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Public investment and human capital with segmented labour markets

Edward F. Buffie[1], Christopher Adam [2]*, Luis-Felipe Zanna[3], Lacina Balma[4], Dawit Tessema[4], and Kangni Kpodar[5]

[1]Department of Economics, Indiana University, 107 South Indiana Avenue, Bloomington, IN, USA
[2]Department of International Development, University of Oxford, 3 Mansfield Road, Oxford, UK
[3]Institute for Capacity Development, International Monetary Fund, 700 19th St NW, Washington, DC, USA
[4]Forecasting and Research Department, African Development Bank, Avenue Joseph Anoma, Abidjan, Côte d'Ivoire
[5]Strategy, Policy and Review Department, International Monetary Fund, 700 19th St NW, Washington, DC, USA
*Corresponding author: Email: christopher.adam@qeh.ox.ac.uk

Abstract

We develop a dynamic general equilibrium macroeconomic model with segmented labour markets and efficiency wages to examine how labour market structures influence the impact of human capital investment in low-income countries. For plausible calibration values, public investment in education is much more effective than infrastructure investment in promoting long-run economic development, but because investment in education affects labour productivity with a lag, policymakers face an intertemporal trade-off which depends on their social discount rate and the weight of distributional objectives in the social welfare function. We show the distortionary structure of labour markets matters in leveraging welfare gains from public investment and in shifting the optimal public investment programme further in favour of human capital, relative to the case of flex-wage full-employment labour markets.

JEL classifications: E62, F34, H54, H63, I25, I31, O43

> 'I briefly highlight four priority areas for future research . . . The second is the need for empirically grounded theoretical labor market models that can be used in the formulation of policy. There is some value in developing single-sector models and representative agent models, but it would be more helpful to have multi-sector models in which labor markets are segmented, incorporating the key features of labor markets in the country being analyzed'.
>
> (Fields, 2011, p. 521)

1. Introduction

Public investment in infrastructure and education has played a central role in growth and poverty reduction strategies designed by many developing countries in recent decades

(AfDB, 2018; UN, 2020), and this role is only likely to become even more important in a post-Covid-19 world as countries seek to restore pre-pandemic growth and repair the scarring effects that lockdowns and closures inflicted on human capital (Agarwal, 2022). There is now a substantial body of work seeking to quantify the macroeconomic effects of such investment scale-ups and their financing (Atolia *et al.*, 2019; Gurara *et al.*, 2019; Zanna *et al.*, 2019). In the main, however, the models used in this literature have retained a characterization of labour markets where perfect wage flexibility and full inter-sectoral labour mobility prevail. This appears restrictive and increasingly unappealing in the context of the high and persistent levels of open unemployment and widespread underemployment that are enduring facts of life in many low-income countries (Adam and Buffie, 2020). Thus while existing models shed light on how public investment programmes affect *aggregate* labour demand, they cannot speak directly to questions of inequality or the challenge of creating more good jobs (Teal, 2011): a decade on from Fields (2011) the need to incorporate richer labour markets in models that can inform policy decisions remains pressing.

In this article, we seek to move the discussion forwards by embedding segmented labour markets within a standard policy-focused multi-sector dynamic macroeconomic model. We then use this structure to examine the macroeconomic, debt and welfare consequences of the kind of public investment programmes being considered in many developing countries and how these outcomes are shaped by the characterization of labour markets.

To do so, we introduce two key modifications into the standard model (e.g. Zanna *et al.* 2019). The first is that firms in the formal sector pay efficiency wages (EWs), while flexible wages prevail in agriculture and in the non-agricultural informal sector, which we characterize as being populated by own-account workers who earn the same returns to labour as in agriculture. Crucially though, labour in smallholder agriculture receives its marginal value product *plus* a share of (implicit) land rents: consequently, while labour mobility enforces equal pay in agriculture and the informal sector, the marginal value product of labour is lower in agriculture. This implies open unemployment in the formal sector will coexist with under-employment in the informal agricultural and non-agricultural sectors. Hence, for any given unemployment rate, aggregate labour productivity increases when labour moves from the informal to the formal sector and/or from agriculture to either non-agricultural sector.[1]

The second modification is the incorporation of public investment in human capital (which occurs alongside the investment in and maintenance of physical infrastructure) that both enhances the productivity of unskilled labour in the formal sector and alters the supply of skilled labour across the economy as a whole.[2] Combined with a fully articulated fiscal structure this allows for the detailed evaluation of the impact of public investment programmes on inequality, growth, unemployment, and underemployment under alternative financing structures.

With these modifications in hand, we show that labour market structures matter, and do so beyond simply endowing the model with greater fidelity to the empirical facts of labour markets in developing countries. In particular, our results suggest that while steady-state levels of output, employment, consumption, and welfare are all higher in a world characterized by frictionless and fully integrated labour markets, the economic and welfare gains from increased public investment are substantially larger when labour market distortions

[1] This is consistent with the development economics literature reaching back to the work on economic dualism by Lewis (1954). For example, Doss et al. (2015) and Chen (2017) suggest 80–95% of land is untitled in most of sub-Saharan Africa. Ejidos in Mexico and public land in China and Vietnam are other examples of communal land tenure systems where the 'use it or lose it' principle applies. Chen (2017) and Gottlieb and Grobovsek (2019) analyse how such systems distort the allocation of labour in Malawi and Ethiopia, respectively. See also Wichern *et al.* (1999), Thurlow and Wobst (2005), Otsuka and Place (2001), and Otsuka (2007).

[2] In this article, we focus exclusively on public investment in education. Clearly private investment education also obviously enhances productivity and the supply of skilled labour. We return to this issue in the conclusions.

from unemployment and underemployment are present. Put simply, to the extent that public investment reduces the distortions present in the initial steady state, the stronger the economic response. This is particularly the case when the public investment programme is biased towards human capital, suggesting the optimal share of infrastructure in public investment should be lower in the presence of labour market distortions of the type that characterize developing countries.

The remainder of the article is organized as follows. Section 2 anchors the article in a brief survey of the empirical evidence on the structure of labour markets in developing countries. This review then informs the model specification and calibration which is briefly described in Section 3 (the Online Appendix provides a detailed discussion of the full model and its calibration). Section 4 examines the macroeconomic impact of public investment programmes, variously configured, under alternative representations of the labour market across steady states. Section 5 considers the transition dynamics for the same experiments and their implications for welfare, drawing out the central trade-offs involved in designing such public investment programmes. Section 6 concludes with some considerations for future work.

2. Labour market segmentation and efficiency wages

Labour markets in developing countries are highly varied and the empirical evidence on their structure and operation is not only vast but often contradictory. Here we highlight three central features of the evidence that are germane to the characterization we adopt in this model, namely: (i) the size of the formal sector wage premium; (ii) the prevalence of EWs in the formal sector; and (iii) the scale of the gap in labour productivity between agriculture and the non-agricultural informal sector. While competing theories cannot be ruled out, we suggest that EW models of the type developed in this article can explain these stylized facts in a parsimonious and compelling manner.[3]

2.1 The formal sector wage premium

Empirical estimates of the wage premium differ widely, not only across countries but also across studies of the same country, reflecting differences in the type and quality of data and the extent to which they control for self-selection, observable and unobservable characteristics, and workplace conditions. Nonetheless, the literature contains enough robust evidence to support the claim that the formal sector wage premium is ubiquitous and large, ranging from 10% to 30% at the low end to 70% to 150% at the high end. To give but one example, Funkhouser (1997) finds that the low-skill wage premium in El Salvador is 61% for females and 107% for males. Moreover, the data for both developed and less-developed countries (LDCs) show very high correlations of inter-industry wage differentials across *all* occupations, not just occupational groups that work closely together.[4]

2.2 Efficiency Wages in the formal sector

This evidence is consistent with EW effects as the *source* of the wage premium. EW models predict large firms would pay higher wages than small firms and that industry would pay more than agriculture. Fafchamps and Söderbom (2006) provide compelling evidence of EW effects in African manufacturing. Moreover, medium-scale and large firms reside mainly in the formal sector and over the past 20 years, empirical studies have amassed abundant, compelling evidence that EWs operate throughout the formal sector in LDCs.

[3] A substantially extended version of this review and argument can be found in Adam and Buffie (2020).

[4] In Brazil, for example, the correlation coefficient between the wage premiums for managers and security workers is as high as 0.896 (Abuhadba and Romaguera, 1993). Moreover, there is also a fair bit of evidence that workplace conditions are generally better in the formal sector than in the informal sector. Fields (2012) has this picture in mind when he avers that 'Apart from low earnings levels and lack of social protections, a large number of jobs [in the informal sector] are downright miserable.'

