Estimating disguised unemployment in major middle-income countries by means of non-linear input-output analysis, 2000-2014

Authors:

1. Pablo R. Liboreiro, Lecturer at Technical University of Madrid. E-mail: pablo.rodriguezl@upm.es. Tel.: +24-650205747. Postal Address: 11 Juan XXIII Street, Madrid 2804, Spain. ORCID: 0000-0001-7736-2366.

Acknowledgments:

The author thanks the three anonymous referees and the editor for their valuable comments, and also thanks the International Input-Output Association for acknowledging his work.

Disclosure statement:

The author reports there are no competing interests to declare.

Estimating disguised unemployment in major middle-income countries by means of non-linear input-output analysis, 2000-2014

Abstract. According to the disguised-unemployment hypothesis, significant wage differences between sectors and businesses in less-developed countries result from segmented labour markets and overcrowding of the flexible market segment. So stated, this hypothesis implies a way to measure non-open unemployment: by the amount of labour that must be withdrawn from the labour market for the relative-wage structure to become less extreme. Indeed, it is possible to estimate disguised unemployment by means of a non-linear input-output model and assuming the U.S. wage structure to be non-dualistic so that the exercise of comparing the actual employment of a country with a simulated `non-dualistic' employment can be undertaken. This simulation experiment was carried out for seven middle-income countries (Brazil, China, Indonesia, India, Russia, Mexico, and Turkey) from 2000 to 2014 using data from the 2016 Release of the World Input-Output Database. The results of the simulation experiment are consistent with the disguised-unemployment hypothesis, as well as with related literature.

Keywords. Disguised unemployment, dualistic labour markets, middle-income countries, non-linear input-output analysis.

1 Introduction

It is a generally known issue that in less-developed countries, large wage differentials exist between sectors and businesses. These are sometimes related to differences in the relative scarcity of distinct grades and kinds of labour. Thus, it is often considered that, because less-developed countries lack 'human capital', the skill premium is higher than in more-developed countries. However, these large wage differentials also seem to be found among grades and kinds of labour requiring similar skills (Mazumdar, 1999; Felipe & Hasan, 2006). This means that in less-developed countries there are great differences in the marginal product of workers with seemingly similar skills, a phenomenon often explained by the disguised-unemployment hypothesis.

According to the disguised-unemployment hypothesis, the labour market in less-developed countries is segmented into two sections: one for large-scale modern businesses and another for small-scale traditional businesses. In the former section, wages are set according to institutional or internal efficiency criteria, and workers are restrained from competing for jobs by offering themselves at a lower wage rate. In the latter section, wages are set according to market-clearing prices so that any worker can be employed if he/she accepts a reward corresponding to the value of the output attributable to his/her marginal product. As long as there is no regular system of sufficiently generous unemployment benefits, any worker who cannot find a job in the first section of the labour market must find an occupation in the second one. Thus, since the first section of the market can absorb only a small part of the labour force, the second section becomes overcrowded, leading to large wage differences between similar kinds of labour. In this way, it is said that in many less-developed countries, there is an element of 'disguised unemployment', meaning that the difference in the marginal product of two workers with the same skills employed in different sectors is greater than the difference in the marginal disutility of their tasks[1].

The disguised-unemployment hypothesis has received variable attention from scholars over time. It

[1] It should be noted that the disguised-unemployment hypothesis is not the only hypothesis explaining the great differences observed in the marginal product of labour in less-developed countries. Actually, some scholars have proposed that a phenomenon like this may be due to unobserved differences either in the skills of workers or in the disutility of different types of work (Rosenzweig, 1988; Gindling, 1991; Magnac, 1991; Maloney, 1999, 2004; Pratap & Quintin, 2006). This alternative hypothesis is not considered in the present study.

was rigorously exposed for the first time by J. Robinson (1936) and applied to the specific case of Eastern European countries by P.N. Rosenstein-Rodan (1943). After Lewis's influential work (1954) and subsequent formalizations based upon it (Georgescu-Roegen, 1960; Ranis & Fei, 1961), attention fell on a specification of the disguised-unemployment hypothesis -the so-called 'surplus labour' hypothesis- in which the case is regarded of the marginal product of a certain amount of labour being less than its reward. The surplus-labour hypothesis focused the debate among early scholars (Viner, 1957; Harberler, 1957; Schultz, 1964; Rosenzweig, 1988) to the extent that a general formulation of disguised unemployment was set aside[2]. Recently, the disguised-unemployment hypothesis has been restated in view of the dualistic nature of formal versus informal labour markets (Fields, 1975, 1990; Mazumdar, 1977, 1999), and some case studies conclude that a non-negligible portion of informal employment is a kind of disguised unemployment (Dickens & Lang, 1985; Heckman & Hotz, 1986; Günther & Launov, 2012)[3].

In the present study, the disguised-unemployment hypothesis is assumed in order to estimate the volume and structure of this sort of unemployment in major middle-income countries. To date, estimates of disguised unemployment in less-developed countries have focused mainly on the case where a part of labour is assumed to be employed so that its marginal product is less than its reward (that is, in the specific case of surplus labour). In this way, many estimates seek to gauge a production function and assume that some sectors or businesses do not maximize profits, so the volume of underemployed labour is measured as the amount of labour that must be removed to reach profit maximization. Thus, if l_j is the amount of labour actually employed in sector j and l_j^* is the amount of labour that should be employed for sector j to maximize profits, then the surplus labour of sector j is defined as $l_j - l_j^*$ when $l_j > l_j^*$. This method was applied to the case of peasant villages (Kalirajan, 1995; Hussain, 2003) and to that of socialist or transition economies (Wu, 1998; Li, 2004; Hernández-Catá, 2015) -typical cases in which surplus labour is expected to exist in a significant amount. Although certainly refined, the method proposed in these studies does not make possible the estimation of disguised unemployment as this generally results from the existence of dualistic labour markets in which the non-maximization of profits is not a necessary condition for disguised unemployment to be present. Likewise, the method frequently requires case studies in which detailed information is available for several production units within the same sector, which prevents large-scale estimates from allowing comparisons between countries.

Indeed, with the exception of Morishima & Murata (1971) and Gollás & Hernández (1993), scarcely any attempts have been made to estimate the amount of disguised unemployment according to its general definition, which regards the possibility of disguised unemployment even if the profit-maximization condition is met. These two studies are similar, as the latter closely follows the former, and both assume that disguised unemployment is a special case of a change in the relative-wage structure. According to this assumption, it is possible to estimate disguised unemployment by estimating each sector's labour employment regarding two different relative-wage structures. Thus, if the actual relative-wage structure is considered $[w_j]_n$, then the actual labour employment results of sector j amount to l_j. Furthermore, if a relative-wage structure is considered that can be assumed to

[2] Even today, there is frequent confusion in the literature between the general notion of disguised unemployment and the specific notion of surplus labour, to the point that almost all studies that refer to disguised unemployment actually refer to surplus labour.

