Dualism and aggregate productivity*

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Abstract

This paper shows how to calibrate a two-sector general equilibrium model of production using a small number of parameter assumptions and readily available data. The framework is then used to analyze the costs of labor market dualism. The paper quantifies the effects of rural-urban wage differentials and urban unemployment on aggregate productivity, wages and returns to capital, factor shares, and sectoral structure. One of the main findings is that labor market rigidities can have a major impact on the extent of industrialization.

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1 Introduction

The aggregate consequences of certain labor market distortions are not well understood. This paper will analyse the effects of one particular type of distortion, namely a wage differential between rural agriculture and an urban non-agricultural sector. This form of dualism has been much studied in development economics and the theory of international trade, and a number of potential effects have been identified, together with policy measures that could eliminate dualism. Yet we know remarkably little about the likely magnitude of the various effects, or the gains to be expected from policy intervention.[1]

The paper provides a simple framework for examining these questions. The paper first shows how to calibrate a two sector general equilibrium model of production, in a way that is undemanding in terms of both data requirements and parameter assumptions. The paper describes assumptions under which unobserved technology parameters and the intersectoral allocation of capital can be recovered from data on sectoral output and employment shares. As I will discuss below, this approach has a variety of potential applications. At least in principle, it shows that researchers studying growth and development issues could use the general equilibrium models of trade theory to move beyond the artificial simplification of an aggregate production function.

The paper uses the calibration results to examine the aggregate effects of labor market dualism in developing countries. The main focus will be the consequences of dualism for aggregate total factor productivity (TFP). It is well known that, for countries at an early stage of development, the marginal product of labor is likely to differ across sectors, and perhaps especially between rural agriculture and the urban sector. If the marginal product of labor is higher in one sector than another, this implies that aggregate TFP could be raised by a reallocation of labor to the sector where it has higher marginal productivity. The paper quantifies this effect, and also considers the rarely studied effects of dualism on sectoral structure, wages and returns to capital, and the distribution of factor income. The effect on TFP is of especial interest given recent work highlighting the wide variation in TFP across countries (see Hall and Jones 1999, Klenow and Rodriguez-Clare 1997 and Prescott 1998 for major contributions).

The paper's findings suggest a new view of the costs of dualism. First of all, and contrary to the intuition of some economists, the paper shows that even sizeable intersectoral differentials in the marginal product of labor have only modest effects on aggregate TFP and output, at least if the elasticity of substi-

[1] See for example Freeman (1992, 1993), who argues that not enough is known about the magnitude of the distortions associated with labor market imperfections.

tution in production is low. This finding is consistent with previous research, but is obtained within a more general framework, and under a wide variety of parameter assumptions.

Secondly, the analysis reveals a previously overlooked consequence of dualism. A distorted labor market can be associated with a sectoral structure that is very different to the undistorted case. To put this in more colorful terms, where we observe that a country has not industrialized, the paper shows that the nature of the urban labor market is a possible explanation. This reinforces the case for studying the interactions between labor markets and the development process in poorer countries, a research need previously identified by Agénor (1996) and Freeman (1992).

The paper has the following structure. Section 2 sketches the main contributions of the paper and shows how they go beyond the existing literature. Section 3 sets out the general model, defines both the first-best allocation and the dualistic one, and shows how the differences between the two may be understood using standard trade theory. Section 4 introduces the strategy for calibrating the model, starting with the case where sectoral production functions are Cobb-Douglas, and then turning to CES production functions. Section 5 describes the data and assumptions. Section 6 reports the calibration results and uses them to compare the dual economy with the first-best allocation. Section 7 provides further discussion, and emphasizes various reasons for seeing dualism as a major policy concern, including the effects on sectoral structure noted above. Section 8 concludes.

2 Relation to existing literature

The central focus of this paper will be on the connection between dualism and aggregate total factor productivity. The term "dualism" carries a number of meanings, but here it is used to denote a wage differential between the urban and rural sectors, widely thought to be an important distortion in developing country labor markets (Rosenzweig 1988, p. 751).

The analysis considers two versions of this form of dualism. The simplest is an exogenously given intersectoral wage differential, as sometimes assumed in trade theory. The second is a framework closer to that of Harris and Todaro (1970), in which dualism is associated with urban unemployment as well as a wage differential.[2] Both forms of dualism give rise to the same result, namely

[2]Clearly many other justifications for wage differentials are possible. The work of Caselli (1999) and Caselli and Coleman (2001) uses the idea that workers must acquire skills before switching sectors. This cost drives a wedge between the net present values of wages in different

that even quite large departures from equality of marginal products do not greatly affect aggregate TFP and output. The specific models can easily be criticised, but it is clear that alternative specifications for the labor market are unlikely to generate larger output effects, unless they are associated with either a greater differential between marginal products or an alternative mechanism that links productivity and the labor market.

In the Harris-Todaro framework, there are two key assumptions. First, an exogenously fixed wage in the urban sector implies that the urban labor market fails to clear, leading to urban unemployment. Second, intersectoral migration takes place unless expected wages are equal in the urban and rural sectors. Since it is expected wages which are equalized, rather than actual, there will be an intersectoral wage differential in equilibrium. The wage differential will be related to the extent of urban unemployment.

The paper calibrates a model of this general form, based on the version of the Harris-Todaro model introduced by Corden and Findlay (1975). Although the calibrated model is stylized, its simplicity has considerable advantages. The calibration exercise requires, somewhat remarkably, only data on agricultural output and employment shares, and assumptions about three parameters: the elasticity of substitution in production, the share of labor in national income, and the urban unemployment rate. As a result, the calibration is simple to carry out, the underlying assumptions are readily understood, and results can be communicated for a variety of cases.

In this respect, the paper shares some characteristics with the classic analysis of Johnson (1966). He studied the effects of factor market distortions in general equilibrium, and argued that the effects of wage differentials on aggregate output are probably limited. The latter conclusion was based on visual inspection of production possibility frontiers drawn for the Cobb-Douglas case, and is therefore less general than the analysis undertaken below.[3]

The obvious alternative to the approach used in this paper would be a more detailed applied general equilibrium (AGE) model, as used in the literature on international trade. Such models have been used to study the effects of wage differentials in Dougherty and Selowsky (1973), de Melo (1977), and Williamson (1987, 1989). These papers tend to focus on the output effects of eliminating wage differentials for specific countries or historical cases. This allows a substantial gain in realism, but also has some disadvantages. Above all, there is the usual "black box" problem. It is not always clear which parameter assumptions

sectors.

[3]See Mundlak (1970) for further discussion of some of his results.

are driving the results, or whether the findings would generalize to other cases. The extra complexity of the AGE models also makes it hard to understand and interpret the results using existing trade theory. In contrast, the simplicity of the model used here allows a straightforward sensitivity analysis, and all of the key results can be interpreted in the light of textbook trade theory effects.

My work also differs from the existing AGE literature in giving more emphasis to the impact of dualism on wages and returns to capital, the distribution of factor income, and particularly sectoral structure, issues which have received little attention thus far. Although the AGE literature is vast, the majority of related contributions tend to focus on the interactions between labor market structure and the effects of trade policy, rather than considering the aggregate effects of labor market distortions to be interesting in their own right. This includes the otherwise closely related work of Devarajan, Ghanem and Thierfelder (1997, 1999), Maechler and Roland-Holst (1997) and Thierfelder and Shiells (1997).

Indirectly, the current paper could offer insight into a range of other issues. Jones (1965) pointed out that simple general equilibrium models of production have not only been a workhorse of trade theory, but have also found applications in almost all branches of applied economics. The calibration method used in this paper, developed for a simple 2 x 2 model, could be applied to a number of development issues. For example, it could easily be adapted to study the quantitative importance of the Rybczynski effect, or the effects of growth on urban unemployment.

The paper also casts indirect light on the effects of minimum wage legislation, when the coverage of such legislation is incomplete. In the analysis of this paper, the sectors are labelled ‘agriculture’ and ‘modern’. The two sectors could be labelled more generally as ‘uncovered’ and ‘covered’ respectively, as in the work of Mincer (1976) and Fields (1997) on minimum wages when there is wait unemployment. Under this alternative interpretation of the paper, the analysis quantifies the effects of a sector-specific minimum wage on aggregate output and wages, and reveals the consequences of eliminating such controls.

The current paper is related to various recent contributions, and especially Chanda and Dalgaard (2003). Their work analyses the consequences for aggregate TFP of differences in sectoral structure across countries. Even if the levels of sectoral TFP are the same across countries, these sectoral composition effects could lead to differences in aggregate TFP (see also Graham and Temple 2001). Although this issue could be studied directly using the framework of the current paper, here I focus on the consequences of rural-urban wage differentials for aggregate productivity, an issue not considered in detail by Chanda and Dalgaard.