Estimates of the impact of unemployment on real wages confirm the existence of wage curves in Argentina, Chile, China, Colombia, Côte d'Ivoire, Mexico, South Africa, South Korea, Turkey, Uruguay, and a host of other LDCs (Blanchflower and Oswald, 2005). There is also powerful, if indirect, evidence supportive of EWs in the stylized facts documented in the many microeconomic studies of developing country labour markets. Again, see Adam and Buffie (2020).

2.3 Productivity gaps between the agricultural and informal sectors

Empirical studies of structural transformation provide a substantial body of (often contested) estimates on the scale of the productivity gap and hence the scale of the increase in aggregate labour productivity as labour moves from agriculture to other sectors, including the informal sector. Gollin *et al.* (2014) suggest the average productivity gap for the poorest quartile of countries is around three, after controlling for home production in agriculture, for differences in the cost of living and amenities, and for sector differences in hours worked and in human capital acquired from experience and schooling. Caselli (2005) and Restuccia *et al.* (2008) find gaps of a similar scale. Recent work focusing on the measurement of labour inputs—specifically the tendency for labour force surveys to systematically overstate hours worked in agriculture—suggests the average productivity gap may be around half the original estimates, but still large (e.g. Arthi *et al.* (2018) and McCullough (2017) on data from Ethiopia, Malawi, Tanzania, and Uganda). None of the studies cited above compute separate productivity gaps for the formal and informal sectors. Nonetheless, together with estimates of the formal sector wage premium, these estimates can be used to derive measures of the average productivity gap for the informal sector component of non-agriculture.

2.4 Summary

These stylized facts underpin the EW framing we adopt in this article. In the model developed in the next section EWs and open unemployment are a feature of the formal sector only, while the non-agricultural informal sector and agriculture sector form a flex-wage sector in which agricultural labour is paid its marginal value product *plus* a share of land rents and this anchors the wage in the non-agricultural informal sector. This particular structure can, however, be readily adapted to reflect the much broader variety of labour market structures that are present across different emerging market and developing countries including, for example, cases where involuntary unemployment is present in both the formal and non-agricultural informal sectors. We discuss these extensions in the concluding section.

3. The model

The full model and its calibration are set out in Buffie *et al.* (2020) and reproduced in the Online Appendix. Here we briefly describe the main features of the model, concluding with an extended discussion of the specification of the labour market and the role of public investment in education.

3.1 General structure

The economy consists of three sectors producing one traded and two non-traded goods: the traded sector, x, may be thought of as agriculture. Non-traded output consists of informal goods and services, j, and a formal good, n, which is a substitute in consumption with an imported good which, in turn, serves as the numeraire. All quantity variables except labour and land are detrended by $(1+\mathfrak{g})^t$, where $\mathfrak{g}$ is the exogenous long-run growth rate of per capita income, and t is the time index. Production, q, in all three sectors is represented by Cobb–Douglas production functions with constant returns to private factors:

$$q_{x,t} = a_x z_{t-1}^{\psi_x} k_{x,t-1}^{\alpha_x} S_{x,t}^{\theta_x} H^{\chi} (e_{b,t} L_{x,t})^{1-\alpha_x-\theta_x-\chi}, \tag{1}$$

$$q_{n,t} = a_n z_{t-1}^{\psi_n} k_{n,t-1}^{\alpha_n} S_{n,t}^{\theta_n} (e_{n,t} e_{b,t} L_{n,t})^{1-\alpha_n-\theta_n}, \tag{2}$$

and

$$q_{j,t} = a_j z_{t-1}^{\psi_j} k_{j,t-1}^{\alpha_j} S_{j,t}^{\theta_j} (e_{b,t} L_{j,t})^{1-\alpha_j-\theta_j}. \tag{3}$$

All sectors utilize capital k, low-skill labour L, high-skill labour S, and government-supplied infrastructure, z, which is a public good that enhances productivity in all sectors, albeit differentially. Land, H, is a sector-specific input in sector x. The productivity of low-skilled labour is enhanced by the quantity and quality of basic education, denoted by e_b. In addition, in the formal sector, where EW considerations apply, the productivity of low-skill labour also depends on work effort e_n (see below).

On the demand side, we adopt a conventional distinction between saving and rationed households both of whom have preferences defined over food (the agricultural good), informal goods and services, and formal goods, where formal goods are a composite of the domestic and imported varieties. Rationed households, denoted by the subscript $s = 1$, consist of unemployed individuals and low-skill workers in the agriculture and informal sectors. They live hand-to-mouth, consuming all of their income each period, which consists of net-of-tax labour income plus pro-rated shares of remittances, land rents in agriculture, and transfer payments from government. For future reference, and noting that individuals may leave or join this group, we define the members of this household group as the '*ex ante* poor'.

Capital owners, skilled labour, and low-skill labour in the formal sector make up the saving class, denoted $s = 2$. Savers' income consists of net-of-tax factor incomes, returns on financial assets (foreign and domestic bonds), and appropriately pro-rated shares of remittances, land rents in agriculture, and transfer payments. The saving household invests in physical capital and foreign bonds, both of which are subject to adjustment costs, and in domestic government bonds. With the capacity to save and borrow, this second group maximizes a standard iso-elastic utility function of the form:

$$V = \sum_{t=0}^{\infty} \beta^t \left(\frac{c_{s,t}^{1-1/\tau}}{1-1/\tau} \right), \tag{4}$$

where β is the discount factor; τ is the elasticity of intertemporal substitution; and c_s is the consumption of savers.[5]

The government spends on household transfers, debt service, and capital maintenance, and invests in infrastructure and public education.[6] It collects revenue from user fees for infrastructure services, from a conventional array of taxes, and from remittances. When revenues fall short of expenditures, the resulting deficit is financed through domestic and

[5] This dichotomy between saving and non-saving households, while conventional in the literature, is stark and has the implication that the ex ante poor begin to save only once they migrate from the informal to the formal sector or from being low-skilled to high-skilled. While this is probably a reasonable approximation of reality, this process can be formalized if we assume all households are 'saving households' but their behaviour is governed by a Stone–Geary utility function of the form $V' = \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t - \bar{c})^{1-1/\tau}}{1-1/\tau} \right)$ such that they save only when their income allows them to consume more than some reference level of $\bar{c}$, which is above per capita income in the informal sector. Critically, all the steady-state results discussed below are unchanged; the only difference is that the intertemporal substitution is now governed by $\tau(c_t - \bar{c})/c$ instead of τ.

[6] The productivity of public infrastructure capital may be compromised through a combination of inefficient public investment (see Berg *et al.*, 2019) and/or deficient maintenance expenditures, the consequence of which is accelerated capital depreciation.

external borrowing, some of which may be granted on concessional terms. Fiscal adjustment is achieved through the application of simple tax and spending rules. We discuss the public investment in education in the next sub-section.

Finally, the model is closed in a conventional manner. Flexible wages and prices equate demand to supply in the market for skilled labour, the market for low-skill labour, and the markets for the two non-traded goods, while the EW mechanism determines formal sector wages and equilibrium unemployment. The fiscal balance is satisfied through tax and debt adjustments depending on the fiscal rule, while overall external balance is satisfied when the (sustainable) growth in the country's net foreign debt equals the current account deficit.

