper is structured as follows. First, we review dividend theory, focusing on its appeal but also its conceptual critiques. Then, we review existing methodological approaches, underscoring individual strengths and complementarities. Building on this assessment, we suggest integrating regression and decomposition approaches into a mixed decomposition approach. We apply this new approach to document the magnitude of the dividend across 24 African countries during the 1980-2010 period.

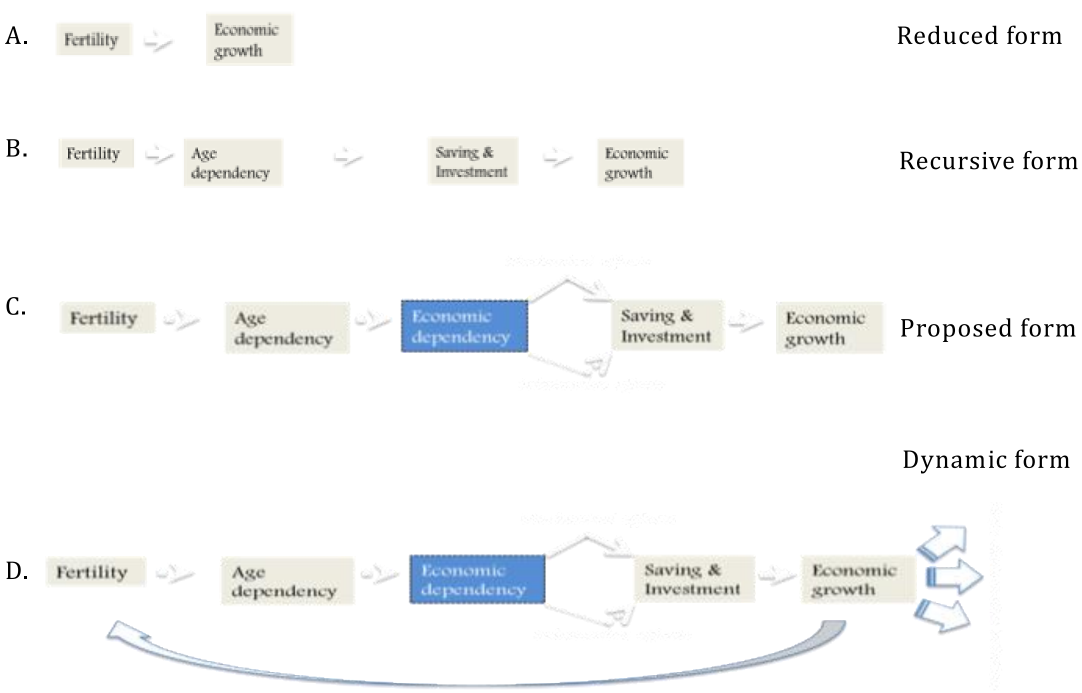
DIVIDEND THEORY

The theory of a demographic dividend, as formulated by Bloom et al. (2002) currently enjoys great popularity in scientific and policy circles.[2] Along with the acclaim, however, has come scrutiny. One early critique was over the narrow and rigid treatment of age-dependency. In its simplest formulation (Figure 1A), the theory rests on normative assumptions about the salience of the ages <15 and >64 as markers of dependency. This assumption of a universal, stable, and age-based definition of dependency overlooks widespread evidence of child work, extended schooling, adult unemployment, or delayed retirement (Basu 2012, Aboderin 2013, Guengant and Kamara 2012). The critique is not merely about the accuracy of a specific age threshold and, as such, it is not addressed by simply adopting new age thresholds. Instead it suggests that age-dependency is not a number, and calendar age not a marker of status. Rather, status is both relational and tied to key life events such as marriage, employment, nest-leaving, or parental death: For instance, orphanhood often thrusts children into parental roles without adequate resources or preparation. Conversely, many young adults are condemned to stay 'forever young' in the face of stiff barriers to employment and nest-leaving (Calves and Schoumaker 2004). Sociologically, transfers between the old and young follow cultural scripts that transcend a universal definition age. In demographic perspective, these

[2] Part of its appeal comes from its plausibility. Part of the appeal also lects its de-emphasis of population growth as a key mediator, as well as resurgent interest in the possible consequences of contemporary population changes in both lower-income countries (fertility declines) and industrialized nations (aging).

transfers can be seen as a unique combination of age, but also period and cohort effects.[3] As such, they are not to remain static. Rather, they can shift in response to fertility change and its implications on the costs of children (Axinn 1993). or, they can in fact precede and trigger transitions, as posited in Caldwell's wealth flows theory (1982). In short, economic dependency can't be equated with, or automatically follow, changes in age dependency. Data from Mason and Lee (2014) empirically makes that clear. Figure 1 Appendix, which is derived from these authors' massive data collection effort across the world, shows the band of dependency and how it varies across countries. We define this band as the age range where earnings exceed consumption. As the figure shows, the band varies widely in length, starting points and ending points. [and no clear pattern is discernible].

Figure 1. Conceptual Models of the Demographic Dividend



Fortunately, this critique of age dependency is easily addressed. One can modify the basic framework (Figure 1, Frame B) by adding an extra step from 'age' to 'economic' dependency. One can further concede that these steps are not automatic, as shown by the use of broken lines in Figure 1, Frame C: A decline in fertility need not produce a proportional reduction in age structure, if fertility transitions are stalled in ways that retard the steady decline of the child population. Likewise, a change in age structure need not change age dependency if compensatory responses occur in child work or adult employment (Basu 2012).

[3] For instance, the US baby boomers of today are not simply a disincarnated age group but a distinct generation whose lifestyles and consumption habits might differ from the Millennials' when these eventually reach the same age. This distinctive style will affect the income-transfer behavior of this particular generation .