The relevance of sectoral structure in understanding development has also been emphasized in Gollin, Parente and Rogerson (2000) and Parente, Rogerson and Wright (2000). The key element in both papers is a role for home production. The Parente et al. paper shows that models with this feature are better equipped to explain the international disparity in levels of income. The Gollin et al. paper extends this idea, by asking whether growth models with home production can account for other stylized facts of development, such as the cross-section pattern of productivity in non-agriculture relative to agriculture. These papers do not consider in detail the consequences of rural-urban wage differentials, but the possibility of home production and hence a sizeable non-market sector does have implications for the present analysis. These are briefly considered in section 7 below.

Another strand of research considers the aggregate effects of various other labor market institutions or distortions, such as unionization or search frictions. Theoretical papers include Bertocchi (2003) and Lagos (2001). The primary aim of these papers is to formalize some of the potentially important links between labor markets and aggregate outcomes, rather than to quantify the effects. A paper by Alvarez and Veracierto (1999) provides a quantitative evaluation of the employment and unemployment consequences of various labor market policies and institutions.

3 A model of dualism

This section describes a simple general equilibrium model of a dual economy, essentially the version of Harris and Todaro (1970) due to Corden and Findlay (1975). There are two sectors, rural agriculture and an urban 'modern' sector. The agricultural good is the numeraire. I make the standard simplifying assumption that both goods can be traded on world markets, and the economy is too small to be able to influence world prices. Hence the relative price of manufactures, p, is exogenously fixed by world prices. Appropriate choice of units would allow this price to be normalized to one in the equations that follow, but I prefer to keep the role for the relative price explicit. Note that the calibration exercise treats the relative price as unobserved, and so the results will not be affected by differences in relative prices across countries (due to transport costs, for example).

Aggregate output, capital and labor are denoted Y, K and L respectively. As is common in general equilibrium models of production, the economy is closed to international flows of capital and labor, and the aggregate capital stock and labor supply are taken to be exogenously fixed.

The technologies in the two sectors are:

$$
\begin{aligned}
Y_a &= A_a F(K_a, L_a) && (1) \\
Y_m &= A_m G(K_m, L_m) && (2)
\end{aligned}
$$

where Y_i, A_i, K_i and L_i are output, TFP, capital and labor in sector i (agriculture/modern) respectively. Returns to scale are constant in both sectors, and both factors are paid their marginal products.

Capital is fully employed, so that

$$
K = K_a + K_m \tag{3}
$$

I assume that capital is perfectly mobile between sectors, so that rental rates are equalized:

$$
A_a F_K = p A_m G_K \tag{4}
$$

where the subscript K denotes the derivative with respect to capital.

I assume that parameter values are such that specialization is incomplete. Then, the first-best equilibrium is described by equations (1)-(4) and the following four equations:

$$
\begin{aligned}
w_a &= A_a F_L && (5) \\
w_m &= p A_m G_L && (6) \\
L &= L_a + L_m && (7) \\
w_m &= w_a && (8)
\end{aligned}
$$

where the subscript L denotes the derivative with respect to labor. These equations represent the equality of wages and marginal products, full employment of labor, and a long-run migration equilibrium in which any intersectoral wage differential is eliminated.

The paper will compare this first-best equilibrium with a dualistic one. The dualistic equilibrium is again described by equations (1)-(6) but differs in its specification of the labor market, which follows Harris and Todaro (1970). I assume that the urban wage is fixed above the market-clearing wage that would hold in the first-best equilibrium. This results in unemployment in the urban sector, so (7) is replaced by:

$$L = L_a + L_m + L_u \tag{9}$$

where L_u is urban unemployment.

The model is completed by specifying the migration equilibrium condition. I assume that the unemployed receive no income. Migration takes place between sectors unless the agricultural wage (w_a) is equal to the *expected* wage in the modern sector, which is a function of both the fixed modern sector wage (w_m) and the probability of finding employment at this wage. Assuming that jobs are allocated by a lottery among the urban population, this probability is $1 - u$ where $u = L_u/(L_u + L_m)$ is the rate of urban unemployment.[4] Note the standard Harris-Todaro assumption that workers must be present in urban areas to have a chance of finding urban employment. If we interpret the model in terms of 'covered' and 'uncovered' sectors, the corresponding assumption is that workers cannot look for work in the covered sector while holding a job in the uncovered sector.

Labor market equilibrium occurs when:

$$w_a = (1 - u)w_m \tag{10}$$

This is the equilibrium condition associated with Harris and Todaro (1970). The model described by (1)-(6), (9) and (10) is the version of the Harris-Todaro model introduced by Corden and Findlay (1975). It combines the standard 2 x 2 model of trade theory with the Harris-Todaro labor market assumptions.

Note that one immediate implication of the Harris-Todaro condition is a wage differential across sectors: the ratio of marginal products w_m/w_a is equal to $1/(1 - u)$. Hence output is lower than in the first-best for two reasons. First, because some of the labor force are unemployed, and second, because the marginal products of labor are not equalized for those who are employed.

With this in mind, I introduce a new device for analyzing the nature of the Harris-Todaro economy relative to the first-best allocation. The idea is to make use of theoretical results for the case of exogenous wage differentials, as in the classic analyses of Jones (1971) and Magee (1973, 1976). These models differ from the Harris-Todaro approach in assuming full employment. A common form of such models can be described by equations (1)-(7) together with a fixed wage

[4] The lottery assumption could be relaxed as in Moene (1988). The Harris-Todaro equilibrium condition will then be a good approximation provided that the rate of job turnover is high or the discount rate is low.

differential:

$$w_m = kw_a$$

How can we make use of existing results for such models? The movement from the Harris-Todaro economy to the first-best can be thought of as occurring in two stages, both of which can be understood individually using trade theory. The trick is to construct an artificial economy that forms an intermediate stage between the Harris-Todaro economy and the first-best. In the first stage, moving from the Harris-Todaro to the intermediate economy, we keep total employment fixed. All those currently employed are reallocated so that the marginal products of labor and capital are equalized across the two sectors. In the second stage, we then complete the move to the overall first-best by increasing total employment, by the number of unemployed in the original Harris-Todaro economy. This brings us to the first-best, with no unemployment and once again marginal products of labor that are equalized across the two sectors.

Analytically, the first stage is equivalent to the elimination of a wage differential in a model with an exogenous differential, given by $k = 1/(1-u)$, and in which employment is fixed. Hence standard results for the exogenous wage differential case, such as those of Jones (1971), can be applied to analyze the first stage. One result worth noting is that, at constant commodity prices, a higher premium paid to labor in the modern sector can sometimes be associated with an *increase* in that sector's relative output. Another result, more important to the analysis below, is that if labor's share of income is lower in the modern sector than in agriculture, a rise in the wage premium in the modern sector will be associated with higher wages in *both* sectors (Jones 1971, p. 442). This suggests that dualism may be associated with higher wages than in the first-best, a potential outcome to be confirmed below.

Now consider the second stage of the transition to the first-best, namely the elimination of unemployment, starting from the intermediate point where the returns to both factors are equal across sectors. The movement to the first-best is now just an increase in the labor force in an otherwise conventional 2 x 2 trade model with intersectoral factor mobility. In other words, it can be seen as a change in relative factor abundance that can be analyzed using the standard results of Heckscher-Ohlin trade theory. At constant commodity prices, the rise in employment will have no effect on factor prices, provided the economy remains incompletely specialized. The fall in the aggregate capital-labor ratio does give rise to a Rybczynski effect: with the capital stock fixed, it yields an increase in the output of the labor-intensive sector (here, agriculture) and a reduction in the output of the capital-intensive sector (non-agriculture).

I will adopt the analytical device of a two-stage transition in presenting the calibration results because, as seen above, it allows me to explain and interpret the overall findings using existing trade theory. By analyzing separately the effects of eliminating the wage differential holding employment constant, and then of increasing total employment, it is possible to gain a greater understanding of how the first-best outcomes are related to those under dualism.

Note that, from the analysis above, the introduction of an exogenously fixed wage in the urban sector can be associated with an *increase* in modern sector output. This paradoxical result for the 2 x 2 Harris-Todaro model was first pointed out by Corden and Findlay (1975, p. 66-67) using different reasoning, and has recently been emphasized by Allen (2001, p. 524). One contribution of the calibration exercise below, however, will be to show that this case is empirically unlikely.

Before progressing further, I briefly discuss some limitations of the approach adopted here. As with any influential but stylized model, the Harris-Todaro framework is not without its critics. A clear drawback in this context is that the rigidity of the urban wage is assumed rather than modelled. Some recent contributions, notably Moene (1988) and MacLeod and Malcomson (1998), have analyzed models in which the urban wage is endogenously determined. Both these papers work with relatively simple representations of the production technologies in the two sectors, however. Combining their specifications for the labor market with more complex technologies would not be straightforward. The use of such a model would also make it harder to relate the findings to existing trade theory, and harder to shed new light on some of the effects identified by trade theorists.

The model used here is stylized in other respects as well. Recent work on migration by Stark (1991) and others emphasizes that migration decisions are often collective and made in the interests of a household. Among the important real-world considerations I abstract from are the potentially substantial share of rural household income gained in nonfarm work, the flow of resources between members of households divided between urban and rural areas, and more general forms of household income sharing.