[3] It should be pointed out that the notions of disguised unemployment and informal unemployment do not necessarily imply each other. Informal employment is often characterized by its legal status, referring to all economic activities of workers that, in law or practice, are not covered or insufficiently covered by formal agreements. Conversely, a worker is said to be in a state of disguised unemployment if his/her marginal product is less than the marginal product of another worker with the same skills. In this way, a worker may be in a state of disguised unemployment even when his/her economic activities are covered by formal agreements (e.g., state-subsidized disguised unemployment). Furthermore, it is possible that the marginal product of a worker in the informal sector is similar to that of another worker with the same skills in the formal sector (e.g., working 'under the table' to avoid taxes).

be 'non-dualistic' $\left[w_j^*\right]_n$, such as that which exists in some developed countries, then a different amount of labour employed in sector j results: l_j^*. So, the disguised unemployment of sector j is defined as $l_j - l_j^*$ when $w_j < w_j^*$. This definition of disguised unemployment was stated by Morishima & Murata (1971) from J. Robinson's (1936) original insight and therefore can be termed the Robinson-Morishima-Murata definition of disguised unemployment[4].

This definition and the method it implies not only make it possible to estimate disguised unemployment in its most general form but also are especially suitable for estimating disguised unemployment from the data summarized in standard input-output tables. Indeed, the studies of Morishima & Murata (1971) and Gollás & Hernández (1993) are both based on the characterization of a Klein (1952)-type input-output model with Cobb-Douglas production functions, which they apply to different input-output data sets: input-output tables for Japan for the years 1951, 1955, 1960 and 1965 in the case of Morishima & Murata (1971), and input-output tables for Mexico for the year 1980 in the case of Gollás & Hernández (1993). Regarding that these are the only two estimates made to date taking into account the Robinson-Morishima-Murata definition of disguised unemployment, it seems convenient to assume this exact definition but to carry out a new estimate using a non-linear input-output model other than that already proposed, also taking into account the data currently available for several middle-income countries.

The present study should therefore be considered as a new attempt to measure disguised unemployment according to the Robinson-Morishima-Murata definition by means of a different input-output modelling approach. This model is a non-linear input-output model with some Keynesian features and 'extended Leontief' production functions, following Guerra & Sancho (2014) and Fernández-Vázquez (2015). The model is formulated in such a way that it can be solved by numerical methods, particularly by a Newton algorithm. Taking as data those available in WIOD Release 2016 for seven middle-income countries (Brazil, China, India, Indonesia, Mexico, Russia, and Turkey)[5] for the period 2000-2014, the model is calibrated for each country and year in such a way that, for the actual relative-wage structure, actual sector employment and prices result. Next, assuming the U.S. relative-wage structure to be non-dualistic, and taking the wage rate of better-paid manual-labour-intensive industries as 'numeráire', the amount of disguised unemployment is estimated according to the Robinson-Morishima-Murata definition and using the numerical method proposed. Finally, the results obtained are reviewed and discussed, and some conclusions are highlighted.

2 Stating a non-linear input-output model

In order to estimate disguised unemployment according to the Robinson-Morishima-Murata definition, it is necessary to regard a multi-sector model in which changes in employment were related to changes in wages through changes in the marginal product of labour. Thus, typical linear models such as Leontief's are not useful for this purpose because, to the extent that constant returns-to-scale is assumed for all sectors, changes in employment are not related to changes in the marginal product of labour. It is then necessary to formulate a non-linear model that can be solved with acceptable precision by analytical or numerical methods once several parameters vary (in the present case, relative wages). Thus, a non-linear input-output model with diminishing returns in the employment

[4] Actually, J. Robinson (1936) pointed out that 'the phenomenon of disguised unemployment may be regarded as a special case of a change in relative wages'. Morishima & Murata (1971) mathematically developed this idea and rigorously formulated a definition of disguised unemployment based on Robinson's insight.

[5] These are the seven largest middle-income countries in terms of GDP. However, this sample is more heterogeneous in terms of GDP per capita than an alternative sample composed of the seven largest high-income countries in terms of GDP (the so-called 'G-7': Canada, France, Germany, Italy, Japan, UK and the US). Specifically, during the period 2000-2014 the coefficient of variation of GDP per capita for the G-7 was less than 0.15, while for the sample considered in the present study the coefficient of variation of GDP per capita is around 0.50.

of labour is stated, such that it can be easily calibrated with actual input-output tables like those available in the WIOD dataset and by a Newton algorithm.

An economy composed of $i, j = 1, \dots, n$ sectors is assumed, with each sector producing a single type of commodity. Following Guerra & Sancho (2014) and Fernández-Vázquez (2015), sector *j*'s production technique is supposed to be characterized by a production function of an 'extended Leontief' form:

$$x_j = \min\left\{\frac{x_{1j}^{\beta_{1j}}}{\alpha_{1j}}, \dots, \frac{x_{nj}^{\beta_{nj}}}{\alpha_{nj}}, \frac{n_{1j}^{\zeta_{1j}}}{\epsilon_{1j}}, \dots, \frac{n_{mj}^{\zeta_{mj}}}{\epsilon_{mj}}, \frac{l_j^{\delta_j}}{\gamma_j}\right\} \tag{1}$$

where x_j is the output of sector j, x_{ij} is the sector *i* output used as input by sector j, n_{ij} is the output of foreign sector *k* used as input by sector j, l_j is the labour input of sector j, and α_{ij}, β_{ij}, γ_{ij}, δ_{ij}, ϵ_{ij}, and ζ_{ij} are parameters dependent upon the organisation and techniques of sector j and regarded as constant in the short run. For the sake of simplicity, all imported inputs are considered non-competitive imports, so no substitution is assumed between domestic and imported inputs[6]. Besides, a further simplification can be made, assuming constant returns-to-scale in the use of all inputs except labour, so that:

$$\beta_{ij} = 1 \quad \zeta_{kj} = 1 \quad \delta_j < 1$$

This simplification implies that, as output increases, the same intermediate inputs are needed per unit of output, but the available labour is regarded as less and less adapted to perform the tasks required in each industry. There are several reasons to consider this a plausible case, especially when changes in the short period are regarded. Indeed, it is expected that as less suitable labour is employed, the labour cost per unit of output will rise as the average efficiency of the labour employed declines. Furthermore, if a given state of equipment were considered (which is not the case here), it might be expected that such equipment would need the same intermediate inputs per unit of output to run, but it would become less and less adapted to employ the available labour. Reasoning like these, as well as some empirical evidence in this regard[7], can be considered to make the assumption plausible.

Given the production techniques, it is then possible to state the price system of the economy from a few additional assumptions. Thus, suppose that wage bargains between employers and workers determine the money-wage of some industries and take the money-wage rate of some of these sectors as 'numeráire'. If competition prevails among producers, the short-run economic problem for sector *j* is to maximize profit:

$$p_j x_j - \left(\sum_i p_i x_{ij} + \sum_k q_k n_{kj} + w_j l_j\right) \tag{2}$$

subject to (1) and for a given set of relative prices:

$$\left(p_1, \dots, p_i, \dots, p_n, q_1, \dots, q_k, \dots, q_m, w_1, \dots, w_j, \dots, w_n\right)$$

where p_i is the commodity price of sector j, q_k is the commodity price of foreign sector k, and w_j is

[6] Non-competitive imports are defined as imports of those commodities which can be produced in the country, but only at a much higher price than the world market price after tariffs and transport costs.