On the other hand, the link from dependency ratios to greater savings and investments (and ultimately economic outcomes) requires a more extensive revision. One issue is whether the link is mechanical or substantive: Do the total investments and savings increase simply because the society now comprises more adults and fewer dependents (a mechanical effect)? Or does the new age structure alter individual economic behavior (a substantive effect)? The two processes, also referenced in the literature as 'compositional vs. behavioral' effects or 'accounting vs. causal' effects (Firebaugh and Goesling 2004; Canning and Fink 2008), can operate simultaneously. As such, they must be separated for reasons of conceptual clarity and empirical estimation. Separation is warranted since the two effects need not work in the same direction, pace or time frame. Separation is further warranted because the mechanical effect is both automatic and easier to estimate, as long as one has descriptive data on age distribution and age-specific behavior. In contrast, the behavioral change (or precisely, the contribution of age structure to this change) requires causal evidence that is much harder to estimate. Finally, separation is warranted for meta-analytic reconciliation of findings from different studies. Findings will be harder to reconcile if some studies focus on mechanical components but others focus on substantive components. Again, the total dividend, in the short-run, is a sum of mechanical and substantive influences.

Total Dividend = 'm-dividend' + 's-dividend'

In the longer-run (Fig 1, Frame D), feedbacks and ripple effects must also be considered (Canning 2014, PRB 2014). A short-run change in economic outcomes can feed back to spur further declines in fertility, creating a secondary effect. It can also have ripple influences on social institutions such as the family or educational, political, recreational and legal institutions (PRB 2014). In short, the initial change in age structure can have a 'long arm' reaching into the future, as well as a 'wide reach' into multiple institutions.

Altogether, the dividend can in theory include four components: a short-term mechanical effect (m-dividend), a short-term substantive effect (s-dividend), an echo effect (long arm) and a ripple effect (wide arm). Although the empirical section of this paper concentrates on the short-term components, the broader conceptual discussion must also consider longer-term effects if the evidence from different studies is to be fully reconciled.

METHODOLOGICAL APPROACHES

Past studies of dividend have usually followed one of four methodological tacks, whether regression analysis, microsimulation, demographic projection, and accounting

Regression analysis: The first approach often has a microlevel orientation and it explores a variety of population variables and outcomes. A primary concern in this approach is to go beyond correlation and establish causation through experiments or econometric techniques (Schultz 2005). Because it requires detailed data and stringent methods, it is hard to replicate and this prevents cross-country comparisons. More fundamentally, its micro-level orientation is at odds with the dividend's macro-longitudinal story which features national age-dependency as the prime mediator. As such, the findings grounded in this approach, while rigorous and internally valid, do not directly answer questions about national-level dividends without running into problems of ecological or historical fallacy.

Microsimulation approaches: These approaches share the same commitment to internal validity via rigorous estimation of the causal linkages. They further go beyond blackbox understandings of fertility-development links to model the pathways and interactions with relevant variables (Canning 2014). This detailed modeling a priori yields a fuller picture of the processes but its widespread use is severely limited by its data and modeling need.

Demographic projections and simulations: Demographic projection methods are based on detailed projections of the size and structure of a national population. By adjoining hypothetical assumptions about economic behavior, they project future socioeconomic outcomes, contingent upon these hypothetical scenarios. However, the conclusions rest entirely on the scenarios considered, and the framework is less apt at retrospective evaluation of how much of the dividend has been accrued (policy simulations not academic evaluations).

Accounting/ decompositions: The NTA (Mason and Lee 2005) approach rests on the collection of detailed data on a country's age-specific pattern of economic behavior, specifically how earnings, consumption, savings, and economic transfers vary with age. Based on these profiles (and assuming they remain relatively stable), one can estimate how aggregate national outcomes will change as the country's age structure evolves. The wealth and detail on age-specific economic behavior makes it possible to examine multiple questions about population-economic relations, including about the dividend.

As summarized in Table 1, these approaches differ along conceptual and methodological lines (Table 1). Key conceptual criteria include definition, level of analysis, and mechanism of influence, whereas methodological criteria include design, data availability, and inference. These six criteria are discussed briefly.

Table 1. Main methodological approaches to the study of dividends

PTS OF DIFFERENCE	Microregression	Microsimulation	Demographic projections	National transfer accounts
CONCEPTUAL				
Definition of DD	Broad	Broad	Broad	Strict √
Level of analysis	Micro	Micro	Macro √	Macro √
Mechanisms	Behavioral	Behavioral	Mechanical	Mechanical
METHODOLOGICAL				
Design I	Crosssectional	Cross-sectional	Longitudinal (forward)	Longitudinal (forward &back)
Design & data needs	Hard to meet	VERY hard to meet	Hard to meet	Hard to meet
Inference	Causal √	Causal √	Non causal	Non causal
Basic approach	Regression	Regression	Projection	Accounting / decomposition

The dividend can be defined strictly or broadly, depending on whether one narrowly covers the specific effects of fertility transition via changes in age structure or, alternatively, whether one casts a wider net covering multiple fertility-development relationships. The level of analysis varies from micro to meso to macro, depending on whether they take individual, subgroups or entire societies as units of analysis. One can of course begin with micro-level evidence or group-specific processes or changes to document macro-level change, a topic to which we will return. Specifications of mechanisms can vary from extreme reduction to extreme detail. including includes all plausible ramifications, feedbacks and ripple effects. This paper favors a middle-ground approach to examine the detailed but recursive link between fertility and economic growth.

Turning to methodological criteria, cross-sectional as well as historical designs have been used, with the latter being further subdivided into retrospective and prospective studies. Some of the methods require vast amounts of detailed data and, as a result, they are not easily replicated across countries; this raises questions of external validity if analysts must generalize from the few contexts where the data is available. Past methods also vary in whether they generate internally valid findings, with some presumably affording causal inference while others merely offer correlation and descriptive accounting.