Although these considerations could be integrated into the model, the present framework allows some interesting results to be derived in a way that is both straightforward and transparent. The simplicity of the framework allows a clear focus on the essential aspects of the present analysis, namely the existence of urban unemployment and a wage differential. The model allows a simple illustration that even quite large departures from equality of marginal products do not greatly affect aggregate TFP, and at least in this general formulation, the point has relevance beyond the specific assumptions of the Harris-Todaro model. Section 7 of the paper will consider the extent to which alternative models might give different results.

4 Calibrating the model

To take the Harris-Todaro model to the data, I assume that observed shares of agriculture in employment and output correspond to a Harris-Todaro equilibrium. The assumption that we observe the world in equilibrium is a strong one, but it is typical to most exercises in calibration or AGE modelling, and avoids imposing an arbitrary extent of disequilibrium.

Once the equilibrium assumption has been made, it is relatively straightforward to derive the nature of the first-best allocation, in which urban unemployment and marginal product differentials are eliminated. Recall that the main aim of the paper is to compare these two alternative equilibria, and therefore offer some insight into the costs of dualism, including the effects on aggregate TFP and sectoral structure.

The remainder of this section describes how to derive the first-best allocation, given the observed data. I start with the relatively simple Cobb-Douglas case to illustrate the basic ideas, before turning to the more complicated model with CES production functions. The technologies in the two sectors are:

$$\begin{aligned} Y_a &= A_a K_a^{\alpha} L_a^{1-\alpha} \\ Y_m &= A_m K_m^{\theta} L_m^{1-\theta} \end{aligned}$$

where aggregate output is

$$Y = Y_a + pY_m$$

I will denote the agricultural employment share (L_a/L) by a and the nominal output share (Y_a/Y) by s. Note that all output shares are evaluated at domestic relative prices. Nevertheless, because the calibration procedure treats the relative price as unobserved, it is consistent with variation in relative prices across countries.

Modern sector employment is given by:

$$L_m = (1-u)(1-a)L \tag{11}$$

Denote the share of labor in agricultural income by $\eta_a = w_a L_a / Y_a$ and in modern sector income by $\eta_m = w_m L_m / pY_m$. The share of labor in total national income is:

$$\eta = \frac{w_a L_a + w_m L_m}{Y}$$

Using (10) and (11), this expression can be simplified to $\eta = w_a L / Y$. Hence the share of labor in agricultural income can be written as:

$$\eta_a = \frac{w_a L_a}{Y_a} = \frac{w_a L}{Y} \frac{L_a}{L} \frac{Y}{Y_a} = \frac{\eta a}{s} \tag{12}$$

Given that the agricultural production function is Cobb-Douglas, the agricultural technology parameter α will be given by

$$1 - \alpha = \eta_a = \frac{\eta a}{s} \tag{13}$$

Similarly we can also derive an expression for the labor share in the modern sector, and hence the modern sector technology parameter θ:

$$1 - \theta = \eta_m = \eta \left(\frac{1-a}{1-s} \right) \tag{14}$$

Hence with two Cobb-Douglas production functions, constant returns to scale, and intersectoral factor mobility, we can infer the technology parameters using only an assumption about the aggregate labor share (η) and readily available data on the agricultural employment share (a) and output share (s).

Using the production functions, we can rewrite the long-run equilibrium condition (10) as:

$$(1-\alpha)\frac{Y_a}{aL} = (1-u)w_m = \frac{(1-u)p(1-\theta)Y_m}{(1-u)(1-a)L}$$

Hence we derive that

$$\frac{Y_a}{pY_m} = \frac{s}{1-s} = \left(\frac{1-\theta}{1-\alpha} \right) \frac{a}{1-a} \tag{15}$$

Using (15) combined with the production functions, it is possible to derive an equation which ties down the urban unemployment rate u in terms of a, α, θ, p, A_a, A_m, K_a and K_m. However, I will assume throughout that we do not know the last five variables, so that it is better to work instead with an assumed value for the urban unemployment rate, u. The paper will show that using only data on a and s, and assumptions about u and η, it is possible to calculate the agricultural employment share in the first-best economy, denoted b. A corollary is that the calibration procedure can proceed while treating the relative price (p) and sectoral TFP terms (A_a and A_m) as unobserved.[5]

In the first-best economy, workers will be paid the same in each sector. Thus we can derive an equation corresponding to (15), where Y_a' and Y_m' are sectoral outputs under the first-best allocation, and r is the agricultural share of output in the first-best economy:

$$\frac{Y_a'}{pY_m'} = \left(\frac{1-\theta}{1-\alpha}\right)\frac{b}{1-b} = \frac{r}{1-r} \tag{16}$$

In the Harris-Todaro economy, denote the proportion of capital used in agriculture by $x = K_a/K$, and the proportion in manufacturing by $(1-x)$. For the first-best economy, denote this proportion by z.

Using the production functions, the following two equations must hold:

$$\frac{r}{1-r} = \frac{Y_a'}{pY_m'} = \frac{A_a z^\alpha K^\alpha b^{1-\alpha} L^{1-\alpha}}{pA_m(1-z)^\theta K^\theta (1-b)^{1-\theta} L^{1-\theta}} \tag{17}$$

$$\frac{s}{1-s} = \frac{Y_a}{pY_m} = \frac{A_a x^\alpha K^\alpha a^{1-\alpha} L^{1-\alpha}}{pA_m(1-x)^\theta K^\theta (1-a)^{1-\theta}(1-u)^{1-\theta} L^{1-\theta}} \tag{18}$$

By dividing (17) by (18), and then using (15) and (16), it is possible to derive the following equation implicitly defining b:

$$\left(\frac{z}{x}\right)^\alpha \left(\frac{1-x}{1-z}\right)^\theta \left(\frac{a}{b}\right)^\alpha \left(\frac{1-b}{1-a}\right)^\theta (1-u)^{1-\theta} = 1 \tag{19}$$

Assuming that rental rates are equalized, we have

$$\alpha\frac{Y_a}{K_a} = p\theta\frac{Y_m}{K_m}$$

Then we have in the Harris-Todaro economy, using (15),

$$\frac{K_a}{K_m} = \frac{x}{1-x} = \left(\frac{\alpha}{\theta}\right)\frac{Y_a}{pY_m} = \left(\frac{\alpha}{\theta}\right)\left(\frac{1-\theta}{1-\alpha}\right)\frac{a}{1-a} \tag{20}$$

and similarly in the first-best economy, using (16),

$$\frac{z}{1-z} = \left(\frac{\alpha}{\theta}\right)\left(\frac{1-\theta}{1-\alpha}\right)\frac{b}{1-b} \tag{21}$$

[5] The observed output and employment shares, and assumed urban unemployment rate, do place a joint restriction on these unknown variables. But this restriction is only ever required in order to double check the calibration results, by computing the change in total output using the sectoral production functions and intersectoral factor allocations, rather than using the analytical expressions given later in the paper.

where b is the agricultural share of employment in the first-best economy. Solving (20) and (21) for x and z, and substituting in (19) we have

$$\left(\frac{1-a}{1-b}\right)^{\alpha-\theta}\left(\frac{1+\frac{\alpha}{\theta}\left(\frac{1-\theta}{1-\alpha}\right)\frac{a}{1-a}}{1+\frac{\alpha}{\theta}\left(\frac{1-\theta}{1-\alpha}\right)\frac{b}{1-b}}\right)^{\alpha-\theta}(1-u)^{1-\theta}=1$$

Simplifying further,

$$\left(\frac{1-a\left(1-\frac{\alpha}{\theta}\left(\frac{1-\theta}{1-\alpha}\right)\right)}{1-b\left(1-\frac{\alpha}{\theta}\left(\frac{1-\theta}{1-\alpha}\right)\right)}\right)^{\alpha-\theta}(1-u)^{1-\theta}=1 \tag{22}$$

Rearranging gives

$$b=\frac{\theta(1-\alpha)}{\theta-\alpha}-\left(\frac{\theta(1-\alpha)}{\theta-\alpha}-a\right)(1-u)^{\frac{1-\theta}{\alpha-\theta}} \tag{23}$$

Hence equation (23) yields the agricultural share of employment in the first-best economy, assuming that an observed economy is in a Harris-Todaro equilibrium.

It would also be useful to know the ratio of output in the first-best economy to that in the Harris-Todaro economy, which I denote by Λ. Note that the output gain will also be the gain in TFP, given that the total labor force and the capital stock are being held fixed. This does assume that aggregate TFP is calculated using labor force data rather than employment data, but this is true of most cross-country comparisons, given the problems in obtaining reliable employment data for developing countries.