3.2 The labour market and human capital formation

3.2.1 Labour demand, EWs in the formal sector, and unemployment

We start with low-skilled labour. Work effort of these workers in the formal sector depends on their own wage, the wage in the informal sector, and the unemployment rate u:

$$e_{n,t} = g_0 + g_1 \ln\left(\frac{w_{n,t}}{P_t}\right) - g_2 \ln\left(\frac{w_{j,t}}{P_t}\right) + g_3 \ln \mathrm{u}_t, \tag{5}$$

where

$$\mathrm{u}_t = \frac{\overline{L}_t - \sum_q L_{q,t}}{\overline{L}_t}$$

and $q = x, n, j$. Workers exert more effort when paid a higher real wage and when low pay in the informal sector and high unemployment increase the attractiveness of retaining their formal sector job.[7]

Firms in the formal sector recognize the connection between labour productivity/effort and the real wage, and therefore they optimize over both w_n and L_n. The profit-maximizing choice for w_n satisfies the well-known Solow condition

$$\frac{\partial e_{n,t}}{\partial (w_{n,t}/P_t)} \left(\frac{w_{n,t}/P_t}{e_{n,t}}\right) = 1. \tag{6}$$

Equations (5) and (6) imply $e_{n,t} = g_1$. Effort is constant in general equilibrium. Without loss of generality, we therefore set $e_n = g_1 = 1$ at the initial equilibrium. By this condition and equation (5), the wage curve defining formal sector wages is

$$\ln\left(\frac{w_{n,t}}{P_t}\right) = 1 - g_0 + g_2 \ln\left(\frac{w_{j,t}}{P_t}\right) - g_3 \ln \mathrm{u}_t. \tag{7}$$

In the set-up adopted here, EW considerations do not apply in the informal sector and agriculture, where self-employment and family-run farms predominate. These two sectors therefore form an integrated labour market with flexible wages. Total labour supply is inelastic at $\overline{L}_{xj}$, and workers move freely between the two sectors. Critically, however,

[7] Effort in equation (5) may be derived either as a general version of Shapiro and Stiglitz (1984), where effort is a continuous variable and the utility loss from being fired for shirking is increasing in the unemployment rate and decreasing in the informal wage, or by appending a separable term in the utility function that captures the non-pecuniary loss from effort (Collard and de la Croix, 2000; Danthine and Kurmann, 2004, 2010). Neither method affects the other first-order conditions associated with the solution to the household's optimization problem.

workers in the agricultural sector may retain some claim on land rents, claims that are forfeit if the worker leaves the family farm to seek employment in the (urban) informal sector. As a result, perfect, frictionless labour mobility does not guarantee that (shadow) wages and the value of the marginal product of labour are the same in sectors x and j. Rather, arbitrage in this integrated labour market ensures only that

$$(1 - f_{wj})w_{j,t} = (1 - f_{wx})\left(w_{x,t} + \sigma r_{h,t}\frac{H}{L_{x,t}}\right), \tag{8}$$

where f_{wj} and f_{wx} denotes labour tax rates and $0 \leq \sigma \leq 1$ denotes the share of land rents, $\sigma r_{h,t}H$, accruing to workers. When property rights are secure, so that $\sigma = 0$, net-of-tax wages in agriculture and the informal economy are equalized. However, when property rights are tenuous or non-existent in agriculture, $\sigma = 1$, labour receives its marginal value product (w_x) plus a share of land rents. It follows from this condition that where $\sigma > 0$ a reallocation of labour from agriculture to the informal sector increases aggregate labour productivity.[8] Wage rigidity and open unemployment in the formal sector thus coexist with multiple types of underemployment (in sector j relative to sector n and in sector x relative to both sectors j and n).

3.2.2 Sectoral labour supplies and migration

Two factors influence the sectoral supplies of low-skill labour. First, in aggregate, public investment in upper-level education (see below) converts some low-skill workers into high-skill workers so that:

$$\overline{L}_t = \overline{L}_0 - (S_t - S_0). \tag{9}$$

Some fraction of these new high-skilled workers is drawn from the unemployed and the remainder from the pool of low-skill workers in the agricultural/informal sector. The latter share is defined as Δ_{xj} in equation (10) below. The second factor is new job openings in the formal sector. Here we assume that workers in the combined x, j sector compete with the unemployed for jobs in the formal sector. Likewise, we assume that workers previously employed in agriculture and the informal sector obtain ξ% of newly created jobs in the formal sector. Thus low-skill labour in the x, j sector is defined as:

$$\overline{L}_{xj,t} = L_{x,t} + L_{j,t} = L_{x,0} + L_{j,0} - \Delta_{xj}(S_t - S_0) - \xi(L_{n,t} - L_{n,0}) \tag{10}$$

We discuss the calibration of Δ_{xj} and ξ in Section 3.3.

3.2.3 Public investment in human capital

The final element of the labour market is public investment in human capital. Education investments are specialized: that in upper-level education (senior years of secondary schooling plus post-secondary training) augments the supply of skilled labour, while basic education enhances the productivity of low-skilled labour. As noted above, both investment processes take longer to pay off than does investment in infrastructure. On the (admittedly restrictive) assumption that investment in education treats only new entrants into education, the time lag is 6 years for investment in basic education i_b and 8 years for investment in upper-level education i_u, which for depreciation rates δ_b and δ_u, implies[9]:

[8] Standard models of sharecropping introduces a similar wedge between w_x and the marginal value product of labour for the tenant.

[9] This will be true in steady state: it is of course a simple matter to allow for such investment to impact age cohorts simultaneously but differentially on the transition path.

$$S_{b,t} = i_{b,t-6} + (1-\delta_b)S_{b,t-1} \text{ and } S_{u,t} = i_{u,t-8} + (1-\delta_u)S_{u,t-1}. \quad (11)$$

Finally, fixed input–output coefficients ϕ_1 and ϕ_2 connect increases in education capital to the supply of high-skill labour S:

$$S_t = S_0 + \phi_1(S_{u,t-1} - S_{u,0}) \quad (12)$$

and the productivity of low-skill labour e_b:

$$e_{b,t} = 1 + \phi_2(S_{b,t-1} - S_{b,0}). \quad (13)$$

3.3 Calibrating labour market structures

Our labour market structure requires the calibration of five key sets of parameters.

3.3.1 Returns to education

Evaluated at the initial steady state, the shadow rental rate for basic education is:

$$r_b = (\lambda_x q_x + \lambda_n P_n q_n + \lambda_j P_j q_j)\phi_2 \quad (14)$$

where the λ parameters denote the effective labour shares in production in each sector $q = (x, j, n)$ and $\phi_2 = \frac{de_b}{dS_b}$ from (13). For upper-level education, the rental rate is:

$$r_u = [w_s(1-\Delta_{xj}) + (w_s - w_{xj})\Delta_{xj}]\phi_1, \quad (15)$$

where $\phi_1 = \frac{dS}{dS_u}$ from equation (12), Δ_{xj} is the share of new high-skilled workers drawn from the agriculture/informal sector, and w_{xj} is the weighted average wage in the agricultural and informal sectors. Net returns to basic and upper-level human capital are thus given by:

$$R_b = \frac{r_b}{P_s} - \delta_b \quad (16)$$

and

$$R_u = \frac{r_u}{P_s} - \delta_u. \quad (17)$$

where P_s is the supply price of skills.

Two points merit comment. First, R_b is a partial equilibrium return that does not take into account the impact of increases in infrastructure and higher productivity of low-skill labour on unemployment and underemployment. The general equilibrium returns, which incorporate these effects, and indeed the effect of induced increases in the private capital stock on labour demand, are much higher than R_b. The rationale for calibrating to partial instead of general equilibrium returns, however, is principally that it is estimates of the former that can be found in the empirical literature. R_u is also a partial equilibrium return: again, while this measure captures the *direct* gain from converting low-skill labour into high-skill labour, it too excludes the general equilibrium gains from increases in the supply of skilled labour and crowding-in of private capital which reduce unemployment and underemployment by raising the productivity of low-skill labour.

Secondly, because of the time lag that separates investment in education from the time at which returns are realized, R_b and R_u are necessarily higher than the (partial equilibrium)

internal rates of return (*IRR*) to basic and upper-level education. For a given R_u and gestation time t_1, the IRR_u is the value of ρ satisfying

$$\frac{R_u + \delta_u}{\rho + \delta_u} e^{-\rho t_1} = 1. \tag{18}$$

Clearly, as the gestation lag increases the wedge between *R* and *IRR* increases. For example, for R_u equal to 30% and a depreciation rate δ_u of 5%, the *IRR* decreases rapidly, dropping from 30% at $t_1 = 0$ to 12% at $t_1 = 6$ and to 9.1% at $t_1 = 10$. For any target value for the equilibrium IRR_u and gestation lag we can back out the implied value of R_u, and likewise for R_b. This correspondence is useful since most of the empirical literature is couched in terms of internal rates of return.

The empirical literature on returns to education in developing countries is substantial. Psacharopoulos and Patrinos (2004) compile estimates of private and social returns to education in 84 countries with estimated average social returns of 21.3% for primary education, 15.7% for secondary education, and 11.2% for tertiary education. More recent studies by Barouni and Broecke (2014), Montenegro and Patrinos (2014), and Peet *et al.* (2015) suggest an upward bias in Psacharopoulos and Patrinos (2004), especially for primary education.[10] Assuming comparisons of social returns would yield similar results, we chose an *IRR* of 12% for basic education and 10% for upper-level education. The associated value for R_u is then backed out from equation (18) for a time lag of 8 years. A similar procedure is applied to back out the value of the return to basic education R_b for a time lag of 6 years.