If we subject the main existing methods to these six criteria (Table 1), none will meet all the desirable criteria. Each method has its merits and its challenges. Choosing one method over another thus involves some tradeoff, most notably between ecological validity (right level of analysis), internal validity (ability to make causal inferences) or external validity (ability to generate country-specific results). Ultimately, 'which method is best' depends on one's priorities. Academic researchers might place a premium on internal validity and precision while policy analysts might value practicality, feasibility, and country-specificity, as long as findings are broadly accurate. For applied researchers interested in the development potential of a dividend, ecological validity would be a must, followed by internal validity, and then external validity. In other words, the researcher must first be sure to address the right question at the right level of analysis, then worry about the reliability of the estimated dividend, before considering how dividends vary across various countries.

Some of the methods seem complementary A tradeoff might thus be averted if one could draw from two or more complementary methods. Such integration could achieve the best of both worlds, i.e., satisfy the need for rigor as well as practicality.

The next question then becomes which of these approaches can be usefully integrated. If we take a strict definition of the dividend (i.e., the effects of fertility transitions via age structure), the NTA approach is an excellent starting point if only because it meets the basic criterion of ecological validity, while also based on detailed information. In order to improve the ecologically-valid findings from NTAs, regression analysis (and its emphasis on internal validity) seems an appropriate complement. The marriage of NTA and regression analysis is interesting not only because it meets these two validity criteria but also –as we will show— because it helps capture both the mechanical and substantive components of a dividend. After this synthesis, the only criterion missing is external validity, in light of the difficulty to find the data needed to active the NTA approach. This is why we resort to a data-poor variant of this mixed approach.

A MIXED DECOMPOSITION APPROACH

General formulation. Decomposition is a staple of demographic research, even if its variants remain insufficiently integrated (Vaupel 2002). A basic demographic decomposition expresses the historical change in a social outcome into the contributions of compositional versus behavioral change. It can be applied to any social outcome S_t expressed as a weighted average of group-specific values. These groups can be defined based on any number of criteria (region, income, or education, for instance) and their number of categories can vary as long as they are mutually exclusive and exhaustive. In the case of demographic dividends, age is the relevant grouping criterion, with the relevant outcomes being some economic behavior. NTA models include data on earnings, consumptions and a variety of transfers but one can focus simply on the net surplus (S) or the balance between earnings and consumption. With these stipulations, the national value of S_t at any given point is given in [1] and its historical change in [2]

$$\boldsymbol{S_t = \sum w_{jt} s_{jt}} \qquad \textbf{[1]}$$

$$\Delta \boldsymbol{S} = \sum \bar{\boldsymbol{s}}_{\boldsymbol{j}} \Delta \boldsymbol{w}_{\boldsymbol{j}} + \sum \bar{\boldsymbol{w}}_{\boldsymbol{j}} \Delta \boldsymbol{s}_{\boldsymbol{j}} \qquad \textbf{[2]}$$

The first component in [2] lects the influence of changing composition, i.e., how the number of people in different age groups has changed historically (changes in age structure) The second (behavioral) component captures the change in economic behavior within individual categories. Equation 2 thus apportions in percentage terms, how much of the national change arose from changes in age composition versus change in group-specific behavior. This first decomposition is straightforward but not fully satisfactory from the standpoint of dividend analysis. While it does capture the mechanical component of the dividend, it does not its behavioral component. We do know from the second term in Eq 2 how much people's behavior changed. Yet one has no idea why behavior changed and whether the changing age structure was factor. If one could reliably apply regression analysis to estimate the effect of age dependency (J) on the economic behavior of individual age groups [Equation 3] then the changes in individual behavior could be explained through a procedure of regression decomposition [Equation 4] and the results inserted into [2] to yield [5].

$$s_{jt} = a_{jt} + b_{jt}J_t + e_{jt} \qquad [3]$$

$$\Delta \boldsymbol{s}_j = \Delta \boldsymbol{a}_j + \bar{\boldsymbol{J}}\Delta \boldsymbol{b}_j + \bar{\boldsymbol{b}}\Delta \boldsymbol{J} + \Delta \boldsymbol{e}_j \qquad [4]$$

$$\Delta \boldsymbol{S} = \sum \bar{\boldsymbol{s}}_j \Delta \boldsymbol{w}_j + \sum \bar{\boldsymbol{w}}_j \Delta \boldsymbol{a}_j + \sum \bar{\boldsymbol{w}}_j \bar{\boldsymbol{J}} \Delta \boldsymbol{b}_j + \sum \bar{\boldsymbol{w}}_j \bar{\boldsymbol{b}} \Delta \boldsymbol{J} + \sum \bar{\boldsymbol{w}}_j \Delta \boldsymbol{e}_j \qquad \textbf{[5]}$$

m-dividend *s-dividend*

The full procedure in [5] is labeled mixed decomposition because it incorporates a regression decomposition into a basic demographic decomposition. Importantly, this equation now includes the mechanical (m-dividend) as well as the (s-dividend), with the total dividend being the sum of these two terms.

If a researcher has detailed age-specific profiles of economic behavior such as being collected under the NTA project, and if s/he has reliable causal evidence on how age dependency ratio affects this economic behavior, then s/he can use equation [5] to estimate the total dividend. However, these data conditions are rarely met. [In their NTA project, Mason and Lee have an impressive array many countries, but only 17 African countries have been covered so far and none has been covered at multiple points in time]. In such conditions where ideal data are lacking, workable approximations must be sought.

Application to limited data environments

In the very common circumstances where a researcher does not have detailed, age-specific and historical, data on economic behavior, s/he can fall back on existing national statistics on age structure, the productivity of the labor force, employment.
The detailed NTA approach is clearly more desirable because it eschews the narrow assumptions of a universal definition of age structure, which our alternative approach can't avoid. However, what the new approach lacks in age detail, it more than makes up in historical depth, substantive breadth, practicality, theoretical grounding, and x.