Given that commodity prices are exogenously fixed, the output ratio is given by the ratio of nominal outputs:

$$\Lambda=\frac{Y_a'+pY_m'}{Y_a+pY_m}$$

Using (15) and (16), the expression for Λ can be written as

$$\Lambda=\frac{pY_m'\left(1+\frac{Y_a'}{pY_m'}\right)}{pY_m\left(1+\frac{Y_a}{pY_m}\right)}=\frac{Y_m'}{Y_m}\left(\frac{1+\frac{b}{1-b}\left(\frac{1-\theta}{1-\alpha}\right)}{1+\frac{a}{1-a}\left(\frac{1-\theta}{1-\alpha}\right)}\right) \tag{24}$$

Making use of the modern sector production function, and (20) and (21) we can derive:

$$\Lambda=\left(\frac{1+\frac{a}{1-a}\left(\frac{1-\theta}{1-\alpha}\right)\frac{\alpha}{\theta}}{1+\frac{b}{1-b}\left(\frac{1-\theta}{1-\alpha}\right)\frac{\alpha}{\theta}}\right)^{\theta}\left(\frac{1-b}{1-a}\right)^{1-\theta}(1-u)^{\theta-1}\left(\frac{1+\frac{b}{1-b}\left(\frac{1-\theta}{1-\alpha}\right)}{1+\frac{a}{1-a}\left(\frac{1-\theta}{1-\alpha}\right)}\right) \tag{25}$$

Overall, the key equations are (13), (14), (23) and (25). These equations allow us to calculate the agriculture share in the first-best economy, and the ratio of output in the first-best economy to that in the dual economy, using only information on the four variables u, a, s, and η.

Note that if $\theta > \alpha$ then $b < a$ from inspection of (22). In other words, agricultural employment is lower in the first-best economy than in the dual economy, if the modern sector is relatively capital intensive. This is consistent with Corden and Findlay (1975), who show that in general the outcome is determined by the 'manufacturing elasticity', the proportional change in labor input in manufacturing divided by the proportional change in marginal product. For the Cobb-Douglas case, this elasticity is greater than one. Corden and Findlay show that, as found here, agricultural employment will then be higher in the dual economy than in the first-best, provided that the modern sector is relatively capital intensive.

Although the Cobb-Douglas case is an easy one to handle, it is clear that the results are likely to be insufficiently general. Compared to the dual economy, output is higher in the first-best because extra labor is brought into employment, and because labor is reallocated between agriculture and non-agriculture. Clearly the elasticities of substitution between capital and labor in the two sectors will be key parameters governing this process. As Dougherty and Selowsky (1973) point out, the higher the elasticity of substitution, the larger the gain from labor reallocation, because the marginal product of labor changes more slowly as labor is reallocated. This suggests that it would be useful to experiment with different elasticities of substitution.

The simplest way to do this is to follow Kelley et al. (1972) and work with CES production functions. To keep the model tractable, I impose the restriction that the elasticity of substitution is the same in both sectors. Hence the technologies are now:

$$\begin{aligned} Y_a &= A_a \left[\delta_a K_a^{-\rho} + (1-\delta_a) L_a^{-\rho}\right]^{-\frac{1}{\rho}} \\ Y_m &= A_m \left[\delta_m K_m^{-\rho} + (1-\delta_m) L_m^{-\rho}\right]^{-\frac{1}{\rho}} \end{aligned}$$

where the elasticity of substitution $\sigma = 1/(1+\rho)$. As before, I use $b = L'_a/L$ to denote the proportion of employment in agriculture, $r = Y'_a/Y$ the share of agriculture in output and $z = K'_a/K$ the proportion of capital employed in agriculture, all in the first-best equilibrium. Once again Y'_m, K'_m and L'_m are the first-best levels of output, capital and labor in the modern sector respectively. In the first-best, the share of labor in national income is denoted ϕ, and the shares of labor income in agricultural and modern sector value added are denoted ϕ_a and ϕ_m respectively.

Appendix 1 shows how to derive two equations in terms of b, z and observable variables, which can then be solved for the first-best allocation of employment b and capital z. The first equation is:

$$\frac{b}{1-b} = \left(\frac{a}{1-a}\right)\left(\frac{1-x}{x}\right)(1-u)^{\frac{-\rho}{1+\rho}}\left(\frac{z}{1-z}\right) \tag{26}$$

The second equation is:

$$\frac{b}{1-b} = \left(\frac{z}{1-z}\right)\left(\frac{1-x}{x}\right)\left(\frac{s}{1-s}\right)\left(\frac{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{1-x}{1-a}\right)^{1+\rho}\left(\frac{1-b}{1-z}\right)^{\rho}(1-u)^{-\rho}}{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{x}{a}\right)^{1+\rho}\left(\frac{b}{z}\right)^{\rho}}\right) \tag{27}$$

Hence the calibration procedure is as follows. Three parameters have to be chosen: the aggregate labor share η, the elasticity of substitution $\sigma = 1/(1+\rho)$ and the urban unemployment rate u. We can then use data on agriculture's share of employment (a) and output (s) to solve for the share of agricultural capital in total capital, x, in the dualistic economy. Given a solution for x, we can then solve the two equations (26) and (27) numerically for b and z. Thus using only data or assumptions on a, s, η, u, and σ, it is possible to derive what agriculture's share of employment in the first-best economy (b) would be. It is then possible to calculate the ratio of output (and TFP) in the first-best economy to that in the Harris-Todaro economy, and other relevant outcomes, using the further equations derived in Appendix 1.

5 Data and assumptions

This section describes the data and assumptions that will be needed in the calibration exercise. I consider three different cases for the agricultural output and employment shares, based on data from three regional groupings of developing countries. The regions are sub-Saharan Africa, East Asia, and Latin America. The three regions differ in terms of their level of development and the extent of industrialization. A secondary consideration is that technology parameters, at least in agriculture, could vary with geographic location.

In calibrating the model, one important consideration is the choice of labor's income share (η). Evidence from developed countries tends to suggest that the labor share is roughly in the range 0.60 to 0.70. It is sometimes argued that the share may be lower in developing countries (see for instance Collins and Bosworth 1996). As discussed in Gollin (2002), however, the importance of self-employment and unincorporated enterprises makes measurement of the aggregate factor shares difficult for poorer countries. From a pragmatic point of view, it is useful to adopt a lower value for η than Gollin obtains. This is because it makes the sectoral labor shares (η_a and η_m) more likely to be less than one, as is clear from equation (12). Accordingly, in what follows I set $\eta = 0.50$. Refinements of the 2 x 2 trade model that would be more consistent with higher labor shares are left to further research.

Next, I choose representative values for a and s for each of the three regional groups. Table 1 shows the median agricultural output and employment shares for 1960 and 1985 for these groups. The data are taken from the World Bank, and the samples exclude small countries, defined as those with a labor force lower than 250,000 in 1985.[6] Based on these data, I calibrate the model for a typical country in each regional grouping using the following values. The agricultural employment and output shares, a and s, are assumed equal to 0.80 and 0.50 respectively for sub-Saharan Africa, 0.65 and 0.35 for East Asia, and 0.50 and 0.30 for Latin America.

These choices depart slightly from those suggested by Table 1, in order to ensure that the implied labor shares (η_a and η_m) are less than one. Given that these departures are required, this is again evidence that the model does not well approximate reality for all observed combinations of a and s. This is perhaps not wholly surprising, given the highly stylized nature of the model. Nevertheless, the results are still likely to be of some interest, not least because there is an obvious case for understanding the costs of dualism in a simple framework before moving to the analysis of more complex and realistic models.

Table 1
Agricultural employment and output shares in 1960 and 1985

		a	s
Sub-Saharan Africa	1960	0.86	0.47
	1985	0.75	0.34
East Asia	1960	0.63	0.29
	1985	0.41	0.18
Latin America and the Caribbean	1960	0.52	0.23
	1985	0.30	0.13

Notes

[6]The data are taken from the *World Development Indicators* CD-Rom. Where necessary, the WDI data are supplemented by figures from the 1990 *Production Yearbook* of the Food and Agricultural Organization of the United Nations (FAO) and the 1987 *World Development Report*.

The variable 'a' is the share of agricultural employment in total employment and 's' is the agricultural output share.

Another key assumption concerns the urban unemployment rate. To gain some idea about appropriate magnitudes, I have calculated figures based on the ILO's *Yearbook of Labor Statistics, 1995.* Agricultural or rural areas are often not represented in these unemployment statistics, and this suggests that it is indeed valid to assume that all the reported unemployment is in the urban sector. This allows the derivation of an urban unemployment rate $u = U/(1-a)$ using data on the national unemployment rate (U) and the agricultural share of employment a.

The calculated urban unemployment rates (not reported) vary between zero and about 35%. The figures for Africa are very low, but are not based on labor force surveys, and are therefore likely to be inaccurate. This is particularly so given the ambiguity surrounding the concept of unemployment in developing countries. For instance, the World Bank (1995, p. 28) reports that in Ghana the measured rate of unemployment is 1.6%, but the underemployment rate is calculated to be about 24%. Knight (1998) writes that "on sensible definitions the open unemployment rate probably now exceeds a quarter in Zimbabwe and a third in South Africa" (p. 11). Elsewhere in the world, an urban unemployment rate between 20% and 30% is calculated for such countries as El Salvador, India, and Sri Lanka.