These *IRR*s are contested among labour and development economists. The mixed results on education variables in cross-country growth regressions and the extensive microeconomic literature on poor educational outcomes in LICs, suggest that *IRR*s are arguably much lower than the 10–12% considered here.[11] Given this uncertainty about the true returns to education in LICs, we also consider the implications for the optimal investment mix of reducing IRR_u and IRR_b to 5–8%.

3.3.2 Public investment in basic and upper education

Government expenditure on education is between 3% and 7% of GDP in the great majority of LDCs, of which approximately 40% of spending is on primary and pre-primary education and the remainder on secondary and tertiary.[12] Given our own classification of education spending, we allocate half of spending on secondary and tertiary education to basic education and the remainder to upper-level education, setting steady-state investment in each at 2.8% and 1.2% of GDP, respectively.

3.3.3 Unemployment rate

The unemployment rate in the model, $\mathfrak{u}$, is the *national* unemployment rate in the low-skill formal labour market. This is the conceptually correct definition of the unemployment rate, given that the informal sector and agriculture form an integrated labour market. The equivalent urban unemployment rate, calculated using the official government definition, is 12.9%.[13] Fox (2015) reports that the range is 11–15% in most of sub-Saharan Africa.

[10] See also Schultz (2004), Colclough *et al.* (2010), and Diagne and Diene (2011), where the estimated private return to primary education is 50–66% lower than the average estimate for LICs in the Psacharopoulos and Patrinos (2004) survey.

[11] For example, Pritchett (2001, 2006).

[12] World Bank Development indicators based on UNESCO Institute of Statistics.

[13] The urban labour force is $\bar{L}_0 - L_{x0} + S_0 - S_{x0}$.

3.3.4 Labour migration

Next we need to calibrate the share of new high-skill workers drawn from the pool of low-skill workers in the combined x, j sector, Δ_{xj}, and the fraction of newly created/vacant formal sector jobs filled by workers from this sector, ξ. Data do not exist to quantify either of these parameters, although it is reasonable to assume that ξ is large, and while there may be an urban bias in the supply of secondary and tertiary education, it seems unlikely that $1 - \Delta_{xj}$ will differ significantly from the formal sector share in the total supply of low-skill labour—i.e., $(L_n + L_u)/(L_n + L_u + L_x + L_j)$—which in the base case is equal to 11.1%. In the absence of empirical evidence, the values assigned to Δ_{xj} (0.80) and ξ (0.50) are therefore pure guesses.[14]

3.3.5 The wage curve

The final set of parameters describing labour market structures is those defining the wage curve, namely the elasticity of the real wage in the formal sector with respect to the unemployment rate, g_3, and the real wage in the informal sector, g_2. Estimates of wage curves in the formal sector place g_3 between 0.05 and 0.15 (see Adam and Buffie, 2020). For the base case, we chose the midpoint value of 0.10. The value for g_3 depends on the fraction of low-skill formal sector employees who, if they lose their job, are willing to work in the informal sector. We assume this is close to ξ (the fraction of newly created and/or vacant formal sector jobs filled by workers from the x, j sector). Hence we set $g_2 = 0.5$.

4. Simulation results: long-run effects

The general equilibrium interactions in the model are intuitive but also complex. We therefore proceed in two steps. First, to focus on the central insights of the model, we briefly describe the long-run general equilibrium effects of increasing each component of public investment one at a time, in infrastructure, basic education, and upper-level education, respectively. These insights then help us understand the results in the second step, where we explore blended investment programmes combining infrastructure investment with investment in human capital. In all these cases two-thirds of human capital investment is applied to basic education and one-third to upper-level secondary and tertiary education. It is at this stage we consider alternative labour market structures, comparing the behaviour of the model economy under the segmented labour market/EW structure outlined in the previous section with that under a conventional flex-price clearing labour market structure.

4.1 Preamble: increasing public investment components one at a time

Table 1 shows the steady-state impact of an increase in each component of public investment equal to 1% of initial GDP, holding the other components at their initial levels. Across the simulations, the VAT, all other taxes and recurrent maintenance expenditures (as a percentage of the public capital stock) as well as public debt ratios are held constant, so the net fiscal gain/loss required to satisfy fiscal balance across steady states is expressed in terms of the change in transfers (as a share of initial GDP). For each run, we report the results where the elasticity of substitution in consumption between the domestic formal sector good and imports is low, $\varepsilon_3 = 0.5$, so that the output of the formal sector is essentially non-traded, and where $\varepsilon_3 = 5$, so that the formal sector good is highly substitutable with

[14] Note that the calibration of Δ_{xj} depends in part on the assumed value for ξ. Suppose, for example, that investment in secondary and education converts thirty low-skill workers into high-skill workers, with eight workers drawn from sector n and 22 from sector x, j. If four of the eight workers drawn from sector n would have been unemployed, then four jobs open up in the formal sector. If $\xi = 0.5$, two of the jobs are filled by workers from x, j. Hence $\Delta_{xj} = 0.80$.

Table 1. Long Run Effects of Increased Public Investment

		Long-run effects of increasing individual components of public investment (Increase of one percent of initial GDP)									
		[a] Infrastructure		[b] Basic education		[c] Upper-level education		[d] Basic education		[e] Upper-level education	
	IRR [1]	$IRR_z = 20\%$		$IRR_b = 12\%$		$IRR_u = 10\%$		$IRR_b = 8\%$		$IRR_u = 5\%$	
	[2] [3]	$\varepsilon_3 = 0.5$	$\varepsilon_3 = 5$	$\varepsilon_3 = 0.5$	$\varepsilon_3 = 5$	$\varepsilon_3 = 0.5$	$\varepsilon_3 = 5$	$\varepsilon_3 = 0.5$	$\varepsilon_3 = 5$	$\varepsilon_3 = 0.5$	$\varepsilon_3 = 5$
Real GDP		4.6	5.1	10.1	10.1	6.2	9.1	7.3	7.3	4.7	6.9
Real aggregate consumption		3.8	4.3	10.3	10.2	6.5	9.3	7.1	7.0	4.6	6.7
Private capital stock		3.9	4.8	10.6	10.5	2.7	8.4	7.6	7.5	2.1	6.4
Sectoral output											
Agriculture		4.6	4.1	9.5	9.6	3.0	0.4	6.8	6.8	2.2	0.2
Formal sector		4.8	6.5	10.0	9.9	10.1	20.8	7.1	7.0	7.4	15.4
Informal sector		4.6	5.0	11.3	11.3	6.6	9.2	8.6	8.5	5.4	7.4
Sectoral prices	[4]										
Formal sector		−2.3	1.7	0.1	0.1	−13.6	−10.7	0.1	0.1	−10.4	−8.0
Informal sector		−0.2	0.2	−2.3	−2.4	−6.2	−4.3	−1.7	−1.7	−4.6	−3.2
Employment											
Formal sector		0.6	2.3	5.2	5.1	−4.2	6.9	3.6	3.5	−3.2	5.4
Informal sector		−0.1	0.6	−0.7	−0.8	−4.4	−0.3	−0.1	−0.2	−2.9	0.3
Agriculture		0.0	−0.4	0.0	0.1	−1.6	−4.2	−0.2	−0.1	−1.3	−3.3
Unemployment	[5]	6.0	5.9	5.8	5.8	5.7	5.3	5.9	5.9	5.8	5.5
Real wages											
Formal (unskilled)		2.8	2.7	5.2	5.2	6.3	6.5	3.8	3.8	4.7	4.7
Informal		5.5	5.2	10.0	10.0	12.0	10.7	7.2	7.2	8.9	7.8
Skilled		4.3	5.4	10.1	10.0	−29.0	−24.1	7.3	7.3	−22.6	−18.5
Fiscal adjustment	[6]	−0.35	−0.24	0.47	0.47	−0.64	0.02	0.03	0.03	−0.74	−0.23
Private investment crowding-in	[7]	0.52	0.65	0.98	0.97	0.25	0.77	0.70	0.70	0.19	0.59
Real income of 'ex ante' poor	[8]	5.50	5.40	10.30	10.30	18.00	18.10	7.40	7.40	14.00	13.90

Notes: [1] Initial internal rates of return to components of public investment; [2] Elasticity of substitution in consumption between domestic formal sector good and imported good; [3] Unless otherwise indicated, values reflect percentage change from baseline; [4] Sectoral real exchange rates (price of import good Pm = 1; [5] Unemployment rate; [6] Tax rates and debt-to-GDP are held constant between steady states so that fiscal adjustment is measured as required change in transfer to the private sector measured as percent of baseline GDP; [7] Crowding in measured as indicated private investment per unit of public infrastructure investment; [8] Real income of 'ex ante' poor includes income gains from ex ante poor who become skilled or obtain high-wage jobs in the formal sector.
Source: Authors' calculations.

the imported variety.[15] The first three columns correspond to baseline rates of return to public investment while in the final two we report the results when the returns to education are reduced.