The general idea is to use theoretical models of economic growth that include age structure and other drivers of growth posited in dividend theory. The analysis itself would proceed in two steps that include (1) decomposition of the growth model into the contributions of change in age structure and other drivers, then (2) estimation of the contribution of changes in age structure on the other drivers. The first steps will generate the m-dividend, while the second step will additionally identify the s-dividend.

Models of economic growth have often included age structure in their analyses. Solow (1957) for instance accounts for three sources that include increases in the stock of physical capital, in the size of the labor force, and in technical progress. Physical capital represents the machines and equipment used in producing economic output. The size of the labor force captures the demographic changes in population (growth and changes in age structure), and technical progress is a mix of education and technology. A modified Cobb-Douglas function expresses growth in more detailed terms of physical capital (K), human capital (h), employment (L) and total factor productivity (A)

$$Y = AK^{\alpha}(hL)^{\beta}$$

Building on this formulation, one can decompose economic growth as:

$$\Delta y_t \cong \Delta A_t + \alpha \Delta k_t + (1-\alpha)\Delta h_t + \Delta l_t + \Delta w_t \qquad [10]$$

Where *y* is GDP per person employed (Y/L)
A is the total factor productivity; *k* is the stock of physical capital per person employed (K/L); *h* is the human capital; *l* is the rate of employment (L/W); *w* is age structure (W/P)

The final term in Eq. 10 is the mechanical influence of age structure, i.e. the 'm-dividend'. The other components represent changes in theoretically-important growth factors, including physical capital per person, human capital, rate of employment, and total factor productivity. Importantly, dividend theory expects national changes in age structure to affect these drivers through savings and investment in economic development. These investments most directly boost the stock of physical capital if governments commit the freed resources to build the country's productive infrastructure. However, they also boost investments in education that later build the stock of human capital; joint improvements in, and interaction of, human and physical capital are expect to enhance total factor productivity . In sum, in addition to its direct, mechanical effects, change in age structure can have substantive effects via influences on the various drivers of economic growth. There are also cogent reasons why changes in age structure can affect the rates of employment although the direction of effects is indeterminate. In sum, there are sound theoretical reasons why age structure might substantively affect these four drivers of economic growth. The problem becomes just one of statistical estimation. The parameters to estimate include α and β in the Cobb-Douglas equation, as well as γ_1, γ_2, γ_3, γ_4 which represent the effects of age structure on total factor productivity, physical capital, human capital, and employment, respectively.

Equation 10 can then fully be rewritten as [11].

$$\begin{aligned}\Delta y_t \cong\ & \Delta A_0 + \bar{w}\Delta\gamma_1 + \bar{\gamma}_1\Delta w + \Delta e_1 + \\ & \alpha\Delta k_0 + \alpha\bar{w}\Delta\gamma_2 + \alpha\bar{\gamma}_2\Delta w + \alpha\Delta e_2 + \\ & (1-\alpha)\Delta h_0 + (1-\alpha)\bar{w}\Delta\gamma_3 + (1-\alpha)\bar{\gamma}_3\Delta w + (1-\alpha)\Delta e_3 + \\ & \Delta h_0 + \bar{w}\Delta\gamma_4 + \bar{\gamma}_4\Delta w + \Delta e_4 + \\ & \Delta w\end{aligned}$$

The last term (Δw) is the m-dividend, and sum of the highlighted terms constitutes the s-dividend.

DATA AND ESTIMATION

We illustrate the application of this method with African data. This region is a good case study because of great geographic and historical variation in its recent fertility and economic trends. Economically, the region has experienced dramatic swings from a severe economic downturn in the 1990s and a remarkable recovery after 2000. Within this general trend, national experiences varied in intensity and timing. Similar diversity is found on the demographic front. At present, African countries run almost the full gamut of transition stages from pre-transitional to quasi-replacement fertility. This remarkable variation makes it possible to estimate the association between transformations in age structure and economic circumstances. Our focus on the years between 1990 and 2010 is driven by both substantive and practical reasons. Substantively, this corresponds broadly to the onset of fertility decline in the region. More practically, the data needed, especially Barro's do not extend much farther in time.

Completing this mixed decomposition requires estimations of two types of parameters to obtain m-dividend and the s-dividend consecutively. To get the m-dividend, one only needs data on the value of α (the x) as well as national statistics on the country's age structure, employment, human capital, and physical capital. The value of α was recently estimated by Barro and Lee (2014) for a number of African countries.[4] Data on most the other national statistics are obtained from the Penn World Tables, except for data on human capital that come from Barro and Lee (2013).

The next challenge is to estimate the γ_{jt}, i.e., the country and time-specific values for the effects of age structure on the proximate drivers of economic growth (total factor productivity, physical capital, human capital, employment). (It is hard to obtain these for each single country and each single year). For that reason, we estimate values for groups of countries and broader time periods. The countries are grouped based on their stage in

[4] Factor share can change over time. In discrete time, the standard growth accounting equation assumes that the factor share is constant. To be up to this assumption, when for a given country, several values of the factor share are available over the period considered, the actual value of the factor share used is the average. It has to be noted that, values of factor share vary very little in the African context (Feenstra et al, 2013).

the fertility transition as indicated by their total fertility rate (pretransitional and early transition; mid; and avanced). The years are clustered into three periods 1990 (1985-1995), 2000 (1995-2005) and 2010 (2005-2015). We estimated the country and period-specific parameters in [5] with a regression pooling data for all countries and years, but also including variables for J (dummies for country) and T (dummies of time period). In the case of total factor productivity (A) for instance,

$$\begin{aligned} Ln(A_{jt}) &= \alpha_{00} + \theta_{00}w_{jt} + \theta_1 J + \theta_2 T + \theta_3 J w_{jt} + \theta_4 T w_{jt} + \theta_5 TJ w_{jt} + e_{jt} \\ &= (\alpha_{00} + \theta_1 J + \theta_2 T) + (\theta_{00} + \theta_3 J + \theta_4 T + \theta_5 TJ) w_{jt} + e_{jt} \\ &= (A_{0t}) + \qquad (\gamma 1_{jt}) w_{jt} + \qquad e_{jt} \end{aligned}$$

[12]

The period-specific and country-specific values of the various γ can then be brought into equation 11.