With all this in mind, I calibrate the model for an urban unemployment rate of 30%. Another way to judge this assumption is to look at the implied wage differential. An urban unemployment rate of 30% corresponds to a marginal product of labor around 40% higher in the modern sector than in agriculture, given that we have

$$\begin{aligned} w_m/w_a &= 1/(1-u) \\ &= 1/(1-0.3) \approx 1.4 \end{aligned}$$

It is important to emphasize that a marginal product differential of this magnitude is not implausible. Squire (1981, p. 102) cites evidence implying that the nominal wage gap for unskilled labor, unadjusted for differences in the cost of living between urban and rural areas, can easily be this large. For his sample of twenty-three developing countries the median differential is 34%. Squire comments, based on data in Clark (1957), that these figures are not out of line with wage gaps observed for seven developed countries in the second half of the nineteenth century. Similarly Williamson (1987) argues that rural-urban real wage gaps in England during the Industrial Revolution were of the order of 30%-50%. Figures from the World Bank (1995, p. 76) suggest that the wage gap may be even higher in many developing countries.

In practice, these observed rural-urban wage gaps may not represent equilibrium phenonomena of the kind envisaged by Todaro (1969) and Harris and Todaro (1970), as discussed by Hatton and Williamson (1991). Furthermore, observed wage gaps do not imply different returns to workers of potentially identical productivity, but could simply reflect differences in average skills across sectors. In these circumstances testing for the presence of differentials is not straightforward, and it can often be argued that measured differentials reflect unobserved characteristics (Magnac 1991). Interpreting the available evidence is also made more complicated by spatial variation in the cost of living. Overall, however, it should be clear that assuming an urban unemployment rate of 30% implies equilibrium wage gaps that are not implausibly high.

6 Calibration results

In this section, I will use the results of section 4 to calibrate the model described in section 3. The basic idea is to combine an assumption about urban unemployment (u) with data on agricultural output and employment shares, under the assumption that the observed data correspond to a Harris-Todaro economy. I can then infer the nature of the first-best economy and compare it with the dual economy. The aim will be to examine the effects of dualism on aggregate output and TFP, sectoral output, sectoral structure, wages and rental rates, and the distribution of factor income.

As argued in section 3, greater understanding of the differences between Harris-Todaro and the first-best can be achieved by thinking of the movement between them as in two stages. In moving away from Harris-Todaro, we can first consider a movement to an intermediate economy in which the wage differential has been eliminated but total employment is held constant at the Harris-Todaro level. Secondly, we then complete the move to the first-best by eliminating unemployment. The results below will follow this decomposition, and it requires only a few simple changes to the algebra of section 4 to analyze the characteristics of the intermediate economy.

I first consider results for the Cobb-Douglas case, presented in Table 2.[7] The table shows the effects of eliminating a wage ratio of about 1.4, holding total employment constant. There is one column for each region. The top two rows

[7]All calculations were carried out by computer programs written by the author, using the mathematical software Maple.

show the sectoral labor shares implied by combining the agricultural output and employment shares with the assumption that the aggregate labor share $\eta = 0.5$. These labor shares are quite similar across regions, consistent with technology parameters that are similar across regions. The large differences in capital intensity across sectors will be discussed later in the paper.

The next six rows reveal the changes in sectoral structure in moving from a dual economy to an intermediate economy with the wage differential eliminated but employment held constant. The two equilibria can be compared in terms of agricultural employment shares (a and b), output shares (s and r) and sectoral capital allocations (x and z). The table also shows the ratio of modern sector employment in the intermediate economy to that in the dual economy.

The next section of the table reports the ratio of modern sector wages in the intermediate economy, to those in the dual economy; the corresponding ratio for agricultural wages; and the ratio of rental rates. The last row of this section reports the labor share in the intermediate economy. Finally, the fourth section of the table reports the ratio of modern sector output in the intermediate economy to that in the dualistic one; the corresponding ratio for agricultural output; and perhaps of especial interest, the change in total output (which also corresponds to the change in aggregate TFP).

Table 2
Eliminating the wage differential ($\sigma = 1$, $\eta = 0.5$, $u = 0.30$)

Variable	Region	Africa	East Asia	Latin America
	1. *Sectoral labor shares*			
η_m	Modern sector	0.20	0.27	0.36
η_a	Agricultural sector	0.80	0.93	0.83
	2. *Sectoral structure*			
a	Old employment share	0.80	0.65	0.50
b	New employment share	0.75	0.54	0.16
s	Old output share	0.50	0.35	0.30
r	New output share	0.42	0.25	0.08
x	Old capital allocation	0.20	0.05	0.10
z	New capital allocation	0.16	0.03	0.02
L'_m/L_m	New/old modern employment	1.26	1.32	1.67
	3. *Factor payments*			
w'_m/w_m	New modern wage/old	0.68	0.69	0.67
w'_a/w_a	New agricultural wage/old	0.98	0.99	0.96
$r^{'}/r$	New rental rate/old	1.10	1.15	1.25
ϕ	New aggregate labor share	0.45	0.44	0.39
	4. *Output changes*			
Y'_m/Y_m	New modern output/old	1.16	1.17	1.36
Y'_a/Y_a	New agricultural output/old	0.86	0.73	0.27
Y'/Y	New total output/old	1.01	1.02	1.03

Notes

The output and employment shares are those of agriculture, as is the capital allocation. 'Old' corresponds to the Harris-Todaro economy, and 'New' to an intermediate economy with the same total employment but no wage differential.

Some of the most interesting results are those in section 3 of the table, which show how factor payments change when the wage differential is eliminated. It can be seen that wages are lower in both sectors in the absence of the differential. It may appear surprising that the wage falls in agriculture, but as noted earlier, this result has been derived in the trade theory literature on exogenous wage differentials with fixed commodity prices. Jones (1971, p. 442-443) shows that if an increased premium is paid to labor in the sector where labor receives the smaller distributive share (in the framework of this paper, if w_m/w_a increases and $\eta_m < \eta_a$) this must raise the wage rate, relative to the return to capital, in *both* sectors. Furthermore, what Jones refers to as the 'magnification effect' implies that the 'real' return to labour or capital moves in the same direction as the relative return. Hence in a model with exogenous wage differentials, the elimination of dualism will be associated with lower wages in both sectors. It should also be noted, however, that for the cases considered here the decline in the agricultural wage is not substantial. This finding nicely demonstrates how calibrating the 2 x 2 model can shed direct light on the quantitative implications of effects identified by trade theorists.

The final section of the table indicates the TFP gains associated with the elimination of the wage differential, holding total employment constant. It is clear that these gains are small, even though I am considering a case where the modern sector wage is initially roughly 40% higher than that in agriculture. The output gains typically associated with the elimination of a wage differential may appear surprisingly low, but this result is consistent with previous work using other approaches, notably that of Johnson (1966).

Now I consider the difference made to these findings by the increase in employment, in the second stage of the transition from dualism to the first-best. Table 3 reports the overall first-best outcomes relative to the Harris-Todaro economy. Considering section 2 of the table, the most interesting result here is the large rise in modern sector employment in moving to the first-best. This is driven by two forces: the contraction of the agricultural sector, and the elimination of unemployment. In the African and East Asian cases, modern sector employment rises by more than two-thirds. In the Latin American case, it almost doubles.

The ratios of factor payments in section 3 of the table are unchanged compared with those in Table 2. This simply reflects a standard result in this form of 2 x 2 trade model, namely that factor prices are independent of factor endowments while the economy remains incompletely specialized.

The final section of the table indicates the output and TFP gains in moving from dualism to the first-best. One point to note is that, compared with the intermediate economy described in Table 2, modern sector output has fallen and agricultural sector output has risen. This reflects the Rybczynski effect at work, in the second stage of the transition from the dual economy to the first-best. The reduction in the capital-labor ratio, with employment increased and the capital stock unchanged, leads to a fall in the output of the capital-intensive good and a rise in the output of the labor-intensive good.

Table 3
Overall results ($\sigma = 1$, $\eta = 0.5$, $u = 0.30$)

Variable	Region	Africa	East Asia	Latin America
	1. *Sectoral labor shares*			
η_m	Modern sector	0.20	0.27	0.36
η_a	Agricultural sector	0.80	0.93	0.83
	2. *Sectoral structure*			
a	Old employment share	0.80	0.65	0.50
b	New employment share	0.77	0.59	0.31
s	Old output share	0.50	0.35	0.30
r	New output share	0.45	0.30	0.16
x	Old capital allocation	0.20	0.05	0.10
z	New capital allocation	0.17	0.04	0.05
L'_m/L_m	New/old modern employment	1.67	1.67	1.98
	3. *Factor payments*			
w'_m/w_m	New modern wage/old	0.68	0.69	0.67
w'_a/w_a	New agricultural wage/old	0.98	0.99	0.96
r'/r	New rental rate/old	1.10	1.15	1.25
ϕ	New aggregate labor share	0.47	0.46	0.43
	4. *Output changes*			
Y'_m/Y_m	New modern output/old	1.14	1.16	1.32
Y'_a/Y_a	New agricultural output/old	0.94	0.90	0.59
Y'/Y	New total output/old	1.04	1.07	1.10

Notes

The output and employment shares are those of agriculture, as is the capital allocation. 'Old' corresponds to the Harris-Todaro economy and 'New' to the first-best.