Four key results that underpin the rest of the analysis stand out from this table. First, in the long run, investment in basic education strongly dominates investment in infrastructure. These gains result from mutually reinforcing general equilibrium effects: by increasing the productivity of unskilled labour and promoting balanced sectoral growth, education-biased public investment minimizes the decrease in prices in the formal sector P_n thereby promoting expansion in this sector. The boom in the formal sector, in turn, drives up the marginal product of private capital and fuels a boom in private capital accumulation and large secondary gains in aggregate labour productivity—the supply of good high-wage jobs, L_n increases by 5%. Strong crowding-in of private capital also lessens the toll of diminishing returns.[16] These effects are robust to the calibration values for the returns to education. Reducing the IRR from 12% to 8% in column (d) still sees consumption increase by 60–90% more and real income of the poor 35% more than under the scenario with investment specialized in infrastructure.

Second, investment in upper-level education also strongly dominates investment in infrastructure. Because it is the most skill-intensive sector in the economy, the formal sector benefits disproportionately from an increase in the supply of skilled labour. As with basic education, this result holds even with a reduced rate of return to upper-level education.

Third, the tradability of formal sector output plays a key role in determining the impact of investment in upper-level education on GDP, the supply of good high-wage jobs, and the government budget. Since the formal sector is far more dynamic than agriculture or the informal sector, the key constraint on the expansion in the sector is the decrease in its relative price. The elasticity of substitution for the formal good plays only a limited role in the case of investment in infrastructure or basic education, but it makes a big difference in the case of investment in upper-level education. The reason is that the more tradable is the formal sector good in consumption, the more the expansion in supply is against a relatively flat demand curve which limits the fall in the formal sector price.

Finally, the choice between investment in upper-level and basic education entails a growth-inequality trade-off. A straightforward comparison of GDP or consumption favours investment in basic education, but because of its role in raising skill levels across the economy as a whole, investment in upper-level education does more to reduce poverty: real income of the *ex ante* poor increases an additional 8 percentage points both for $\varepsilon_3 = 0.5$ and $\varepsilon_3 = 5$. In the latter case, where the GDP differential is small, investment in upper-level education is certainly competitive with if not superior to investment in basic education.

4.2 Core results: blended investment and labour market structures

We now take these core insights to bear on our principal results. Table 2 quantifies the long-run effects of investment programmes that results in a step increase in steady-state public investment from 10% to 14% of initial GDP. Columns (a) and (b) consider an infrastructure-only programme, columns (c) and (d) a human capital-only programme, and (e) and (f) a blend of 40% infrastructure and 60% human capital investment.[17] Columns (a), (c), and (e) report the case for the segmented labour market, while (b), (d), and (f) reports results for an 'undistorted' integrated labour market. The integrated labour market has a single market-clearing unskilled wage, such that $w_n = w_j = w_x$, the EW mechanism is

[15] Macroeconomic models commonly calibrate the elasticity of substitution between domestic manufactured varieties and imported varieties of goods at around 10. In the case where half of formal output is non-traded, this implies an overall elasticity of substitution between formal sector output and imported consumer goods of 5.

[16] Across steady states, the returns to investment in infrastructure drop 14–15%; for investment in basic education, the return decreases only 6% (from 30% to 28.1%).

[17] In the latter two cases, two-thirds of investment is applied to basic education and one third to upper-level secondary and tertiary education.

Table 2. Long Run Effects of 'Big Push' Public Investment Programmes

		Long-run effects of 'big push' public investment programme (Increase of four percent of initial GDP)					
		[a]	[b]	[c]	[d]	[e]	[f]
		Infrastructure only		Basic and upper-level education		Infrastructure, basic and upper-level education	
		Infrastructure = 4%		Infrastructure = 0%		Infrastructure = 1.6%	
		Basic = 0%		Basic = 2.67%		Basic = 1.6%	
		Upper 0%		Upper 1.33%		Upper = 0.8%	
	Notes [1], [2]	Integrated	Segmented	Integrated	Segmented	Integrated	Segmented
Real GDP		13.7	14.3	38.7	40.2	31.2	32.5
Real aggregate consumption		10.7	11.4	39.0	40.8	30.6	32.1
Private capital stock		12.9	13.3	39.1	39.8	31.3	31.9
Sectoral output							
Agriculture		11.9	11.6	25.8	25.0	22.2	21.5
Formal sector		16.1	18.0	52.6	58.0	41.6	46.0
Informal sector		13.9	14.2	42.7	43.3	33.4	33.9
Sectoral prices	[3]						
Formal sector		−3.4	−4.6	−10.5	−13.1	−8.5	−10.7
Informal sector		0.2	0.4	−10.9	−10.6	−7.2	−6.9
Employment							
Formal sector		−0.5	6.5	4.1	21.3	3.2	17.5

(continued)

Table 2.. (continued)

		Long-run effects of 'big push' public investment programme (Increase of four percent of initial GDP)					
		[a] [b] Infrastructure only		[c] [d] Basic and upper-level education		[e] [f] Infrastructure, basic and upper-level education	
		Infrastructure = 4%		Infrastructure = 0%		Infrastructure = 1.6%	
		Basic = 0%		Basic = 2.67%		Basic = 1.6%	
		Upper 0%		Upper 1.33%		Upper = 0.8%	
	Notes [1], [2]	Integrated	Segmented	Integrated	Segmented	Integrated	Segmented
Informal sector		1.4	1.6	−3.1	−2.9	−1.4	−1.1
Agriculture		−0.6	−1.1	−4.0	−5.2	−2.7	−3.7
Unemployment	[4]	0.1	5.8	−0.9	4.7	−0.5	5.0
Real wages							
Formal (unskilled)		14.1	7.6	40.3	22.5	32.1	17.8
Informal		14.1	14.8	40.3	42.7	32.1	33.9
Skilled		14.2	15.1	−13.0	−11.6	−3.2	−1.8
Fiscal adjustment	[5]	−1.06	−1.02	1.29	1.34	0.74	0.79
Private investment crowding-in	[6]	0.56	0.58	0.88	0.92	0.84	0.89
Real income of 'ex ante' poor	[7]	14.13	15.28	55.23	58.88	42.61	45.31

Notes: [1] Initial (partial equilibrium) returns to public investment set to baseline estimates (IRR infrastructure = 20%; basic education = 12%; upper-level education = 10%). [2] Unless otherwise indicated, values reflect percentage change from baseline; [3] Price of tradable agriculture is numeraire (Px = 1); [4] Unemployment rate (with baseline $u = 6.0\%$ in segmented labour market case and 0.1% in integrated labour market case); [5] Tax rates and debt-to-GDP are held constant between steady states so that fiscal adjustment is measured as required change in transfer to the private sector measured as percent of baseline GDP; [6] Crowding in measured as indicated private investment per unit of public infrastructure investment; [7] Real income of 'ex ante' poor includes income gains from ex ante poor who become skilled or obtain high-wage jobs in the formal sector.
Source: Authors' calculations.

switched off, and new formal sector jobs are sourced from the informal sector in proportion to the distribution of skills.[18]

As indicated in Table 2, investing only in infrastructure is highly inefficient in comparison with the gains generated by programmes that invest entirely or partly in human capital. For the same aggregate investment, a human-capital only or a blended programme increases total consumption by a further 16–26 percentage points, real wages in the informal sector by 10–25 percentage points, and real income of the ex ante poor 28–44 percentage points, respectively, above that achieved for an infrastructure-only programme. While the all-human-capital programme in columns (c) and (d) generates significantly larger increases in output, consumption, and real income of the poor than the programmes in columns (e) and (f), we know investment in human capital affects productivity with a long lag: as we show in the next section, the blended investment programme delivers larger development gains than the all-human-capital programme over an extended medium run.