FINDINGS

This section presents the main results in sequence, beginning with the m-dividend, then the s-dividend before discussing the implications for the total dividend. Finally, we discuss what the new framework and its related analyses imply for current debates on the dividend, including whether it is automatic, large, and its contingency upon contextual conditions. We also discuss how the framework can reconcile disparate evidence from different studies. To recall, the m-dividend is the mechanical component, linked to mere compositional changes. It is derived directly from the decomposition of the Cobb-Douglas equation. The s-dividend on the other hand, stems from the influences of changes in age structure on total factor productivity, physical capital, human capital, and employment, respectively and cumulatively.

The m-dividend:

Estimates of the m-dividend for all the study countries are given in Table 2. The first block of columns shows the results for the entire period from 1980 to 2010. Within this block, the columns first show the total economic growth (in logged GDP values) then the decline in total fertility rate during this period (TFR), then finally the contributions of the different components to growth as derived from the Cobb-Douglas formulation. These components are listed in the same order as given in Equation (X), i.e., total factor productivity (A), physical capital, human capital, employment, and finally age structure. This last term represents our m-dividend. It is shaded in the table for emphasis The countries are grouped in four major clusters depending on their economic growth whether strong positive, mild positive, mild negative, or strongly negative

The results show the following: First, for all the countries experiencing a fertility decline, there was some m-dividend. In the nine countries experiencing both substantial growth and some fertility decline, changes in age structure accounted for X% of the growth on average, with individual percentages ranging from 12% (Egypt) to 38% (Swaziland). The percentages are much higher but these numbers are likely to be unstable because of the small size of the denominator (growth). Conversely, there was also a palliative dividend in countries that saw a rapid decline in fertility but also a substantial decline. For instance, Zimbabwe experienced (a substantial fertility decline during that period but negative economic growth). This economic downturn was largely due to other circumstances (physical infrastructure and total factor productivity) but it would have been even worse without the braking influence of change in age structure (-84.5%).

Second, at no point can we see a country experiencing a major fertility decline without a corresponding boost to economic growth or braking of economic decline. Indeed, there is a fairly strong correlation between individual levels of fertility decline and the corresponding economic benefits.

The same correspondence between the magnitude of the m-dividend and the corresponding economic benefits is found when one looks historically at the experience of individual countries. For each country, the benefits were largest during periods with greater fertility decline.

Table 2. Demographic decomposition results for the mechanical contributions of changing age structure to economic growth (1990-2010)