[7] Analysing the case of the input-output table for the Spanish economy, Fernández-Vázquez (2015) found no statistical evidence to reject the null hypothesis $\beta_{ij} = 1$ for almost all sectors. Also, Prof. Fernández found δ_j to differ significantly from one, obtaining $\delta_j < 1$ in all sectors considered. These findings can be considered as evidence in favour of the simplification made here.

the wage rate of sector *j*, all expressed in terms of the wage-unit. This implies prices being equal to marginal costs, and if it is assumed that no intermediate input has a limited supply, this can be expressed as:

$$p_j = \sum_i \alpha_{ij} p_i + \sum_k \epsilon_{kj} q_k + w_j \gamma_j^{1/\delta_j} \frac{1}{\delta_j} x_j^{(1-\delta_j)/\delta_j}$$

which implies a set of *n* equations that can be written using matrix notation as:

$$\mathbf{p} = (\mathbf{I} - \mathbf{A}^T)^{-1} \left(\hat{\mathbf{h}} \mathbf{x}^{(\mathbf{I}-\hat{\mathbf{d}})\, \hat{\mathbf{d}}^{-1}} + \mathbf{E}^T \mathbf{q} \right) \quad (4)$$

where:

$$\mathbf{h} = \left[w_j \gamma_j^{1/\delta_j} \frac{1}{\delta_{j_j}} \right]_n \qquad \mathbf{d} = [\delta_j]_n \qquad \mathbf{A} = [\alpha_{ij}]_{nn} \qquad \mathbf{E} = [\epsilon_{ij}]_{mn}$$

So, commodity prices in terms of the wage-unit are an increasing function of output level given that decreasing return-to-scale prevails and $\delta_j < 1$. In this sense, and unlike Leontief's linear model, the price system cannot be solved independently of the quantity system; therefore, it is necessary to make certain assumptions about how the final demand for commodities is determined.

To the extent that the analysis is limited to the case in which organisation and techniques are regarded as constant, aggregate demand can be considered as the sum of two quantities: one that depends on the actual income and another that depends on other factors such as the state of expectations, foreign income, etc. In order to simplify the analysis, it can be assumed that the former equals the consumption and the latter equals the remaining components of demand (investment, government spending, and exports) and that household preferences are such that consumption's share of income remains constant in the short run, so:

$$PC = \nu Y \quad (5)$$

with *C* representing a composite consumption index, *P* a consumption price index, and *Y* aggregate income, the last two expressed in terms of the wage-unit. If both the elasticity of substitution between different commodities and the elasticity of substitution between domestic and foreign goods can be assumed to be unitary, and all final imported commodities are assumed to be competitive imports, then *C* can be expressed as a geometric mean such that:

$$C = \iota \prod_j C_j^{\theta_j} \quad (6)$$

where:

$$C_j = \lambda_j c_{ij}^{\mu_j} m_j^{1-\mu_j}$$

Where c_j represents the domestic commodities consumed, m_j the foreign commodities consumed, and θ_j and μ_j are parameters dependent on consumer preferences. This geometric mean is a nested Cobb-Douglas demand function and, from there, and according to Shepard's Lemma, the form of the consumer price index can be immediately deduced:

$$P = \frac{1}{\iota}\prod_j \left(\frac{P_j}{\theta_j}\right)^{\theta_j} \quad (7)$$

where:

$$P_j = \frac{1}{\lambda_j}\left(\frac{p_j}{\mu_j}\right)^{\mu_j}\left(\frac{q_j}{1-\mu_j}\right)^{1-\mu_j}$$

with q_j representing the price of foreign commodities consumed in terms of the wage-unit. This assumption on household preferences, although somewhat artificial, makes it possible to simply introduce the possibility of both substitutions between different commodities and between commodities produced inside and outside the country. As long as this implies that expenditure-shares in income remain constant in the short run, it is necessary to express income in terms of the variables considered to characterize consumption. However, this is straightforward since income is equal to the value added arising from production, that is:

$$Y = [\mathbf{p}^T(\mathbf{I}-\mathbf{A}) - \mathbf{q}^T\mathbf{E}]\mathbf{x}$$

which is to say:

$$Y = \mathbf{i}^T[\widehat{\mathbf{p}}(\mathbf{I}-\mathbf{A}) - \widehat{\mathbf{q}}\mathbf{E}]\mathbf{x}$$

with $\mathbf{i}$ being a unitary *n*-column-vector. In this way, the vector of domestic consumption expenditure in terms of the wage unit can be expressed according to (6) and (8) as:

$$\mathbf{B}[\widehat{\mathbf{p}}(\mathbf{I}-\mathbf{A}) - \widehat{\mathbf{q}}\mathbf{E}]\mathbf{x}$$

where:

$$\mathbf{B} = \mathbf{b}\mathbf{i}^T$$

and:

$$\mathbf{b} = [\mu_j\theta_j\nu]_n$$

as elasticities of substitution are unitary and expenditure-shares remain constant.

Finally, it can be assumed that the value in terms of the wage-unit of the components of demand other than consumption (investment, government spending, and exports) are determined independently of income in the short run so that they can be considered as given by a vector:

$$\mathbf{f} = [f_j]_n \quad (10)$$

where f_j is the amount of final exogenous expenditure on commodity *j*, measured in terms of the wage-unit.

Considering (9) and (10), the quantity system can be expressed as:

$$(\mathbf{I}-\mathbf{A})\mathbf{x} = \widehat{\mathbf{p}}^{-1}\{\mathbf{B}[\widehat{\mathbf{p}}\,(\mathbf{I}-\mathbf{A})\mathbf{x} - \widehat{\mathbf{q}}\mathbf{E}\mathbf{x}] + \mathbf{f}\} \quad (11)$$

Thus, it turns out that, in the same way that the price system depends on quantities, so the quantity system also depends on prices. Therefore, it is necessary to jointly solve both systems for either prices or quantities. For this, it is essential to make use of numerical methods for solving non-linear systems of equations. Specifically, solving the system of equations for quantities is equivalent to finding the fixed point of the function:

$$\mathbf{k}(\mathbf{x}) = \mathbf{x} - \mathbf{J}(\mathbf{x})^{-1}\mathbf{g}(\mathbf{x}) \tag{12}$$