While the volume and composition of public investment are the primary drivers of growth and structural change, labour market structures also play an important role. Before discussing these, we note that it is trivially the case that the *level* of output, consumption, capital stocks, and welfare are all unambiguously higher in the initial steady-state when labour markets are fully integrated than when they are segmented. Across steady-states, however, and precisely because of the pre-existing distortions in the steady-state, *increases* in aggregate output and consumption from these different initial levels are around 4% higher with segmented labour markets compared to under flexible labour markets. Formal sector employment growth is substantially higher, while the income of the *ex ante* poor rises by around 6–8% more.

These more favourable steady-state outcomes under segmented labour markets reflect three principal channels. The first is that the EW structure bears down on the formal sector real product wage, which means the supply curve for labour to the formal sector is more elastic than when the labour market is integrated.[19] This drives up the demand for unskilled labour and hence output in the (relatively more productive) formal sector. Second, the gains from reducing open unemployment and underemployment raise the social returns to public investment above the return achievable in the integrated labour market case as some of the *ex ante* poor are drawn into the formal sector, particularly from the agricultural sector. Third, these effects stimulate a stronger private investment response—the crowding-in effect—further strengthening the demand for labour in the formal sector. Importantly, by working together these effects mean both greater aggregate output and greater wage convergence—leading to reduced income inequality—compared to the flex-wage structure. Though not shown here, these effects are consistently stronger (across all programmes) the more tradable the formal sector is, so that its expansion is not choked off as much by the fall in the price of the non-tradable good.

5. Transition dynamics and welfare

5.1 Transition paths

The comparative static results are relatively unambiguous: over the long-run, blended programmes biased towards investment in human capital generate large output and consumption gains, and these are stronger when the investment occurs in the (realistic) context of segmented labour markets with open unemployment and underemployment. The different dynamics of investment in infrastructure compared to human capital, however, sets up

[18] To implement this structure in the model we 'switch off' the wage curve by setting the elasticity of the real formal sector wage with respect to unemployment to zero ($g_3 = 0$) and that with respect to the real informal wage to unity ($g_2 = 1$). To remove the under-employment wedge we restore the assumption of secure property rights by setting $\sigma = 0$ and set the initial unemployment rate arbitrarily low ($u_0 = 0.1\%$).

[19] The real wage in formal sector, w_n rises when L_n increases, but by less than in the integrated labour market case.

important tensions along the transition path, tensions that have implications for welfare. Here we briefly describe the key features of the transition paths of the all-infrastructure and all-human capital investment programmes before turning to a more systematic representation of the welfare implications (see Fig. 1).[20]

The transition paths between steady-states make three fiscal assumptions. First, infrastructure projects are 'shovel-ready': returns to infrastructure are realized only one period after the investment takes place. This may be unrealistic but even complex infrastructure investment projects are likely to come on stream substantially quicker than most human capital investments: what matters here is that the returns to human capital investment are heavily deferred relative to those from infrastructure investment. Secondly, domestic political economy considerations place limits on the degree of domestic fiscal financing so that overall feasibility requires substantial external (concessional) financing. Specifically, we assume that the VAT rate cannot increase by more than 2 percentage points above its initial level (of 20%) and that government is unable to reduce transfers to households by more than 1 percentage point of initial GDP. Thirdly, however, we allow for fiscal reforms to broaden the tax base so that over a period of a decade a steadily increasing proportion of domestic consumption of the agricultural and informal goods is taxed.[21] The implication of these assumptions, given the scale of investments, implies concessional borrowing equivalent to 24% of initial GDP over 8 years, which is repaid over the next 14 years, with a blend of non-concessional external and domestic borrowing delivering the residual fiscal financing.[22]

The key point to emerge from the transition paths is the strength of the intertemporal trade-off hinted at earlier. The more the public investment programme is skewed in favour of investment in human capital, the stronger long-run growth, structural transformation, and poverty reduction, but the weaker is the corresponding gains in the short run. Thus while output and consumption per capita and real wages for both formal and informal sector workers grow by about twice as much after 40 years when investment is specialized in human capital, the gains over the first decade are pretty nugatory. Private investment slumps, total consumption, and real wages stagnate, and there is no measurable improvement in the incomes of the ex ante poor. Only when the returns to education start to flow does private investment surge, growth take off and structural change begin to occur. The qualitative nature of this trade-off is present regardless of how we characterize labour markets, although as we note below there are important quantitative differences.

The key driver is the change in the supply and productivity of labour which, in turn depends in important respects on the assumed structure of the labour market. During the gestation period, investment in human capital leaves the supply side of the economy unchanged so that with no change in the productivity of aggregate labour, the spending effect of the debt-financed increase in aggregate demand dominates, the real exchange rate appreciates and production and consumption shift away from the tradable (agricultural) sector and the formal sector toward the non-traded informal sector.[23] By contrast, when the public investment programme is channelled to physical infrastructure, the complementarity of public capital with private factors *increases* the demand for labour in the formal sector, moderating the real exchange rate appreciation and associated movement out of the tradable sector, stimulating earlier growth.

But as the effects of education yield fruit in the medium term, three things happen, at least in the presence of segmented labour markets. First, upper-level education increases the

[20] The transition paths correspond to column (a), $\varepsilon_3 = 5$ and column (c), $\varepsilon_3 = 5$, respectively.
[21] The tax base widens from 10% of agricultural consumption to 30% and from 30% to 60% of the non-agricultural informal good.
[22] In the base run, 30% of the residual financing gap is met from external concessional borrowing with 70% from domestic borrowing.
[23] The contraction of the formal sector is much weaker when the formal good is effectively non-tradable, i.e. when $\varepsilon_3 = 0.5$.

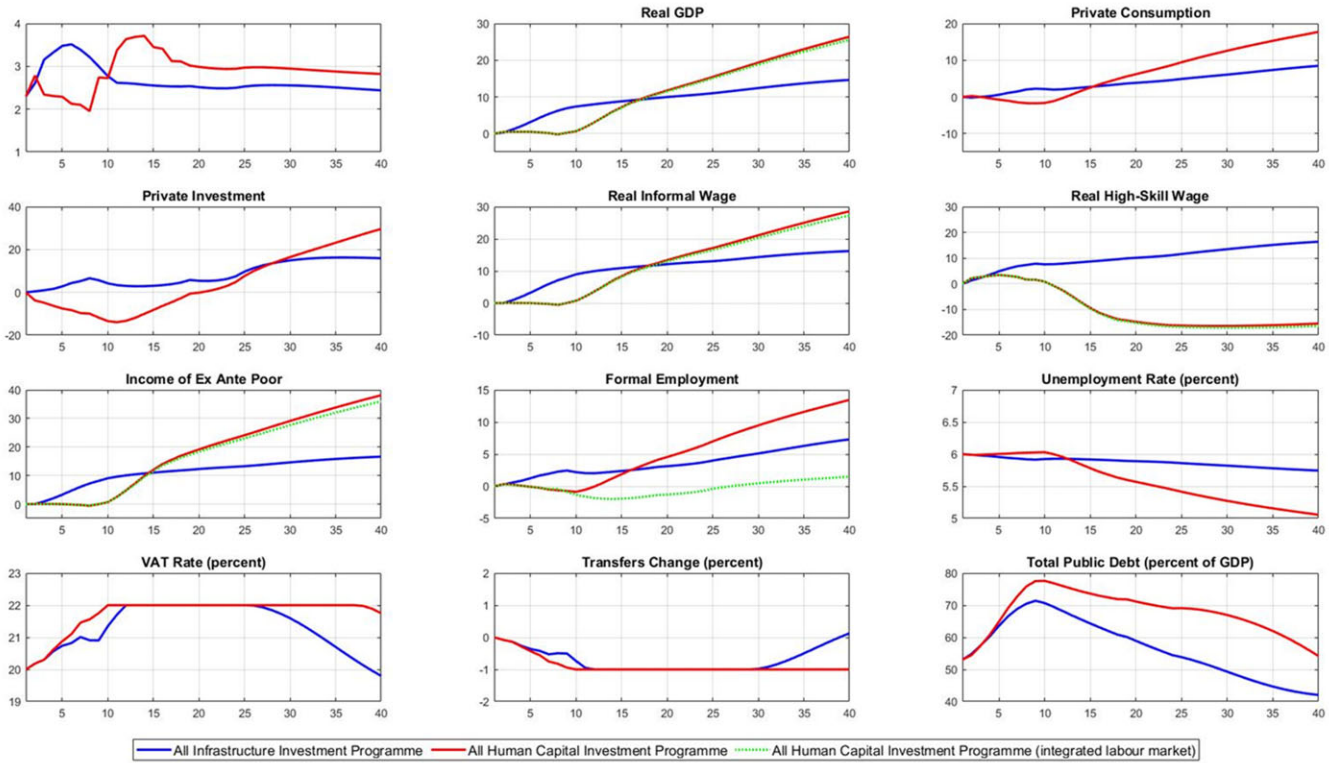

Fig. 1. Transition paths for all-infrastructure and all-human capital (education) investment programmes.