	1900-2010 period				1990-1995 period				1995-2000 period				2000-2005 period				2005-2010 period			
	TOTAL NOMINAL GROWTH ($)	% growth associated with changes in			TOTAL NOMINAL GROWTH	% growth associated with changes in			TOTAL NOMINAL GROWTH	% growth associated with changes in			TOTAL NOMINAL GROWTH	% growth associated with changes in			TOTAL NOMINAL GROWTH	% growth associated with changes in		
		age structu	roductiv	nployment		age structu	roductiv	nployment		age structu	roductiv	nployment								
COUNTRY		δ	ρ	ε		δ	ρ	ε		δ	ρ	ε								
Angola	**1029.4**	-1%	99%	1%	**-501.9**	0%	106%	-6%	**193.1**	*0%*	*106%*	*-7%*	**468.1**	-1%	101%	0%	870.1	0%	101%	-1%
Benin	**92.1**	32%	85%	-17%	**12.2**	63%	67%	-30%	**42.8**	*3%*	*115%*	*-18%*	**19.7**	52%	70%	-22%	17.4	60%	36%	4%
Botswana	**2422.1**	34%	48%	18%	**345.4**	63%	23%	14%	**659.4**	*37%*	*53%*	*10%*	**558.8**	34%	49%	17%	858.3	13%	56%	31%
Burkina Faso	**187.9**	8%	110%	-18%	**15.6**	13%	140%	-53%	**58.2**	*7%*	*103%*	*-10%*	**63.9**	5%	116%	-21%	50.2	10%	95%	-5%
Burundi	**-67.6**	-23%	81%	42%	**-44.8**	13%	68%	19%	**-23.3**	*-5%*	*56%*	*49%*	**-6.5**	-168%	180%	88%	7.0	68%	34%	-2%
Cameroon	**-68.3**	-86%	182%	4%	**-212.5**	-1%	112%	-10%	**80.9**	*19%*	*86%*	*-6%*	**46.4**	38%	84%	-23%	16.9	100%	50%	-51%
Cape Verde	**1938.8**	19%	74%	8%	**331.3**	4%	90%	6%	**622.4**	*11%*	*87%*	*3%*	**367.1**	40%	52%	8%	618.0	32%	51%	17%
Central African Republic	**58.7**	36%	59%	6%	**-25.0**	-15%	133%	-18%	**-13.2**	*-26%*	*123%*	*2%*	**2.1**	139%	-21%	-18%	94.8	10%	91%	-1%
Chad	**309.7**	-2%	109%	-7%	**-24.8**	21%	84%	-6%	**-16.9**	*21%*	*68%*	*11%*	**296.2**	0%	102%	-2%	55.1	15%	116%	-30%
Comoros	**-128.0**	-32%	180%	-48%	**-58.9**	-41%	163%	-23%	**-35.0**	*-66%*	*203%*	*-37%*	**5.4**	21%	-228%	307%	-39.5	17%	125%	-41%
Congo, Dem. Rep.	**-253.9**	0%	108%	-7%	**-217.3**	3%	103%	-5%	**-77.1**	*1%*	*103%*	*-4%*	**10.0**	10%	81%	9%	30.4	11%	85%	3%
Congo, Republic of	**93.0**	66%	-93%	127%	**-189.6**	-20%	132%	-12%	**-31.7**	*-71%*	*264%*	*-93%*	**122.5**	-6%	78%	28%	191.7	2%	88%	11%
Cote d`Ivoire	**-118.2**	-37%	108%	29%	**-89.7**	-31%	114%	17%	**28.2**	*52%*	*75%*	*-27%*	**-73.7**	7%	79%	14%	16.9	36%	72%	-8%
Djibouti	**-156.6**	-128%	359%	-131%	**-299.3**	-9%	108%	1%	**-96.4**	*-31%*	*221%*	*-90%*	**65.7**	89%	-30%	41%	173.4	26%	47%	27%
Egypt	**671.1**	22%	78%	0%	**77.8**	29%	113%	-42%	**183.2**	*21%*	*83%*	*-4%*	**109.4**	50%	13%	36%	300.7	7%	88%	5%
Equatorial Guinea	**11241.1**	0%	101%	-1%	**253.5**	-13%	111%	2%	**3355.2**	*0%*	*101%*	*0%*	**7494.7**	5%	97%	-1%	137.7	239%	-75%	-63%
Ethiopia	**92.9**	7%	102%	-9%	**-16.2**	4%	82%	14%	**9.8**	*1%*	*107%*	*-7%*	**24.9**	4%	83%	12%	74.4	8%	103%	-11%
Gabon	**-900.9**	-46%	129%	17%	**140.1**	-13%	106%	7%	**-775.9**	*-17%*	*98%*	*19%*	**-206.3**	-77%	138%	40%	-58.8	-227%	426%	-99%
Gambia, The	**42.0**	7%	72%	20%	**-19.4**	20%	94%	-14%	**32.6**	*18%*	*77%*	*5%*	**-3.4**	-17%	188%	-71%	32.2	1%	95%	4%
Ghana	**233.6**	15%	70%	14%	**28.8**	23%	-1%	78%	**40.5**	*24%*	*7%*	*70%*	**56.0**	13%	129%	-42%	108.3	10%	94%	-4%
Guinea	**14.6**	48%	115%	-63%	**-20.0**	10%	103%	-13%	**22.8**	*5%*	*111%*	*-15%*	**18.1**	18%	94%	-13%	-6.3	-78%	79%	99%