One of the most important findings is that eliminating dualism, even in the initial presence of substantial urban unemployment, raises aggregate TFP by around 10% at most. A comparison of Tables 2 and 3 shows that most of this output gain is driven by reduced unemployment rather than by the elimination of the wage differential. Overall, the results suggest that the effects of dualism are felt more keenly in sectoral structure than in aggregate output. Section 7 will discuss the implications of this result.

Some of the properties noted here follow from the 'other things equal' nature of the comparison and, in particular, the decision to compare equilibria while holding the capital stock fixed. Although this is the most natural starting point, it does give rise to some counter-intuitive results. For example, with a fixed capital stock, the elimination of dualism is associated with a fall in labor productivity of the employed in both sectors, reflecting the fall in the aggregate capital-labor ratio.[8] This suggests that it would be useful to repeat these experiments allowing the capital stock to be determined endogenously. Complications quickly arise, however, and these will be discussed in detail in section 7.

The two main findings, insignificant output gains but potentially major sectoral shifts, are borne out by more general experiments based on CES production functions. For brevity, I report only the case where agriculture accounts for 65% of employment and 35% of output, which corresponds roughly to East Asia for the early 1960s. As before, the urban unemployment rate is assumed to be 30%. I consider three values for the elasticity of substitution: 0.5, 1.5 and 2.

The results are presented in Table 4. There are two main points to note. First, higher elasticities of substitution are associated with a larger change in output, as one might expect given that diminishing returns will set in more slowly. This pattern can be seen in section 4 of the table. The second main point to note is that the extent of structural change is very sensititive to the elasticity of substitution. With an elasticity of 0.5, there is only a small change in employment shares and total modern sector employment. With an elasticity of 2, the changes are dramatic.

The framework developed here can also be used to analyze the paradox noted by Corden and Findlay (1975), namely that modern sector output may be greater in the dual economy than in the first-best, despite the rigidity in the urban labor market. Corden and Findlay showed that a sufficient condition for this would be fixed coefficients in production in both sectors, combined with the assumption that the modern sector is relatively capital intensive. They also noted that the paradoxical result would still hold for a limited degree of technical substitution. I have carried out experiments for the cases used above, based on a 'typical' country for each of the three regional groupings. These experiments suggest that σ has to be very low before the Corden-Findlay paradox emerges. In each case, σ must be around 0.15 or below for the dual economy to be associated with greater modern sector output than in the first-best. Some economists would be unhappy with assuming an elasticity this low, at least at this level of aggregation, which suggests that the Corden-Findlay paradox is perhaps best seen as a theoretical curiosity.

[8]To see this, note that with Cobb-Douglas production functions, average products are a fixed multiple of marginal products (and hence wages). If wages fall in both sectors then so must the average products of employed labor. Aggregate output can still rise, because more people are employed, and because the composition of employment has shifted towards the sector with higher labor productivity.

Table 4
Results for CES production functions ($\eta = 0.5$, $u = 0.30$, $a = 0.65$, $s = 0.35$)

Variable	Region	$\sigma = 0.5$	$\sigma = 1.5$	$\sigma = 2$
	1. *Sectoral labor shares*			
η_m	Modern sector	0.27	0.27	0.27
η_a	Agricultural sector	0.93	0.93	0.93
	2. *Sectoral structure*			
a	Old employment share	0.65	0.65	0.65
b	New employment share	0.69	0.45	0.24
s	Old output share	0.35	0.35	0.35
r	New output share	0.35	0.22	0.11
x	Old capital allocation	0.05	0.05	0.05
z	New capital allocation	0.05	0.03	0.01
L'_m/L_m	New/old modern employment	1.28	2.24	3.12
	3. *Factor payments*			
w'_m/w_m	New modern wage/old	0.69	0.69	0.69
w'_a/w_a	New agricultural wage/old	0.99	0.99	0.99
r'/r	New rental rate/old	1.13	1.17	1.20
ϕ	New aggregate labor share	0.47	0.46	0.45
	4. *Output changes*			
Y'_m/Y_m	New modern output/old	1.06	1.29	1.49
Y'_a/Y_a	New agricultural output/old	1.05	0.68	0.35
Y'/Y	New total output/old	1.06	1.08	1.09

Notes

The output and employment shares are those of agriculture, as is the capital allocation. 'Old' corresponds to the Harris-Todaro economy and 'New' to the first-best.

7 Further discussion

This section provides some further discussion of the results, and their possible generality. I start with the results concerning aggregate TFP and sectoral structure, before considering the wider implications of the paper's findings. Above all, this section guards against a potentially dangerous misinterpretation of the paper, as somehow saying that dualism is unimportant. Instead, the section argues that dualism could still be a policy concern, but for reasons other than the static efficiency losses described in textbooks. The case for seeing dualism as a major concern could arise from a richer model of the urban labor market, the presence of other reinforcing distortions, or dynamic effects connected to sectoral structure.

We have seen that the aggregate TFP losses associated with intersectoral wage differentials are small. If we stay within the framework of this paper, larger TFP effects might be found if the technology parameters took other values. Johnson (1966, p. 697) drew attention to this issue for Cobb-Douglas production functions, based on plotting production possibility frontiers for various cases. He found that the output losses associated with a wage differential are greater when the exponents in the two sectoral production functions are similar across sectors. This point is relevant to the current paper because, in the experiments reported above, the technology parameters are some distance apart.

One way to retain the same basic framework, but consider alternative parameter values, is to assume that a certain fraction of agricultural output is not measured in the national accounts, perhaps because it is produced for non-marketed domestic consumption.[9] If a fraction ϵ of agricultural output is unmeasured, we can adjust the observed agricultural output shares as follows:

$$s^* = \frac{s}{1 - \epsilon + \epsilon s}$$

where s^* is the 'true' output share adjusted for mismeasurement. If half of agricultural output is unmeasured ($\epsilon = 0.5$) then the output share becomes 0.67 in the African case, 0.52 in the East Asian case, and 0.46 in the Latin American case. In turn this implies that the technology parameters are closer together. Calibrating the model for the Cobb-Douglas case, using these new values for the technology parameters, results in larger output effects, as suggested by the informal visual analysis in Johnson (1966). Nevertheless, the output gains remain a relatively small fraction of GDP, with the possible exception of the Latin American case.

Thus, the basic finding that aggregate TFP is relatively unaffected by marginal product differentials, at least of the magnitude considered here, appears fairly general. It is worth asking whether obvious departures from the model could overturn this conclusion, and it is certainly possible that a richer model of the urban labor market might give very different results. Note, however, that if the unemployed receive at least some income, perhaps in the informal sector, then the intersectoral disparity between marginal products will be smaller for a given urban unemployment rate, and the costs of dualism accordingly smaller. More generally, to obtain larger effects of dualism, an alternative theory of the urban labor market would need a mechanism that drives the marginal products of urban and rural labor further apart, or that links the labor market and aggregate productivity in a different way.

[9] See Parente, Rogerson and Wright (2000) for an analysis of the mix of market and non-market activity in developing countries, within a structural model.

One possibility is to assume that workers are risk averse. They will require a greater wage premium for urban employment to compensate them for the risk of being unemployed (see for example Collier 1975). This will be associated with a larger marginal product differential, and hence the effect of dualism on aggregate TFP will be greater than in the examples considered here.

An alternative route would be to break the connection between wages and marginal products. For example, it could be assumed that workers receive their average product in agriculture rather than their marginal product, through household income sharing. If workers compare the average product in agriculture with the marginal product in the urban sector, the long-run migration equilibrium could be consistent with a large differential in marginal products, and greater effects of dualism on aggregate TFP.

Moreover, the TFP effects are not the end of the story. The comparison of the Harris-Todaro and first-best economies in this paper holds the capital stock fixed, and relaxing this assumption would tend to be associated with larger output effects. The most obvious way to make the capital stock endogenous would be to open the economy to capital flows, but this is not straighforward. With the urban wage and goods prices assumed to be fixed, and the other assumptions retained, then specifying an exogenous rental rate is unlikely to be consistent with a diversified equilibrium. One solution to this would be to introduce a specific factor in non-agriculture, but I leave this to further work.[10]

If we stay with the current framework, the main consequences of dualism appear to be for sectoral structure rather than for aggregate TFP. When the elasticity of substitution in production is relatively high, the movement from the Harris-Todaro economy to the first-best is associated with large gains in modern sector employment, partly due to the elimination of the wage differential and the contraction of agriculture, and partly due to the elimination of unemployment. I now discuss the robustness of this finding.

Various arguments imply that the current model overstates the extent of structural change associated with the elimination of dualism. One reason is that capital may be sector-specific in developing countries (Robinson 1989) and this will tend to limit the extent of sectoral shifts. This argument is less strong than it first appears, however. I have experimented with the sector-specific case for Cobb-Douglas production functions, using results derived in Appendix 2. These experiments tend to suggest that sectoral shifts are indeed moderated under sector-specific capital, although only for the Latin American case are the

[10] Another solution would be to follow Yabuuchi (1993) in assuming that capital is sector-specific, and that only the agricultural sector is open to international capital flows.

differences marked.[11] The total output gains are very similar in magnitude.