Where $\mathbf{k}(\mathbf{x})$ is a system of *n* non-linear equations, whose *n* unknowns are each sector's output, as results from jointly considering (4) and (11):

$$\mathbf{g}(\mathbf{x}) = (\mathbf{I}-\mathbf{B})\cdot diag\left[(\mathbf{I}-\mathbf{A}^T)^{-1}\left(\hat{\mathbf{h}}\mathbf{x}^{(\mathbf{I}-\hat{\mathbf{d}})\,\hat{\mathbf{d}}^{-1}} + \mathbf{E}^T\mathbf{q}\right)\right]\cdot(\mathbf{I}-\mathbf{A})\mathbf{x} + \mathbf{B}\hat{\mathbf{q}}\mathbf{E}\mathbf{x} - \mathbf{f}$$

and $\mathbf{J}(\mathbf{x})$ is its Jacobian matrix, given by:

$$\begin{aligned}\mathbf{J}(\mathbf{x}) = (\mathbf{I}-\mathbf{B})\cdot diag[(\mathbf{I}-\mathbf{A})\mathbf{x}]\cdot(\mathbf{I}-\mathbf{A}^T)^{-1}\cdot diag\left[\hat{\mathbf{h}}\left(\mathbf{I}-\hat{\mathbf{d}}\right)\hat{\mathbf{d}}^{-1}\mathbf{x}^{(\mathbf{I}-2\hat{\mathbf{d}})\,\hat{\mathbf{d}}^{-1}}\right] + \\ +(\mathbf{I}-\mathbf{B})\cdot diag\left[(\mathbf{I}-\mathbf{A}^T)^{-1}\left(\hat{\mathbf{h}}\mathbf{x}^{(\mathbf{I}-\hat{\mathbf{d}})\,\hat{\mathbf{d}}^{-1}} + \mathbf{E}^T\mathbf{q}\right)\right]\cdot(\mathbf{I}-\mathbf{A}) + \mathbf{B}\hat{\mathbf{q}}\mathbf{E}\end{aligned}$$

and the fixed-point iteration procedure evolves from selecting a reasonable starting approximation $\mathbf{x}(0)$ and generating, for $k > 1$:

$$\mathbf{x}(k) = \mathbf{x}(k-1) - \mathbf{J}\big(\mathbf{x}(k-1)\big)^{-1}\mathbf{g}\big(\mathbf{x}(k-1)\big)$$

This is essentially the Newton's method for non-linear systems. It is generally expected to give quadratic convergence, provided that a sufficiently accurate starting value is known and that $\mathbf{J}(\mathbf{x})^{-1}$ exists. In fact, for the present case, the convergence is quite rapid, and a very accurate starting value is not required to solve the system with the desired precision. Furthermore, since the input-output model retains some key features of typical linear input-output models, the solution is expected to be unique. Indeed, according to the assumptions of the present model, changes in gross output require more input in each commodity. Besides, the input matrices are productive, i.e., the sum of the input coefficients of each sector *j* is less than one, $\sum\alpha_{ij} < 1$. Additionally, for the activity levels of some industries to rise, it is necessary that at least the net output of one industry increases. Thus, the uniqueness of solutions is assured by a theorem due to Fujimoto (1986).

By solving the quantity system numerically, it is possible to estimate the amount of disguised unemployment according to the Robinson-Morishima-Murata definition in the following way. First, if the input-output model is calibrated correctly according to the actual data, the solution provided by the iterative method for $\mathbf{x}$ must be equal to the actual output vector, as shown in the input-output tables. Noting that labour employment in sector *j* is a function of that sector's output according to (1), then sector *j*'s actual employment is equal to:

$$l_j = \left(\gamma_j x_j\right)^{1/\delta_j}$$

So the sum of l_j over all the sectors leads to the amount of actual employment (as shown in national accounts). Next, if the relative-wage structure is changed after calibrating the model while keeping the remaining parameters constant, the iterative method will offer another result. If this other relative-wage structure can be assumed to be 'non-dualistic' w_j^*, then the parameter vector $\mathbf{h}$ changes to:

$$\mathbf{h}^* = \left[w_j^*\gamma_j^{1/\delta_j}\frac{1}{\delta_j}\right]_n$$

And the iterative method will offer another result for the output vector, one that can be termed 'non-dualistic' output $\mathbf{x}^*$. Then, according to (1), sector *j*'s 'non-dualistic' employment will result from:

$$l_j^* = \left(\gamma_j x_j^*\right)^{1/\delta_j}$$

Thus, the amount of disguised unemployment will be equal to the difference between the actual amount of employment and the non-dualistic amount of employment in those sectors in which the relative wages were below the 'non-dualistic' level, that is:

$$\sum_{j\in S}\left(l_j - l_j^*\right) \qquad S = \left\{j = 1, \dots, n \mid w_j < w_j^*\right\} \tag{13}$$

According to this, the calculation of disguised unemployment thus proposed is equivalent to asking how much labour should withdraw from the market (for example, through emigration) for the relative wage structure to reach a non-dualistic fashion, given a state of organisation and techniques, and given a volume of investment, government spending and exports, a set of consumer preferences, and a set of foreign prices, all in terms of the wage-unit. In this sense, if any of these variables were to change (including the wage-unit taken as numeráire itself), the amount of disguised unemployment would also change.

Obviously, due to the effect of inter-industry relations, when the relative-wage structure changes, the employment of sectors acting as reservoirs of disguised unemployment change, and so does the employment of other sectors. Specifically, the amount:

$$\sum_j\left(l_j - l_j^*\right) - \sum_{j\in S}\left(l_j - l_j^*\right) \tag{14}$$

is equal to the amount of employment that certain sectors can maintain above their 'non-dualistic' level, thanks to the relatively low wages of some workers and despite their lower consumption. This can therefore be referred to as 'excess' employment.

In this way, it is stated that, once the input-output model is well-calibrated, the determination of disguised unemployment according to the Robinson-Morishima-Murata definition is not a difficult task, as long as the iterative method works correctly. Indeed, in order to calibrate the model, the only parameters that present certain difficulty are γ_j and δ_j. To achieve calibration, from the expression of the marginal cost (3), the following identity can be obtained:

$$\delta_j = \frac{w_j \gamma_j^{1/\delta_j} x_j^{(1-\delta_j)/\delta_j}}{p_j - \sum_i p_i \alpha_{ij} - \sum_k q_k \epsilon_{kj}}$$

And by calculating the average cost from (2), it is possible to affirm that this last relation is equivalent to:

$$\delta_j = \frac{w_j l_j}{\left(p_j - \sum_i p_i \alpha_{ij} - \sum_k q_k \epsilon_{kj}\right) x_j}$$

from which it is possible to obtain δ_j. Once these parameters are obtained, γ_j parameters can be calculated directly from (1), considering the amount of labour actually employed in each sector.

Moreover, the remaining production parameters do not present with a great difficulty. Indeed, α_{ij} parameters are the input-output coefficients of the domestic-input matrix, and ϵ_{kj} parameters are the coefficients of the imported-input matrix. In the event that, in addition to these inputs, any taxes or subsidies on products and/or international transport margins apply, these can be considered simply as if they were quantity taxes so that for purposes of calculation, they are identical to considering an additional foreign sector $m+1$ whose input-output coefficient is unitary and whose price is equal to net taxes plus transport margins paid per product.