Guinea-Bissau	**-84.4**	-28%	127%	1%	**21.6**	-3%	144%	-41%	**-103.3**	*-9%*	*111%*	*-2%*	**-12.5**	-52%	170%	-19%	9.8	71%	9%	20%
Kenya	**19.7**	362%	178%	-440%	**-41.5**	-67%	108%	59%	**-12.9**	*-165%*	*97%*	*167%*	**22.7**	60%	179%	-140%	51.4	6%	97%	-3%
Lesotho	**360.2**	22%	92%	-14%	**64.9**	28%	88%	-16%	**64.1**	*12%*	*49%*	*40%*	**70.9**	25%	133%	-58%	160.3	21%	96%	-16%
Liberia	**65.5**	10%	83%	7%	**-127.0**	-2%	101%	0%	**116.7**	*1%*	*100%*	*-2%*	**-1.0**	3%	73%	24%	76.9	0%	89%	12%
Madagascar	**-55.2**	-20%	132%	-12%	**-51.1**	-4%	103%	1%	**8.7**	*-40%*	*101%*	*39%*	**-10.5**	-38%	156%	-18%	-2.3	-341%	499%	-58%
Malawi	**68.9**	-3%	84%	19%	**18.5**	15%	106%	-21%	**13.7**	*-34%*	*111%*	*23%*	**-8.2**	16%	200%	-116%	44.9	3%	87%	10%
Mali	**168.8**	3%	80%	17%	**7.6**	29%	22%	49%	**43.0**	*7%*	*78%*	*14%*	**64.0**	3%	88%	10%	54.2	-6%	84%	22%
Mauritania	**132.7**	40%	2%	59%	**8.7**	93%	-132%	139%	**-12.4**	*-106%*	*391%*	*-186%*	**51.1**	31%	27%	42%	85.3	16%	64%	20%
Mauritius	**3072.3**	10%	85%	5%	**599.7**	8%	82%	9%	**917.8**	*5%*	*88%*	*7%*	**499.4**	16%	104%	-20%	1055.5	14%	74%	12%
Mozambique	**194.0**	3%	94%	3%	**1.3**	731%	-77%	-554%	**47.7**	*2%*	*86%*	*11%*	**77.2**	-7%	97%	10%	67.7	-6%	105%	1%
Namibia	**1287.9**	28%	19%	53%	**90.1**	95%	-5%	10%	**103.9**	*84%*	*-4%*	*20%*	**574.9**	6%	22%	72%	519.1	26%	26%	49%
Niger	**-27.2**	50%	215%	-165%	**-37.1**	-1%	141%	-40%	**-10.8**	*20%*	*231%*	*-151%*	**3.3**	-170%	21%	250%	17.4	-28%	116%	12%
Nigeria	**405.6**	4%	109%	-12%	**-56.6**	-14%	98%	16%	**18.8**	*37%*	*135%*	*-72%*	**252.0**	0%	108%	-8%	191.5	-4%	100%	4%
Rwanda	**113.3**	25%	80%	-6%	**-44.2**	-62%	97%	65%	**18.9**	*-82%*	*79%*	*103%*	**63.0**	20%	80%	0%	75.6	-2%	95%	7%
Senegal	**119.3**	40%	38%	21%	**-30.2**	-42%	172%	-30%	**52.1**	*21%*	*68%*	*11%*	**69.5**	21%	74%	5%	27.9	28%	51%	21%
Sierra Leone	**4.4**	449%	-289%	-60%	**-80.4**	-10%	101%	9%	**-9.5**	*-51%*	*107%*	*44%*	**41.8**	4%	83%	13%	52.5	5%	88%	7%
South Africa	**838.7**	73%	-60%	86%	**-294.9**	-74%	282%	-109%	**91.7**	*242%*	*-313%*	*171%*	**533.5**	17%	48%	34%	508.4	4%	98%	-2%
Sudan	**438.9**	11%	90%	-1%	**26.2**	41%	216%	-157%	**109.4**	*8%*	*71%*	*21%*	**138.3**	5%	85%	10%	165.0	11%	82%	7%
Swaziland	**428.1**	84%	69%	-53%	**82.8**	21%	49%	30%	**88.9**	*133%*	*102%*	*-135%*	**150.5**	72%	75%	-46%	105.8	113%	47%	-60%
Tanzania	**146.0**	4%	98%	-2%	**-20.4**	-16%	122%	-5%	**23.6**	*10%*	*95%*	*-5%*	**68.5**	0%	103%	-3%	74.2	-3%	103%	0%
Togo	**-32.8**	-104%	312%	-108%	**-47.9**	-9%	128%	-19%	**33.7**	*36%*	*3%*	*61%*	**-29.6**	-36%	147%	-10%	11.1	52%	36%	12%
Tunisia	**1827.4**	30%	70%	1%	**204.3**	50%	35%	15%	**517.8**	*28%*	*79%*	*-7%*	**462.8**	33%	84%	-17%	642.5	16%	66%	17%
Uganda	**195.5**	-2%	115%	-12%	**36.8**	-9%	115%	-5%	**34.0**	*-8%*	*114%*	*-6%*	**45.3**	1%	130%	-31%	79.3	5%	102%	-7%
Zambia	**64.6**	-19%	177%	-58%	**-117.4**	-4%	107%	-3%	**2.4**	*-78%*	*189%*	*-11%*	**64.1**	-18%	137%	-20%	115.6	-2%	123%	-22%
Zimbabwe	**-280.7**	-14%	159%	-45%	**-31.1**	-63%	230%	-68%	**28.2**	*89%*	*-60%*	*71%*	**-222.8**	-2%	146%	-45%	-55.0	1%	89%	10%