Another extension would be to incorporate a role for non-traded goods. Relative price changes could then limit the extent of structural differences between the dualistic economy and the first-best. The simplest way to study this issue is to assume that the proportions of income spent on each good are fixed, within an economy that is closed to international trade. This involves some extensions to the algebra of section 4, and in particular the introduction of a price index. In carrying out this extension I have found, not surprisingly, that the introduction of constant budget shares implies that employment shares are very similar across the dualistic and first-best economies. Less obviously, the magnitude of the output losses appears to be robust to this alternative assumption about price determination. In the case of fixed budget shares, the output costs of dualism are very similar to those in the case of fixed prices, although typically smaller.

If we briefly take this paper's findings at face value, what are the wider implications? It is often thought that intersectoral mobility, and labor market flexibility in general, plays an important role in successful development and growth. For example, in the course of a study of the Korean labor market, Kim and Topel (1995) suggest that the "implied mobility of the labor force [in Korea] may be a boon to development and structural change". The results of this paper suggest, however, that the case for intersectoral mobility may have to go beyond static efficiency considerations. In the absence of mobility, growth will usually be associated with a widening urban-rural wage gap. Yet it turns out that the output loss associated with such a gap is typically small, unless the rural and urban labor markets are so poorly integrated that the wage differential becomes very large.

One response is that the net present value of even a small output loss may be very large. The relevance of this argument to policy depends on the nature of the costs involved in eliminating dualism. If dualism can be eliminated by a one-off policy change, the point is a strong one, but many of the proposals for moving to the first-best are based on policies that are likely to involve substantial recurrent costs. Theoretical analysis of dual economies has often focused on wage subsidies as a solution, but in the likely absence of lump sum taxes, raising the revenue for such subsidies will involve deadweight losses for the duration of the subsidy scheme.[12]

[11]This can be inferred from Tables 3 and 4. Note that z, the share of capital allocated to agriculture in the first-best, is often close to x, agriculture's share of capital in the Harris-Todaro economy. Only in the Latin American case is there much difference.

[12]On wage subsidies in the Harris-Todaro model, see Basu (1980), Bhagwati and Srinivasan (1974), Corden and Findlay (1975) and Ray (1998, p. 382-388).

The case for eliminating dualism might have to be based on other considerations: the consequences of dualism for inequality, and interaction with other imperfections or distortions. Consider distributional effects first. It is clear that the elimination of the rural-urban wage gap and urban unemployment would reduce inequality.[13] Although the elimination of dualism is also associated with a movement in factor shares that usually works in favour of capital, the effect is small.

Larger effects of dualism on TFP may arise if wage differentials interact with other imperfections and distortions. The example Williamson (1987, 1989) emphasizes is the interaction with capital market failure. Say that the modern sector must finance most of its investment from its own profits. As a result, anything which constrains the size of the modern sector will tend to be associated with a lower capital stock and lower labor productivity. More generally, Fishlow and David (1961) established that the joint impact of imperfections in the capital and labor market may be deadweight losses that are rather more significant than those arising from imperfections in one market alone.[14]

Another important reason for concern about dualism, and sectoral structure more generally, is that there could be significant externalities in the non-agricultural sector. These could be associated with the beneficial effects of learning-by-doing, or external economies linked to agglomeration. As we saw above, the elimination of dualism can be associated with dramatic changes in sectoral structure, especially if the elasticity of substitution in production is high. In the presence of sector-specific externalities, these changes in sectoral structure could have significant consequences for welfare, and the presence of dualism would then be a major policy concern. Some of the relevant issues are analyzed in Graham and Temple (2001), who calibrate a model of a dual economy with a sector-specific externality that gives rise to multiple equilibria. Their work implies that movement away from a dualistic equilibrium can be associated with a major improvement in aggregate total factor productivity.

As a final point, note that the paper also casts indirect light on the general equilibrium effects of minimum wage legislation or other forms of wage floor, when coverage is incomplete. This is because we can reinterpret the agricultural sector as one uncovered by minimum wages, and the urban sector as covered.

[13] In the cross-country data, dualism is indeed associated with greater inequality. See Bourguignon and Morrisson (1998).

[14] Note that when a differential in rental rates is present in the 2 x 2 Harris-Todaro model, a reduction in the minimum wage has an ambiguous effect on aggregate output (Khan and Naqvi 1983). A reduction in the rental differential will always raise aggregate output in the 2 x 2 model. This is not the case, however, in a model with a role for land in the agricultural production function. See Chao and Yu (1992).

The paper analyzes a case where the minimum wage generates a 30% unemployment rate in the covered sector. Despite unemployment of this extent, the effects of such legislation on aggregate TFP and on wages in the uncovered sector are generally found to be small for the cases considered here. The minimum wage does succeed in redistributing income towards labor, but again the effect is small.

8 Conclusion

This paper began from the observation that the aggregate consequences of certain labor market distortions are not well understood. The paper studies one particular form of distortion, namely a fixed urban wage that gives rise to urban unemployment and a rural-urban wage differential. The paper reveals the aggregate consequences of this form of labor market dualism, with an especial focus on total factor productivity and sectoral structure.

The paper first shows how to calibrate a two-sector general equilibrium model of production using readily available data on sectoral output and employment shares. Using results introduced here, it is straightforward to recover technology parameters and the intersectoral capital allocation from the available data. This approach may have wider applications. For example, it could easily be adapted to understand the effects of sectoral productivity changes on structural change, aggregate TFP, and urban unemployment. This would allow some of the traditional concerns of development economists and growth economists to be addressed in quantitative terms, using the formal general equilibrium models of trade theory.

In the present paper, the calibration technique is applied to the version of the Harris-Todaro model introduced by Corden and Findlay (1975). It provides some insight into the consequences of dualism for aggregate TFP, factor returns, factor shares and sectoral structure. There are two main findings. First, the elimination of dualism is not associated with particularly large TFP gains, even when one starts from a position of relatively high urban unemployment. This finding is consistent with previous studies, such as that of Johnson (1966), but is obtained using a more general framework and under a wide variety of parameter assumptions. It reaffirms that even quite sizeable departures from equality of marginal products do not have large output effects, whether the departure arises through an exogenous wage differential, or through the Harris-Todaro equilibrium condition.

The second finding is that the elimination of dualism can give rise to large changes in sectoral structure. The novel implication is that a failure to industrialize could have its origin in the labor market. This reinforces the case made by Freeman (1992) for studying the interactions between labor market structure and the growth process in poorer countries. One interesting avenue for future research would be to revisit the concerns of this paper using more sophisticated and realistic applied general equilibrium models that include a role for non-traded goods, and a more detailed specification of labor market rigidities and imperfections.

9 Appendix 1

This appendix describes the calibration technique for the version of the model with CES production functions in both sectors. Once again the labor shares in the two sectors in the dual economy, η_a and η_m, can be recovered using equations (12) and (14). We can then use these equations to recover the share of agricultural capital in total capital, $x = K_a/K$. Start by noting that under intersectoral capital mobility, where r is the rental rate:

$$\begin{aligned} 1-\eta_a &= \frac{rK_a}{Y_a} = \frac{rK}{Y}\frac{K_a}{K}\frac{Y}{Y_a} \\ &= (1-\eta)\frac{x}{s} \end{aligned} \tag{28}$$

If we substitute in for η_a using (12), and rearrange, we find that:

$$x = \frac{s-\eta a}{1-\eta} \tag{29}$$

which defines x in terms of two observable variables (a and s) and the aggregate labor share η. The rest of the solution procedure aims to establish two simultaneous equations in two unknowns, the first-best agricultural employment share $b = L_a'/L$ and the first-best share of capital allocated to agriculture, $z = K_a'/K$.