Regarding the parameters related to demand, and given the previously made assumptions, neither do these imply any significant difficulty. Thus, according to the assumptions, ν is the consumption-share of income, θ_j is the share of commodity j on total consumption, and μ_j is the weight of domestic-made commodity *j*'s consumption on total commodity *j*'s consumption. Likewise, the value of exogenous demand for commodity *j* in terms of the wage-unit, f_j, can be calculated directly from the available data.

3 Estimating disguised unemployment

Taking data from the WIOD Release 2016, the calculations described in the former section were undertaken for seven middle-income countries (Brazil, China, Indonesia, India, Mexico, Russia, and Turkey) and each of the years available (2000-2014). In order to avoid errors derived from the different sector classifications in each of the countries considered, main industries were aggregated into 31 sectors. According to ISIC Rev.3, these are numbered as follows:

Table 1. Main industries considered in the estimate[8]

1	Agriculture & fishing (AtB)	17	Construction (F)
2	Mining & quarrying (C)	18	Wholesale trade (50t51)
3	Food, beverages & tobacco (15t16)	19	Retail trade (52)
4	Textiles & clothing (17t19)	20	Hotels & food services (H)
5	Wood & wood products (20)	21	Inland transport (60)
6	Pulp, paper & printing (21t22)	22	Water transport (61)
7	Coke & fuel (23)	23	Air transport (62)
8	Chemical products (24)	24	Warehousing (63)
9	Rubber & plastics (25)	25	Post & telecommunications (64)
10	Other non-metallic mineral (26)	26	Financial services (J)
11	Iron, steel & nonferrous metals (27t28)	27	Business services (71t74)
12	Machinery & equipment (29)	28	Public administration (L)
13	Electrical & optical equipment (30t33)	29	Education (M)
14	Transport equipment (34t35)	30	Health (N)
15	Other manufacturing (36t37)	31	Other services (O)
16	Electricity, gas & water (E)		

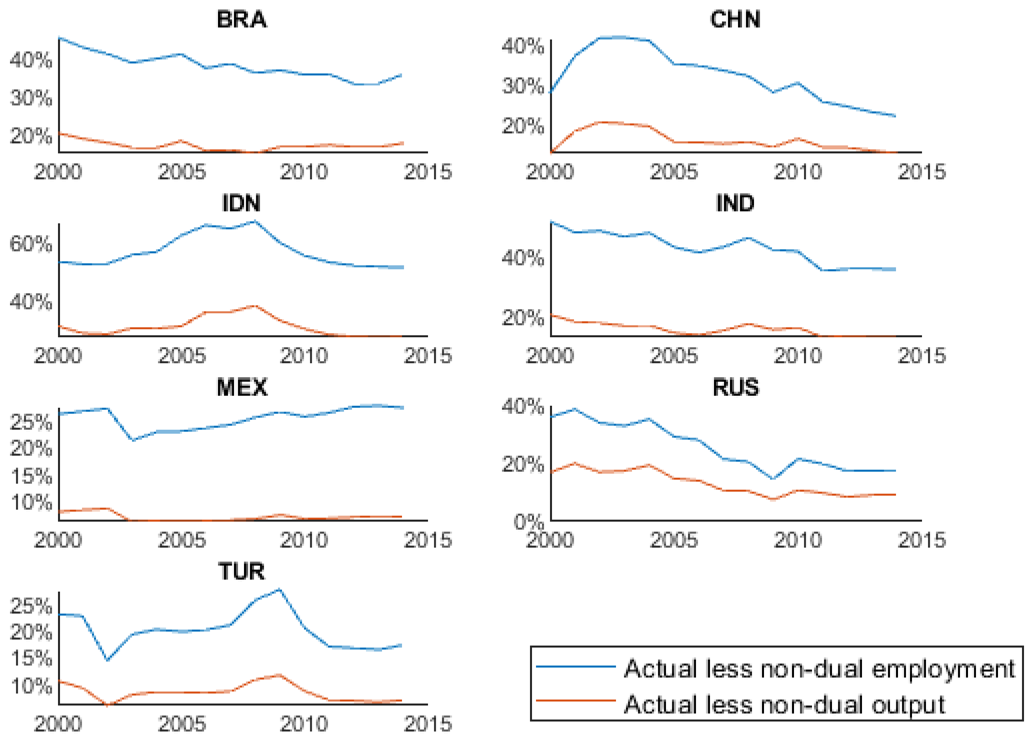
Labour employed by sectors ranging from 1 to 24 plus sector 31 was assumed to be of the same grade and kind (or what amounts to the same, it was assumed that all these sectors employ the same mixture of grades and kinds of labour), and analysis was focused only on these. In this way, it is possible to isolate, to a certain extent, the wage differences that result from industrial dualism from those that result from the scarcity of certain grades of white-collar workers, assuming that in the selected sectors the majority of workers are blue-collar. Then, the average wage rate of the four best-paid among industrial sectors 2 to 16 was taken as the numeráire. The reason for this arbitrary choice is that the well-paid industrial sectors in almost all countries are roughly the same: sectors such as mining, chemical products, or iron, steel and nonferrous metals, where large-scale businesses prevail, and

[8] The pseudo-industries 'Real Estate Activities' and 'Activities of Households as Employers' were not considered in the analysis because their extreme parameters made Newton's algorithm non-convergent for some countries. Although the estimates scarcely differ for countries in which it was possible to include these pseudo-industries, in order for the estimate to incorporate the same biases for the entire sample, it was decided to exclude them from consideration.

wages are set according to institutional or internal efficiency criteria. Thus, by choosing the former as the basis for the numeráire, it is possible to use a similar reference for all countries from which to build a hypothetical non-dualistic relative-wage structure of optimal similarity to allow comparison between countries.

The relative-wage structure that these 25 sectors had in the U.S. in 2000 was assumed to be a non-dualistic relative-wage structure, in the sense that differences in the wage rate were assumed to reflect differences in the disutility of work. In this way, the wage structure of sectors 1-24 plus 31 that result from such assumption and each country's numeráire was calculated for each country and year, the remaining wage structure being assumed as unchanged. This hypothetical wage structure was regarded as non-dualistic. Thus, having obtained two different relative-wage structures for each country -the actual and the assumed non-dualistic- both the actual and 'non-dualistic' employment and output were then estimated according to the procedure described in Section 2. Figure 1 shows the differences between actual and non-dualistic employment and between actual and non-dualistic output, both in relation to their respective actual value.

Figure 1. Actual and 'non-dualistic' employment and output[9].