Notes: Variables expressed as percentage deviations from initial steady state, unless otherwise noted. All-infrastructure and all-human capital investment programmes correspond to columns (b) and (d) of Table 2, respectively. All human capital investment programme (integrated labour market) corresponds to column (c) of Table 2. Transition paths for variables where the deviation between segmented labour market and integrated labour market settings are small are omitted for convenience.

supply of skilled labour available to all three sectors, with the relatively skill-intensive formal sector enjoying the strongest boost. Since in our setup there is no unemployment of skilled labour, the increase in supply sees a sharp decline in the skilled wage premium. Secondly, basic-level education increases effective unskilled labour to all three sectors and further strengthens output growth across the economy. Together, both labour supply effects drive up the marginal product of capital further, boosting private investment. Finally, but only in the segmented labour markets case, the combination of upper-level education converting unskilled labour into skilled labour, the decline in unemployment, and rising labour productivity from basic education across all sectors see the incomes of the ex ante poor rise sharply and more rapidly than aggregate income.

The crossing point in this experiment is around year 15, some 6–7 years after the returns to education first hit the economy (although the private sector investment response is somewhat more attenuated). Though the benefits are large, this is a long time to wait. Of course, if public investment in education begins to pay off more rapidly, for example, if students at all grades rather than just the entry cohort benefit from higher spending, and/or infrastructure spending takes longer before it starts to generate returns, the crossing point comes earlier and the difference between the two programmes becomes less stark.

An important feature of the transition paths is a substantial fiscal burden, especially when the gestation period is long. Unless we assume an implausible degree of domestic fiscal flexibility, this requires large external resource flows which, in the absence of unrequited aid grants, means external debt financing is required to fill the gap. In the case shown here, though the investment cost is comparable across programmes, the all-human capital public investment programme sees the tax rate and transfers hit their limits sooner and stay there longer while the total public debt burden is around 8–10 percentage points of GDP higher for almost 40 years compared to the infrastructure-only case. This is for a relatively favourable fiscal configuration. Concessional financing is available on generous terms,[24] reliance on non-concessional debt is limited (it rises by 2 percentage points of initial GDP during the investment phase, and by a further 2 percentage points during the period concessional debt is being repaid), while the expansion of the tax base generates an additional 2% of GDP in revenue. Even so, with this structure, total public debt peaks at around 80% of GDP (relative to an initial level of 55% of GDP) in the human capital-only public investment programme and at 70% in the infrastructure-only public investment programme. Faced with reduced access to concessional borrowing and less effective base expansion, the fiscal programme would quickly be rendered infeasible, especially if the government faced a rising risk premium on commercial debt.

These results are moderated but qualitatively very similar should we consider the blended investment programme. Blending necessarily operates on both ends of the trade-offs: with less human capital investment in the mix, the long-run gains are reduced, but at the same time the tendency towards up-front stagnation is somewhat diminished. In contrast to the all-human capital case, the mixed investment programme avoids outright contraction in consumption.

Returning to the issue of the labour markets, while the transition dynamics are determined primarily by the strength of the consequences of the growth in labour supply, but two features stand out (Fig. 1). The first is that the larger gains under segmented markets observed across steady states only begin to emerge strongly when the supply-side effects of the education investments start to be felt. Secondly, however, when they do materialize, the ranking is unambiguous: informal and formal sector wages at all skill levels are higher in the presence of EWs across all horizons which, in turn, contribute favourably to the (aggregate) earnings of the *ex ante* poor, again at all horizons. Driving these changes is the EW

[24] The rate of interest is 1.3% against a market rate of 6%, and repayment commences after 9 years.

structure that limits the wage effects of the education investment-induced labour demand in the unskilled formal sector taking root.

5.2 Welfare

These transition paths throw into sharp relief the powerful intertemporal trade-offs that must be negotiated when considering investment in slow-maturing human capital. Even when long-run returns are high and certain, policymakers must steer the economy through a protracted period of low growth and a heavy fiscal burden before reaping the positive growth and distributional gains that investment in human capital will deliver. Whether it is in their interest to do so will, of course, depend on how heavily they discount the future and how much weight they place on the poverty reduction engineered by investment in human capital. In order to explore these choices in more detail we need to turn to some welfare calculations.

Our model is not built from a detailed household- or group-level disaggregation. Given this, a natural way to incorporate the welfare effects of poverty reduction among the *ex-ante* poor is to include their consumption in the social welfare function in a manner that reflects an aversion to inequality, in the spirit of Atkinson (1970) or Shorrocks (1980). We therefore define social welfare as a function of $c_t + \zeta c_t^{eap}$, where c_t is total consumption, c_t^{eap} is the consumption of the *ex ante* poor, and ζ is a measure of the relative welfare weight placed on the consumption of this latter group. Section 1.6 of the Online Appendix provides a detailed derivation of this aggregate and shows that $1 + \zeta$ measures the marginal rate of substitution in utility terms between consumption of the '*ex ante* poor' and the consumption of the non-poor in social welfare. We embed this composite in the social welfare function:

$$SW = \sum_{t=0}^{\infty} \beta_s^t \frac{(c_t + \zeta c_t^{eap})^{1-1/\tau}}{1 - 1/\tau}, \tag{19}$$

where β_s is the *social* discount factor and τ is the elasticity of inter-temporal substitution in consumption. Three comments are in order. First, since the model does not allow us to directly observe the consumption of the *ex ante* poor within total consumption c_t, we rely on the income of this group, y_t^{eap}, to proxy for their consumption. Given that some members of the *ex ante* poor (i.e. those who secure jobs in the formal sector) will find it optimal to save following the public investment surge, using their income to proxy for their consumption will tend to marginally *understate* the welfare gains of this group.[25] Given the amount of between-group movement, this approximation error is small. Second is the choice of social discount factor, β_s. In both developed and LDCs, the social discount factor used to calculate the cost-benefit ratio for public sector projects is usually much higher than the private counterpart. Here we let the social discount factor to range from the private rate, $\beta_s = 0.93$ to $\beta_s = 0.98$, which spans the range cited in Hurst (2019) and recommended by UK Government's *Green Book* guidelines HM Treasury (2018) for public investment. Finally, we allow the weight on the consumption of the *ex ante* poor to range from $\zeta = 0$, to $\zeta = 1$, and $\zeta = 2$.

Table 3 reports welfare gains arising from investment programmes in which we vary the share of investment in physical infrastructure (i_z) and human capital. In all cases, we hold constant the split between upper-level education (one-third) and basic education (two-thirds) and then vary the split between investment in physical infrastructure and in the composite human capital. The top panel reports welfare gains when the investment programme is implemented under conditions of a flex-wage, full-employment, competitive labour market, with the weight on the welfare of the '*ex ante* poor', $\zeta = 0$, while the remaining three panels correspond to the segmented labour market/EW structure for alternative values of ζ,

[25] See Online Appendix 1.6 for details.

starting with $\zeta = 0$ to correspond with the top panel. The cell values are the compensating variation based on the social welfare function (19).[26]

The welfare results are consistent with the patterns observed on the transition path. First, when the social discount rate is the same as the private ($\beta_s = \beta = 0.93$), between a half and a quarter of the welfare-optimal investment programme consists of investment in physical infrastructure, regardless of the assumed structure of the labour market. As the policy maker places more weight on the future, the effect of the gestation lags in human capital weigh less heavily on the welfare calculus and the optimal share of physical infrastructure falls away, decisively below 25% when β_s is 0.97 or higher. Secondly, the more weight policymakers place on the consumption of the *ex ante* poor so that $\zeta = 1$ or $\zeta = 2$, the more human capital investment features in the optimal programme. Even at a social discount factor of $\beta_s = 0.95$ – towards the bottom end of the range—the optimal spending mix involves at most 25% investment in infrastructure and at least 75% in human capital, which generates substantially larger social welfare gains (the compensating variation is approximately twice as large). Although not reported here, as the estimated returns to human capital decrease, the welfare gains from mixed investment programmes decline and the optimal share of infrastructure rises. For example, if the *IRRs* for basic- and upper-level education are reduced from 12% and 10%, respectively, to 9% and 8%, respectively, the optimal infrastructure share in investment rises to between 35% and 50% for $\beta_s = 0.95$. It is striking, however, that these welfare surfaces are very flat and so it would require a mixture of substantial pessimism on the returns to education, comparatively high social discounting, and a low weight on poverty reduction, along with a complete disregard of the merit-good returns to education, to overturn a welfare-based argument that the optimal public investment programme should be built around significant investment in human capital.