The distribution parameters δ_a and δ_m are assumed to be unobserved, and must be recovered from the data. Using the equation for the labor share in agriculture ($\eta_a = w_a L_a/Y_a$) and assuming that labor in agriculture is paid its marginal product, the following equation can be derived:

$$\delta_a = \frac{1-\eta_a}{1-\eta_a+\eta_a\left(\frac{K_a}{L_a}\right)^{-\rho}} \tag{30}$$

A corresponding equation holds for δ_m:

$$\delta_m = \frac{1-\eta_m}{1-\eta_m+\eta_m\left(\frac{K_m}{L_m}\right)^{-\rho}} \tag{31}$$

(An equivalent equation was derived by Klump and Preissler, 2000, p. 45). In the dual economy, equalization of rental rates implies:

$$\begin{aligned} \delta_a A_a^{-\rho}\left(\frac{Y_a}{K_a}\right)^{1+\rho} &= p\delta_m A_m^{-\rho}\left(\frac{Y_m}{K_m}\right)^{1+\rho} \\ \left(\frac{x}{1-x}\right)^{1+\rho} &= \frac{\delta_a}{\delta_m}\left(\frac{pA_m}{A_a}\right)^{\rho}\left(\frac{s}{1-s}\right)^{1+\rho} \end{aligned} \tag{32}$$

With CES production functions, the Harris-Todaro condition (10) can be written as:

$$(1-\delta_a)\,A_a^{-\rho}\left(\frac{Y_a}{L_a}\right)^{1+\rho} = (1-u)p\,(1-\delta_m)\,A_m^{-\rho}\left(\frac{Y_m}{L_m}\right)^{1+\rho} \tag{33}$$

$$(1-u)^{-\rho}\left(\frac{a}{1-a}\right)^{1+\rho} = \left(\frac{1-\delta_a}{1-\delta_m}\right)\left(\frac{pA_m}{A_a}\right)^{\rho}\left(\frac{s}{1-s}\right)^{1+\rho} \tag{34}$$

Now turn to the equations for the first-best economy, where $b = L_a'/L$ is the proportion of employment in agriculture, $r = Y_a'/Y$ is the share of agriculture in output and $z = K_a'/K$ is the proportion of capital employed in agriculture. Y_m', K_m' and L_m' are output, capital and labor in manufacturing respectively. Let the share of labor in national income in the first-best be ϕ, and the shares of labor income in agricultural and manufacturing income be ϕ_a and ϕ_m respectively. Intersectoral capital mobility in the first-best economy yields an equation similar to (32):

$$\left(\frac{z}{1-z}\right)^{1+\rho} = \frac{\delta_a}{\delta_m}\left(\frac{pA_m}{A_a}\right)^{\rho}\left(\frac{r}{1-r}\right)^{1+\rho} \tag{35}$$

We can now start to derive two simultaneous equations in terms of b, z and observable variables, which can then be solved for the first-best allocation of employment b and capital z. The simplest way to derive the first simultaneous equation is to divide the expressions for the marginal products in the Harris-Todaro economy by those in the first-best economy. In the case of labor's marginal products, the result is:

$$\left(\frac{Y_a}{Y_a'}\right)^{1+\rho} = (1-u)^{-\rho}\left(\frac{a}{b}\right)^{1+\rho}\left(\frac{1-b}{1-a}\right)^{1+\rho}\left(\frac{Y_m}{Y_m'}\right)^{1+\rho}$$

and similarly for capital:

$$\left(\frac{Y_a}{Y_a'}\right)^{1+\rho} = \left(\frac{x}{z}\right)^{1+\rho}\left(\frac{1-z}{1-x}\right)^{1+\rho}\left(\frac{Y_m}{Y_m'}\right)^{1+\rho}$$

Combining these two expressions yields the first key equation:

$$\frac{b}{1-b} = \left(\frac{a}{1-a}\right)\left(\frac{1-x}{x}\right)(1-u)^{\frac{-\rho}{1+\rho}}\left(\frac{z}{1-z}\right) \tag{36}$$

To derive the second simultaneous equation, note that as before, we have two equations for the income shares, similar to (12) and (14):

$$\phi_a = \frac{\phi b}{r} \tag{37}$$

$$\phi_m = \phi\left(\frac{1-b}{1-r}\right) \tag{38}$$

The equations corresponding to (30) and (31) are the same in form, with the appropriate change of symbols:

$$\delta_a = \frac{1-\phi_a}{1-\phi_a+\phi_a\left(\frac{K_a'}{L_a'}\right)^{-\rho}} \tag{39}$$

$$\delta_m = \frac{1-\phi_m}{1-\phi_m+\phi_m\left(\frac{K_m'}{L_m'}\right)^{-\rho}} \tag{40}$$

Now we make use of the fact that the distribution parameters δ_a and δ_m are aspects of the production technologies, and so are the same for the Harris-Todaro and the first-best economies. Equating (30) to (39), and (31) to (40), we can derive equations for the labor shares in the first-best:

$$\phi_a = \frac{1}{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{x}{a}\right)^{1+\rho}\left(\frac{b}{z}\right)^{\rho}} \tag{41}$$

$$\phi_m = \frac{1}{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{1-x}{1-a}\right)^{1+\rho}\left(\frac{1-b}{1-z}\right)^{\rho}(1-u)^{-\rho}} \tag{42}$$

Using these equations together with (37) and (38), we have:

$$\frac{\phi_a}{\phi_m} = \left(\frac{b}{1-b}\right)\left(\frac{1-r}{r}\right) = \frac{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{1-x}{1-a}\right)^{1+\rho}\left(\frac{1-b}{1-z}\right)^{\rho}(1-u)^{-\rho}}{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{x}{a}\right)^{1+\rho}\left(\frac{b}{z}\right)^{\rho}} \tag{43}$$

Now we need to eliminate the unobservable variable r. If we combine equations (32) and (35), we find that r, z, x and s are related in the following way:

$$\frac{r}{1-r} = \left(\frac{z}{1-z}\right)\left(\frac{1-x}{x}\right)\left(\frac{s}{1-s}\right) \tag{44}$$

Hence equation (43) can be rewritten as:

$$\frac{b}{1-b}=\left(\frac{z}{1-z}\right)\left(\frac{1-x}{x}\right)\left(\frac{s}{1-s}\right)\left(\frac{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{1-x}{1-a}\right)^{1+\rho}\left(\frac{1-b}{1-z}\right)^{\rho}(1-u)^{-\rho}}{1+\left(\frac{1-\eta}{\eta}\right)\left(\frac{x}{a}\right)^{1+\rho}\left(\frac{b}{z}\right)^{\rho}}\right) \tag{45}$$

Equations (36) and (45) can be solved numerically to obtain b and z.

The remaining results are computed as follows. To calculate the output ratio across the two economies, first note that the equality of wages with marginal products for CES production functions implies the following modern sector labor share for the Harris-Todaro economy:

$$\eta_m=(1-\delta_m)\,A_m^{-\rho}\left(\frac{Y_m}{L_m}\right)^{\rho} \tag{46}$$

and for the first-best:

$$\phi_m=(1-\delta_m)\,A_m^{-\rho}\left(\frac{Y'_m}{L'_m}\right)^{\rho} \tag{47}$$

From (24) in the text, the output ratio across the two economies can be written as:

$$\Lambda=\frac{Y'_m}{Y_m}\left(\frac{1+\frac{Y'_a}{pY'_m}}{1+\frac{Y_a}{pY_m}}\right)=\frac{Y'_m}{Y_m}\left(\frac{1+\frac{r}{1-r}}{1+\frac{s}{1-s}}\right)$$

Using (44), (46), and (47) this can be rewritten as:

$$\begin{aligned}\Lambda &= \left(\frac{\phi_m}{\eta_m}\right)^{\frac{1}{\rho}}\left(\frac{L'_m}{L_m}\right)\left(\frac{1+\left(\frac{z}{1-z}\right)\left(\frac{1-x}{x}\right)\left(\frac{s}{1-s}\right)}{1+\frac{s}{1-s}}\right)\\ &= \left(\frac{\phi_m}{\eta_m}\right)^{\frac{1}{\rho}}\left(\frac{1-b}{(1-u)(1-a)}\right)\left(\frac{1+\left(\frac{z}{1-z}\right)\left(\frac{1-x}{x}\right)\left(\frac{s}{1-s}\right)}{1+\frac{s}{1-s}}\right)\end{aligned}$$

The only additional information this requires is the solution for (42) which can be calculated using the solutions for b and z. Finally, note that we can also obtain the ratio of modern sector wages in the two economies using

$$\frac{w'_m}{w_m}=\left(\frac{Y'_m/L'_m}{Y_m/L_m}\right)^{1+\rho}=\left(\frac{\phi_m}{\eta_m}\right)^{\frac{1+\rho}{\rho}}$$

where the second equality follows from equations (46) and (47). Corresponding expressions can easily be derived for the ratios of agricultural wages and rental rates across the two economies.

10 Appendix 2

This appendix describes simple modifications to the Cobb-Douglas results of section 4 that apply when capital is sector-specific, rather than mobile between sectors. We can consider this case by setting $z = x$. Then the first-best agricultural employment share b_{SS} is implicitly defined by

$$\left(\frac{a}{b_{SS}}\right)^{\alpha}\left(\frac{1-b_{SS}}{1-a}\right)^{\theta}(1-u)^{1-\theta}=1 \tag{48}$$

Given a, u, α and θ this equation can be solved for b_{SS} numerically. We can also find the effects of dualism on aggregate output when capital is sector-specific. Using equation (24) in the main text and substituting in the Cobb-Douglas production functions for Y_m and Y_m', and cancelling terms, gives

$$\Lambda_{SS}=\left(\frac{1-b_{SS}}{1-a}\right)^{1-\theta}(1-u)^{\theta-1}\left(\frac{1+\frac{b_{SS}}{1-b_{SS}}\left(\frac{1-\theta}{1-\alpha}\right)}{1+\frac{a}{1-a}\left(\frac{1-\theta}{1-\alpha}\right)}\right) \tag{49}$$

Other results follow in a straightforward way.

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