As shown in Figure 1, if, according to the model's assumptions, wages did indeed change as noted, then, all else remaining constant, in all the countries and years of the sample, the amount of employment would be significantly reduced. Under the same perspective, for the wage structure to have a non-dualistic fashion, a large number of labourers would have to leave the market. Thus, for wages to change in this way, available labour should be reduced by between 50% (for the most extreme cases such as Indonesia, or India and Brazil at the beginning of the period) and 20% (for the

[9] Series were obtained, respectively, from:

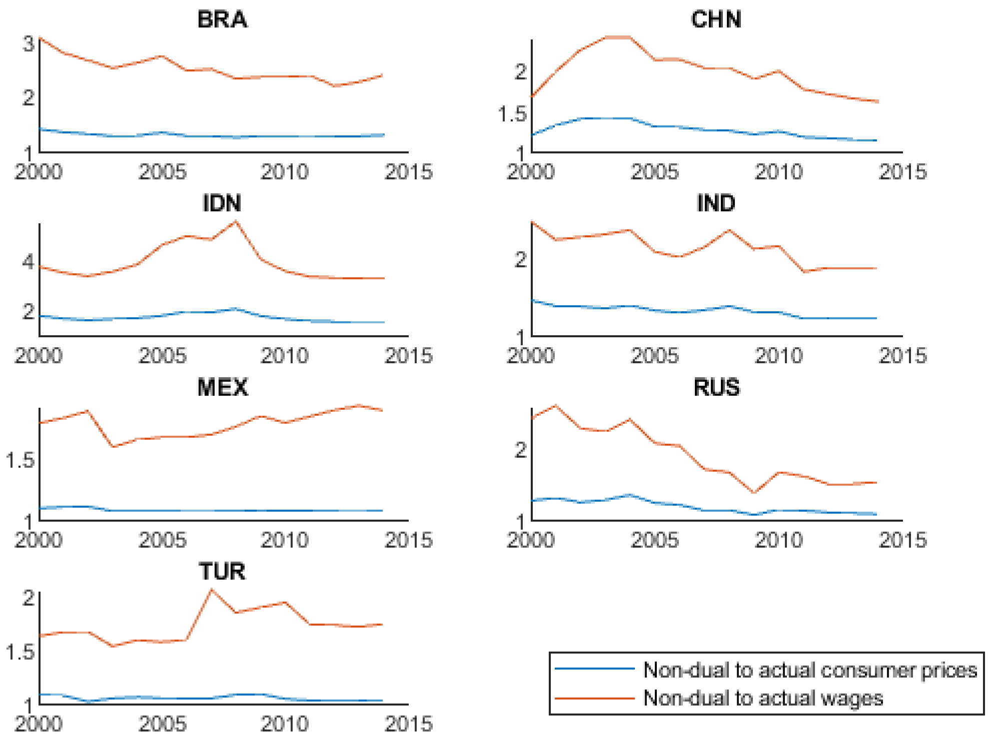
$$\frac{\mathbf{i}^T(\mathbf{l}-\mathbf{l}^*)}{\mathbf{i}^T\mathbf{l}} \text{ and } \frac{\mathbf{i}^T(\mathbf{x}-\mathbf{x}^*)}{\mathbf{i}^T\mathbf{x}}$$

where $\mathbf{x}$ and $\mathbf{l}$ denote actual employment and output vectors, while $\mathbf{x}^*$ and $\mathbf{l}^*$ are ´non-dualistic' employment and output vectors and i a unitary vector.

cases of Turkey, or Russia and China at the end of the period). However, this significant shortening of labour does not seem to lead to such a substantial reduction in output. In fact, it is common for the output volume to be reduced by half or less than the reduction in employment. This surely implies that a large amount of labour in these countries is actually employed, producing no more than their own subsistence consumption in 'hand-to-mouth occupations'. So, this result is consistent with the assumptions of the disguised-unemployment hypothesis, illustrating the extent to which the difference in the marginal product of labour is significant between the different sectors considered.

The relationship between a change in wages such as the one noted and the reduction in employment and output, as shown in Figure 1, is explained by the effect that a change in wages has on prices, according to the assumptions of the model. Figure 2 shows the 'non-dualistic' consumer price level with respect to its actual level and compares it with the ratio of non-dualistic low wages to actual low wages. Both indicators were calculated as Laspeyres indices.

Figure 2. Actual and 'non-dualistic' wages and prices[10].



As presented in Figure 2, the wages of the lowest-paid labourers in the sample countries are so low compared to the wages prevailing in the large-scale industrial sectors that, for the difference to be similar to that in the U.S., the wages of the former would have to more than double, on average. Actually, regarding the less extreme cases in the sample (such as Turkey, or China, India, and Russia at the end of the period), if labour were reduced, as shown in Figure 1, the wages of the lowest-paid blue-collar workers would increase by no less than 60%. However, despite such an extraordinary increase in the lowest wages, consumer prices would increase by much less in all the sample countries.

[10] Both series represent Laspeyres indices given by:

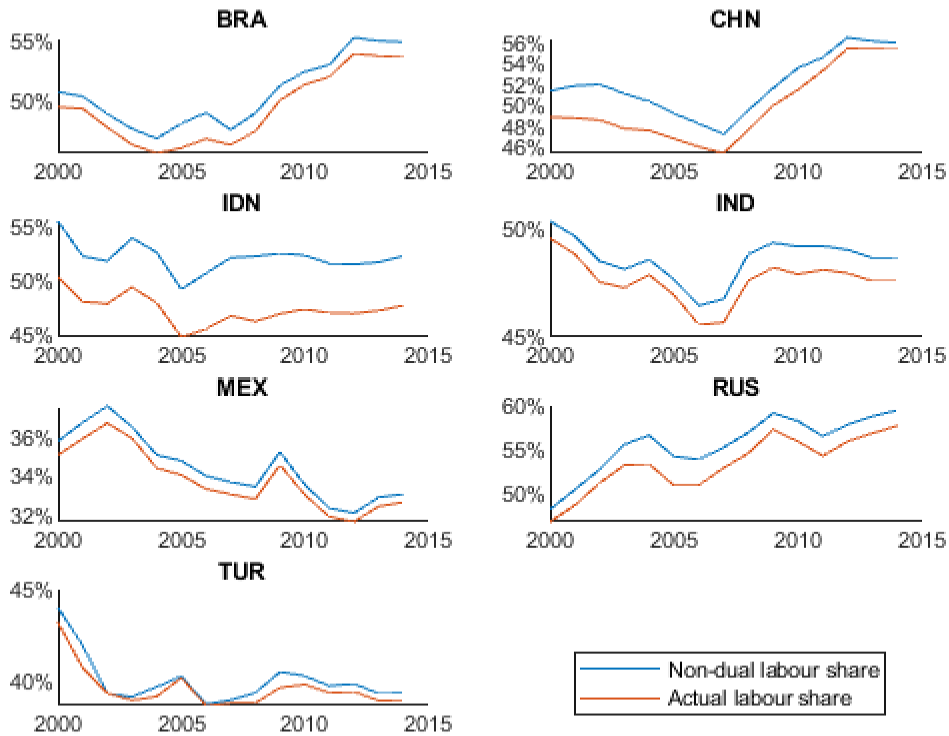
$$\frac{\mathbf{p}^{*T}\mathbf{c}}{\mathbf{p}^{T}\mathbf{c}}\text{, the price index, and } \frac{\mathbf{w}^{*T}\mathbf{l}}{\mathbf{w}^{T}\mathbf{l}}\text{, the wage index}$$

Where **p**, **w**, **c** and **l** respectively denote actual prices, wages, consumption and employment vectors, while Where $\mathbf{p}^*$ and $\mathbf{w}^*$ represent 'non-dualistic' prices and wages vectors.