Table 3. Decomposition results for the substantive contributions of changing age structure to productivity in selected African countries (based on Cobb Douglas growth equation)

	TOTAL PERIOD 1980-2010						1980-85		1985-1990		1990-1995		1995-2000		2000-2005		2005-2010	
COUNTRIES GROUPED ECONOMIC TREND	**Total Change**	**Contributions of various factors** *k*	*i*	*age*	*emp*	*TFP*	**Total Change**	*Contribution of age*	**Total Change**	*Contribution of age*	**Total Change**	*Contribution of age*	**Total Change**	*Contribution of age*	**Total Change**	*Contribution of age*	**Total Change**	*Contribution of age*
LARGE ECONOMIC GROWTH																		
Botswana	**1.461**	*61.9%*	*11.7%*	*13.7%*	*4.7%*	*8.0%*	**0.349**	1.3%	**0.465**	5.6%	**0.096**	*58.5%*	**0.283**	*19.6%*	**0.191**	*20.0%*	**0.077**	*26%*
Mauritius	**1.200**	*27.4%*	*10.4%*	*13.1%*	*5.4%*	*43.7%*	**0.177**	28.7%	**0.325**	11.4%	**0.164**	*9.2%*	**0.220**	*5.3%*	**0.117**	*13.8%*	**0.197**	*14%*
Egypt, Arab Rep,	**1.073**	*97.8%*	*16.0%*	*12.4%*	*-7.8%*	*-18.3%*	**0.320**	2.6%	**0.145**	0.7%	**0.141**	*17.2%*	**0.168**	*22.3%*	**0.088**	*52.1%*	**0.211**	*7%*
Tunisia	**0.766**	*21.6%*	*27.3%*	*31.5%*	*-0.3%*	*19.9%*	**0.079**	33.7%	**0.032**	84.3%	**0.106**	*45.2%*	**0.213**	*27.6%*	**0.167**	*30.6%*	**0.169**	*18%*
Mozambique	**0.675**	*32.1%*	*5.7%*	*-4.9%*	*15.0%*	*52.0%*	**-0.323**	5.6%	**0.164**	-23.7%	**-0.002**	*-2258.8%*	**0.317**	*1.5%*	**0.291**	*-6.6%*	**0.228**	*-5%*
Lesotho	**0.649**	*57.7%*	*25.5%*	*18.3%*	*-21.4%*	*20.0%*	**0.013**	-35.4%	**0.158**	5.8%	**0.110**	*30.6%*	**0.103**	*11.9%*	**0.091**	*28.7%*	**0.174**	*24%*
Tanzania	**0.477**	*-1.3%*	*28.7%*	*4.9%*	*1.3%*	*66.4%*	**-0.101**	-2.3%	**0.063**	10.4%	**0.034**	*34.6%*	**0.083**	*10.0%*	**0.210**	*0.3%*	**0.189**	*-3%*
Swaziland	**0.467**	*-16.7%*	*45.4%*	*37.7%*	*-25.6%*	*59.2%*	**-0.041**	6.0%	**0.309**	5.6%	**0.040**	*20.8%*	**0.042**	*133.2%*	**0.066**	*71.7%*	**0.051**	*98%*
Benin	**0.288**	*-12.0%*	*89.7%*	*16.8%*	*-3.3%*	*8.8%*	**0.125**	-5.6%	**-0.083**	3.1%	**0.075**	*22.2%*	**0.094**	*2.8%*	**0.043**	*45.3%*	**0.035**	*55%*
Rwanda	**0.270**	*95.8%*	*74.8%*	*24.4%*	*-10.2%*	*-84.9%*	**-0.032**	91.2%	**-0.103**	4.2%	**-0.200**	*-63.7%*	**0.110**	*-70.0%*	**0.242**	*22.0%*	**0.252**	*-2%*
MILD ECONOMIC GROWTH																		
Senegal	**0.174**	*-52.1%*	*61.8%*	*29.4%*	*7.0%*	*54.0%*	**0.008**	-233.9%	**0.007**	59.2%	**-0.075**	*-25.4%*	**0.105**	*15.4%*	**0.093**	*21.2%*	**0.035**	*28%*
Namibia	**0.154**	*-40.9%*	*45.8%*	*106.9%*	*118.8%*	*-130.6%*	**-0.155**	5.3%	**-0.086**	-78.3%	**0.087**	*34.2%*	**0.035**	*85.1%*	**0.148**	*7.5%*	**0.126**	*28%*
South Africa	**0.131**	*-19.7%*	*141.9%*	*123.8%*	*155.5%*	*-301.5%*	**-0.059**	-32.1%	**-0.027**	-96.0%	**-0.075**	*-61.3%*	**0.059**	*81.1%*	**0.122**	*15.4%*	**0.109**	*4%*
Kenya	**0.101**	*-3.5%*	*200.9%*	*152.6%*	*-140.4%*	*-109.7%*	**-0.043**	-9.6%	**0.098**	24.2%	**-0.078**	*-66.5%*	**-0.029**	*-146.6%*	**0.055**	*48.8%*	**0.098**	*6%*
Mauritania	**0.055**	*58.7%*	*312.7%*	*151.5%*	*263.1%*	*-686.0%*	**-0.146**	-4.1%	**-0.015**	-23.1%	**0.017**	*72.9%*	**0.004**	*459.6%*	**0.084**	*27.8%*	**0.110**	*16%*
MILD ECONOMIC DECLINE																		
Burundi	**-0.043**	*-188.1%*	*-447.7%*	*-51.4%*	*-2.7%*	*789.8%*	**0.079**	-33.6%	**0.031**	-119.5%	**-0.190**	*15.3%*	**-0.108**	*-7.0%*	**-0.024**	*-308.1%*	**0.170**	*19%*
Cameroon	**-0.139**	*9.6%*	*-133.9%*	*-23.2%*	*-34.7%*	*282.2%*	**0.180**	-10.5%	**-0.335**	2.9%	**-0.198**	*-1.8%*	**0.112**	*17.0%*	**0.069**	*29.0%*	**0.033**	*56%*
Zimbabwe	**-0.154**	*212.7%*	*-149.7%*	*-84.5%*	*-185.5%*	*307.0%*	**0.013**	153.9%	**0.056**	66.3%	**-0.050**	*-58.6%*	**-0.078**	*-48.2%*	**-0.224**	*-3.1%*	**0.130**	*-1%*
LARGE ECONOMIC DECLINE																		
Central African Republic	**-0.257**	*211.6%*	*-23.4%*	*-13.1%*	*-2.3%*	*-72.8%*	**-0.071**	0.3%	**-0.097**	18.2%	**-0.030**	*-33.3%*	**-0.004**	*-225.0%*	**-0.104**	*-8.0%*	**0.049**	*47%*
Gabon	**-0.283**	*92.7%*	*-57.7%*	*-8.3%*	*15.4%*	*57.9%*	**-0.029**	81.9%	**-0.100**	14.9%	**-0.004**	*62.4%*	**-0.133**	*-14.1%*	**-0.022**	*-113.8%*	**0.004**	*516%*
Sierra Leone	**-0.290**	*46.9%*	*-57.6%*	*-14.2%*	*21.4%*	*103.5%*	**0.008**	-231.7%	**0.030**	18.8%	**-0.234**	*-10.2%*	**-0.595**	*-2.9%*	**0.376**	*1.5%*	**0.125**	*6%*
Cote d'Ivoire	**-0.335**	*123.4%*	*-52.0%*	*-17.1%*	*5.7%*	*39.9%*	**-0.197**	-1.3%	**-0.037**	-31.9%	**-0.079**	*-33.8%*	**0.041**	*36.2%*	**-0.083**	*6.1%*	**0.022**	*30%*
Togo	**-0.371**	*29.2%*	*-78.4%*	*-23.0%*	*-30.3%*	*202.6%*	**-0.231**	1.7%	**0.053**	11.9%	**-0.122**	*-8.5%*	**-0.055**	*-55.6%*	**-0.062**	*-44.2%*	**0.046**	*32%*
Niger	**-0.393**	*112.4%*	*-23.1%*	*14.8%*	*-56.8%*	*52.6%*	**-0.275**	3.1%	**-0.132**	2.4%	**-0.091**	*-1.8%*	**-0.016**	*50.6%*	**0.047**	*-46.5%*	**0.073**	*-25%*

DISCUSSIONS AND IMPLICATIONS

The demographic dividend offers a strong theoretical argument for the effects of fertility transitions on economic development. The lack of empirical consensus on the magnitude of dividends has historically remained limited by two factors, namely a) the diversity in methods and frameworks used and b) a scarcity of detailed data to apply the most rigorous approaches. By conceptually distinguishing between the 'mechanical' versus 'substantive' components of the dividend and integrating two analytical traditions –regression and accounting methods- we are able to reconcile seemingly disparate prior findings.

Our application to African settings circa 1980-2010 suggests the following: 1) most countries where fertility fell accrued a mechanical dividend that accounted for between 12% and 38% of the country's economic growth. 2) this mechanical dividend was often augmented by a substantive dividend stemming from influences on investments in physical capital or total factor productivity; 3) compared to the mechanical dividend, the substantive dividend was more inconsistent.

(Our full paper will provide more robust discussion of the implication and findings).

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