Finally, as can be seen from a comparison of the results in the first and second panels of Table 3, the welfare effects arising from a public investment boom are sensitive to the presumed structure of labour markets. Since everything else in the model structure and experimental design is invariant across these panels, the differences between the welfare gains in the second and first panels provide a direct measure of how much additional leverage accrues to public investment in circumstances where it reduces unemployment and underemployment. The comparison presented here is for the case where $\zeta = 0$, but these carry through to the $\zeta = 1$ and $\zeta = 2$ cases as well.

Three principal results stand out. First, while the overall pattern is similar, the welfare gains from public investment are universally *lower* under a full employment flex-wage labour market, regardless of the composition of investment and the baseline returns to infrastructure and education. The additional welfare gains to the reduction of labour market distortions are large: compare, for example, the $\beta_s = 0.93$ case under the baseline returns (i.e. column 1 of the first two panels) where the gains range from 65% when the share of physical infrastructure in the programme is zero to 13% when the infrastructure share is 100%. Second, these gains are larger in absolute terms when public investment is biased towards human capital and, for any share of infrastructure, these gains increase as the social discount rate falls (i.e. the discount factor tends to unity), reflecting the greater weight now placed on gains to increased employment that take time to materialize. Third, a corollary of the above is that compared to the flex-wage case, the optimal public investment programmes in the context of labour market distortions consist of substantially larger proportions of human capital investment: recognizing labour market distortions leads the policymaker to place proportionally more weight on human capital investment, regardless of the returns. Taken together, these results suggest that ignoring key structural features of the labour market in developing countries may impart a significant bias against the inclusion of human capital in public investment programmes.

[26] We restrict the reporting to cases where the formal good is tradable ($\varepsilon_3 = 5$). The results are robust to variations in this parameter.

Table 3 Comparison of welfare gains

Infrastructure share (%)	Welfare weight on ex ante poor	Social discount factor 0.93	0.95	0.97	0.98
Integrated labour markets					
0	0	2.3	4.6	9.2	13.4
25		3.0	5.2	9.5	13.4
50		3.4	5.4	9.2	12.5
75		3.4	5.0	8.1	10.6
100		3.0	4.1	6.1	7.6
Segmented labour markets					
0	0	3.8	6.7	12.3	17.3
25		4.3	7.0	12.1	16.6
50		4.3	6.7	11.1	14.9
75		4.0	5.9	9.3	12.1
100		3.4	4.6	6.7	8.3
0	1	5.6	9.0	15.3	20.8
25		6.0	9.2	14.9	19.9
50		6.1	8.8	13.7	17.9
75		5.8	7.9	11.6	14.7
100		5.1	6.4	8.6	10.3
0	2	6.4	9.9	16.6	22.3
25		6.8	10.1	16.1	21.3
50		6.8	9.7	14.9	19.2
75		6.5	8.8	12.7	15.8
100		5.8	7.2	9.5	11.1

Notes: Cell entries report the value of the Social Welfare Function (Equation 19) under alternative characterizations of the labour market for variations in the share of infrastructure in the public investment programme (the rows within each panel), the weight on the welfare of the 'ex ante' poor, and the social discount factor (the columns within each panel). The increase in aggregate public investment is common across all experiments at 4% of initial GDP while the relative shares between investment in basic and upper-level education is held constant at two-thirds basic and one-third upper-level. Internal rates of return to public investment are 20% for infrastructure, 12% for basic education, and 10.3% for upper-level education (see text for details). All runs assume the elasticity of substitution in consumption between domestically produced formal goods and imports is high. The shading picks out the maximum value for each column by panel.
Source: Authors' calculations.

6. Conclusions

We have developed a model that reflects some of the key features of labour markets in low-income developing countries, namely segmented labour markets, widespread underemployment in agriculture, and involuntary unemployment in the formal sector. Using this model we examine how big-push public investment programmes with different mixes of investment in human capital and infrastructure affect growth, debt, and various dimensions of inequality and poverty. Our analysis draws attention to three main considerations. The first is that when the returns to public infrastructure investment and to investment in human capital align with the central estimates from the empirical literature, there is a strong case for a substantial share of public investment to be devoted to strengthening the provision of basic and upper-level education, particularly if concerns about income inequality are salient. Second, we show that a failure to reflect key structural characteristics of labour markets in low-income countries significantly understates the general equilibrium returns to public investment, particularly in human capital. Finally, however, since the gestation lags in building human capital typically far exceed those associated with building physical infrastructure, the more public investment is biased towards education the lower are the

short-term returns to investment and the greater the fiscal pressures—in terms of higher debt and domestic taxation—the authorities must navigate over the medium term. If governments are too myopic then these higher long-term social returns may not be realized.

We close with some comments on two modelling choices we have made, concerning the decision to focus exclusively on public investment in education and the specific characterization of the labour market.

First, the model presented here assumes that all human capital investment is undertaken by the public sector in a manner that exogenously augments the effectiveness of unskilled labour, in the case of basic education, and the quantum of skilled labour, in the case of upper-level education, where investment in the latter also pulls workers out of the unskilled labour pool. Education in this set-up is a pure public good: households are 'treated' by the education process which impacts their optimal consumption, saving, and physical investment decisions but they do not choose the quantity or quality of human capital to accumulate. While our structure reflects the dominant role of direct public sector provision of education in driving human capital formation in many low-income countries and as such is relevant to the public policy question we are concerned with here, it clearly misses important interactions between public and private provision. There are a number of ways in which private investment in education could be incorporated into this framework. One straightforward approach is proposed by Atolia *et al.* (2019), who allow for the effectiveness of public investment in education to be a function of the amount of labour households devote to accumulating education, the opportunity cost of which is the prevailing wage. The tractability of this approach, however, benefits from the single-sector, single-representative agent structure: extending this to allow for the greater heterogeneity across productive sectors and household types—so that different agents may accumulate human capital at different rates—and, importantly, allowing for the possibility that public and private education may differ in terms of quality, would entail a sharp step up in model complexity. While the particular focus of this article on labour market structures suggests this added complexity is not warranted here, developing full-blown dynamic general equilibrium models that allow for the co-existence of private and public investment in education is an important research agenda.

Finally, while the model presented here reflects the dominant structures present in the least developed economies, the empirical evidence on labour market structures across all developing countries is much more nuanced. For example, there is plenty of evidence of wage curves also being present in the informal sector, particularly in middle-income developing countries. While informal sector wages in these settings are still more responsive to the unemployment rate than wages in the formal sector, they are far from being fully flexible and market clearing. As shown in studies of labour market dynamics in Central and Latin America by Neri (2002), Berg and Contreras (2004), Bosch and Maloney (2010), Ulyssea (2010), large movements into and out of unemployment during booms and recessions are common; salaried jobs in the informal sector showed high rates of separation toward unemployment and inactivity; while transitions out of informal sector employment contributed *much more* to unemployment than transitions out of formal sector employment. There is also some direct evidence of job rationing in the informal sector (Kingdon and Knight, 2004; Nattrass and Walker, 2005; Heintz and Posel, 2008). Primarily, a majority of the unemployed could not find work; the reservation wage of the unemployed is far below their predicted earnings; and job refusals are rare. It is straightforward to reflect these characteristics in this class of models by allowing EWs to prevail in both the formal and non-agricultural informal sector (Buffie *et al.*, 2020). Equally, however, our structure can readily be modified to allow for unemployment/underemployment of high-skill labour; for wage and productivity gaps to exist between estate and smallholder agriculture;[27] and for binding minimum wage laws (Adam and Buffie, 2020). This list is not exhaustive. In some

[27] The estate sector accounts for a large share of agricultural output in much of Latin America and parts of sub-Saharan Africa. Typically wages and labour productivity are substantially higher than on smallholder farms.

environments it may also be important to allow for external migration of skilled labour or to explicitly model public sector employment, for example when privatization or downsizing of the parastatal sector is part of a programme to create more fiscal space for core investments in infrastructure and education.

Supplementary material

Supplementary material is available on the OUP website. These consist of an Online Appendix containing the full model description and detailed model calibration.

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