Indeed, consumer prices often rise by half as much or less than wages do because, according to the assumptions made, as employment decreases, labour productivity increases, so that unit cost increases are less than wage increases. Likewise, the increase in prices is greater in relatively closed economies such as India or China compared to more open economies such as Turkey or Mexico, since the use of foreign inputs dampens the increase in unit costs.

Thus, the shortening of labour necessary for the change in wages would lead not only to a significant increase in the real wages of the lowest-paid labourers but also to a decrease in the purchasing power of the remaining social classes. Indeed, to the extent that the wages of workers in large-scale industries serve as a numeráire, their real wages would vary inversely to the level of consumer prices. This would imply a loss of purchasing power for this social group of between 50% (in the extreme case of Indonesia) and less than 10% (for the cases of Mexico and Turkey), with the average loss of purchasing power being around 20%. This loss of purchasing power would also be suffered by the employees of the remaining sectors, whose wages were assumed to remain constant. Likewise, the more significant shortage of labour affects the functional distribution of income. In this sense, Figure 3 shows the actual and 'non-dualistic' labour share in income distribution, according to the estimate.

Figure 3. Actual and 'non-dualistic' labour share[11].



As seen in Figure 3, if labour were shortened for wage levels changed as noted, and according to the model's assumptions, labour share would increase. On average, the labour share would increase by 1 or 2 percentage points, although in the most extreme cases (such as Indonesia or China at the beginning of the period), the change in wages would cause an increase of up to 4 percentage points. So, quasi-rents obtained by stock-owners would be significantly reduced in real terms, due to the lower relative scarcity of capital, higher prices, and lower output volume. In this way, it turns out that the reduction of labour force necessary for wages to vary in the assumed way would result, according

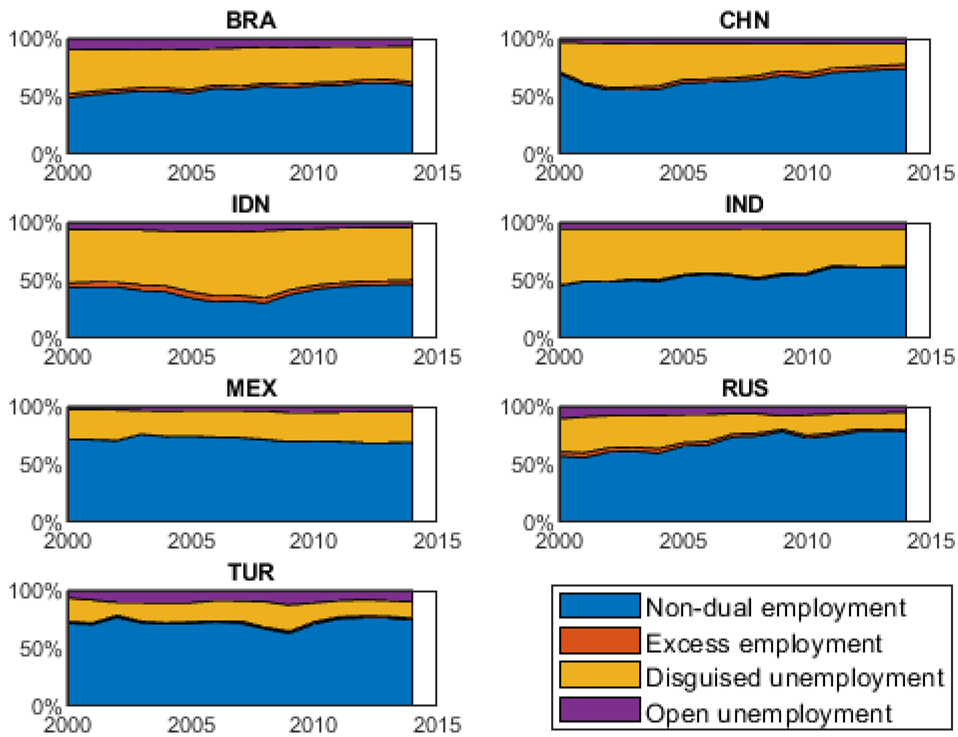
[11] Actual and 'non-dualistic' labour share in income were calculated, respectively, as:

$$\frac{\mathbf{w}^T\mathbf{l}}{[\mathbf{p}^T(\mathbf{I}-\mathbf{A})-\mathbf{q}^T\mathbf{E}]\mathbf{x}}, \text{ and } \frac{\mathbf{w}^{*T}\mathbf{l}}{[\mathbf{p}^{*T}(\mathbf{I}-\mathbf{A})-\mathbf{q}^T\mathbf{E}]\mathbf{x}^*}$$

to the assumptions made, in an income distribution that favours the lowest-paid labourers at the cost of all the other social classes. The result would be higher levels of domestic prices and a higher level of productivity so that the average real income per employee would increase, despite the fact that the volume of output would decrease and, therefore, so would total real income.

If the results of the estimate carried out are rearranged according to the main hypothesis assumed, then it is possible to obtain an approximation of the disguised unemployment of each country. Thus, the labour force can be considered as composed of four aggregates: a) *non-dualistic employment*, which results from the simulation carried out and which is equal to the amount of employment that would exist if relative wages changed, all else remaining constant in terms of the wage-unit; b) *disguised unemployment*, which is defined as the difference between actual employment and non-dualistic employment in those sectors whose actual wages are lower than non-dualistic wages, and which is obtained from (13); c) *excess employment*, which is defined as the difference between actual employment and non-dualistic employment in those sectors whose actual wages are higher than non-dualistic wages, and which results from (14); and d) *open unemployment*, which is obtained from the statistics of each country. Figure 4 shows the structure of the labour force as implied by the estimate's assumptions.

Figure 4. Estimated structure of the labour force[12].



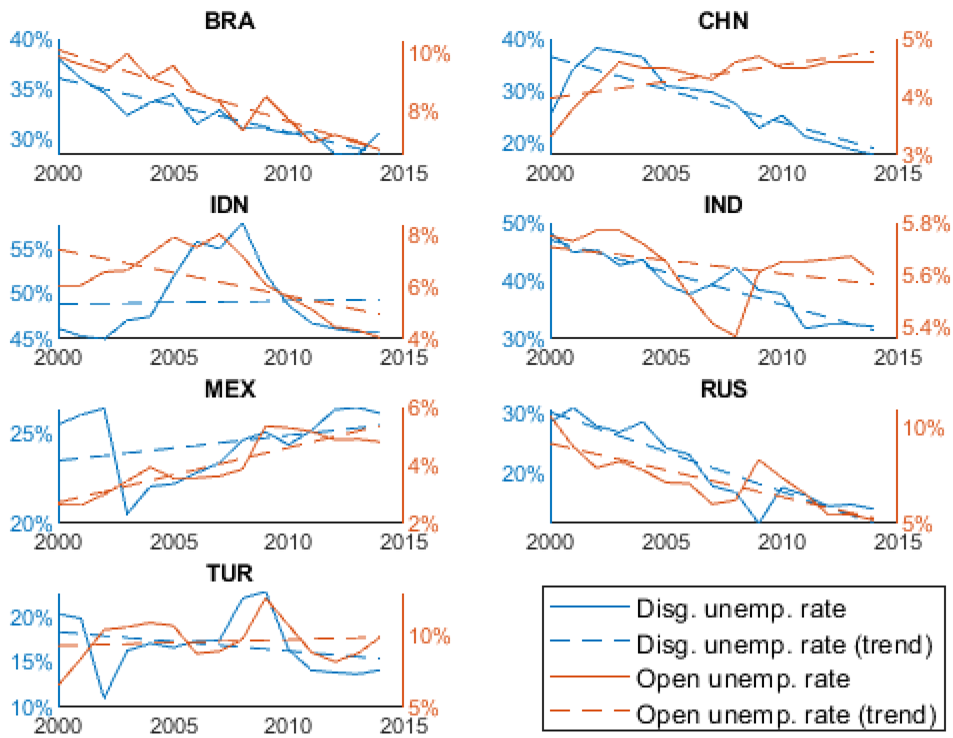
As shown in Figure 4, in all the countries and years of the sample, a significant part of labour seems to be disguisedly unemployed, according to the Robinson-Morishima-Murata definition. In this way, it seems that for low wages to increase relative to high wages until the difference between the two becomes similar to that of the U.S. in 2000, a significant amount of labour would either have to withdraw from the market or enter open unemployment. In the latter case, the unemployment figures for the countries considered would be very high: in extreme cases (such as Indonesia or India), the unemployment rate would oscillate around 50%, while in less extreme cases (such as Turkey, or China and Russia at the end of the period) the unemployment rate would not fall below 20%. Likewise, it seems that excess employment does not represent a significant amount of labour in almost any

[12] Open unemployment statistics were taken from the ILOSTAT Database Release 2021.

country or year in the sample, so that a considerable reduction in actual employment in low-wage sectors would not seem to have a significant effect on the remaining sectors. This is due to the compensatory effect on consumption that a wage increase would have in the low-wage sectors, as well as because of the scarcity of inter-industry links in sectors like retail trade or other services that seem to act as reservoirs of disguised unemployment.

Since disguised unemployment is assumed to be a measure of slackness in the labour market, the question arises about its relationship to open unemployment. In this sense, Figure 5 shows the disguised-unemployment rate together with the open-unemployment rate, as provided by standard statistics.

Figure 5. Disguised unemployment and open unemployment rates[13].



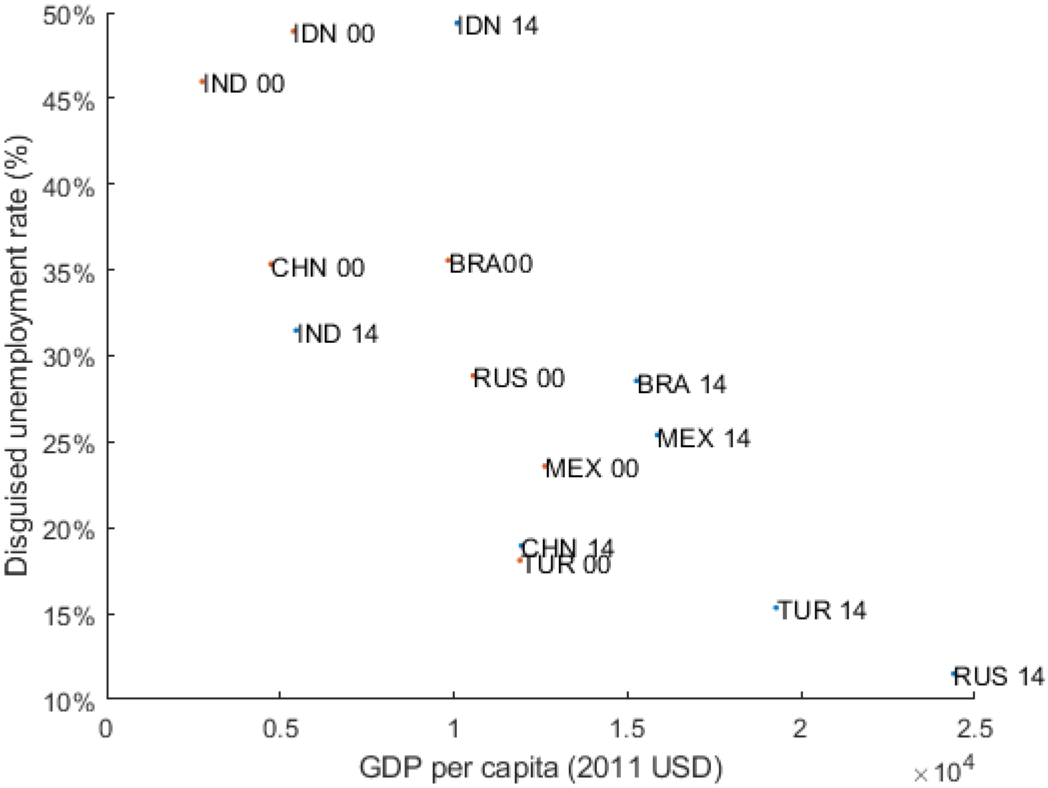
As shown in Figure 5, the disguised-unemployment rate series have short-term variations (and even trends) similar to the open-unemployment rate series in several sample countries, although not in all. Thus, in all countries except Brazil and Russia, both rates seem to have similar short-term variations, evident in the context of the financial crisis of 2008. Likewise, in Brazil, India, and Russia, both the disguised- unemployment and open-unemployment rates seem to decrease at similar rates. In contrast, in Mexico, they seem to increase in a similar way. Also noteworthy is that the disguised-unemployment rate varies more in both the short and long run than the open-unemployment rate for all countries considered. This result is consistent with the disguised-unemployment hypothesis, which implies that, in countries such as those in the sample, short-term changes in demand for the products of the main industries lead to a diversion of labour from occupations with different levels of productivity (Robinson, 1936; Günther & Launov, 2012; Fernández & Meza, 2015).

Regarding country-specific differences in both the level and the trend of the disguised-unemployment rate series, as shown in Figure 5, some stylized facts can be observed. Thus, considering differences in the average disguised-unemployment rate, it can be observed that this is higher in lower-middle-income countries such as Indonesia or India than in higher-middle-income countries such as Turkey

[13] Trends of both series were calculated using ordinary least squares.

or Russia. On the other hand, if differences in trend are regarded, it is observed that the countries where the disguised-unemployment rate has been lowered the most are also those that achieved high growth rates in this period (such as China, Russia, and India). If both observations are put together, the estimated disguised-unemployment rate can be related to the income level per capita, as seen in Figure 6.

Figure 6. Disguised unemployment rate as a function of GDP per capita[14].

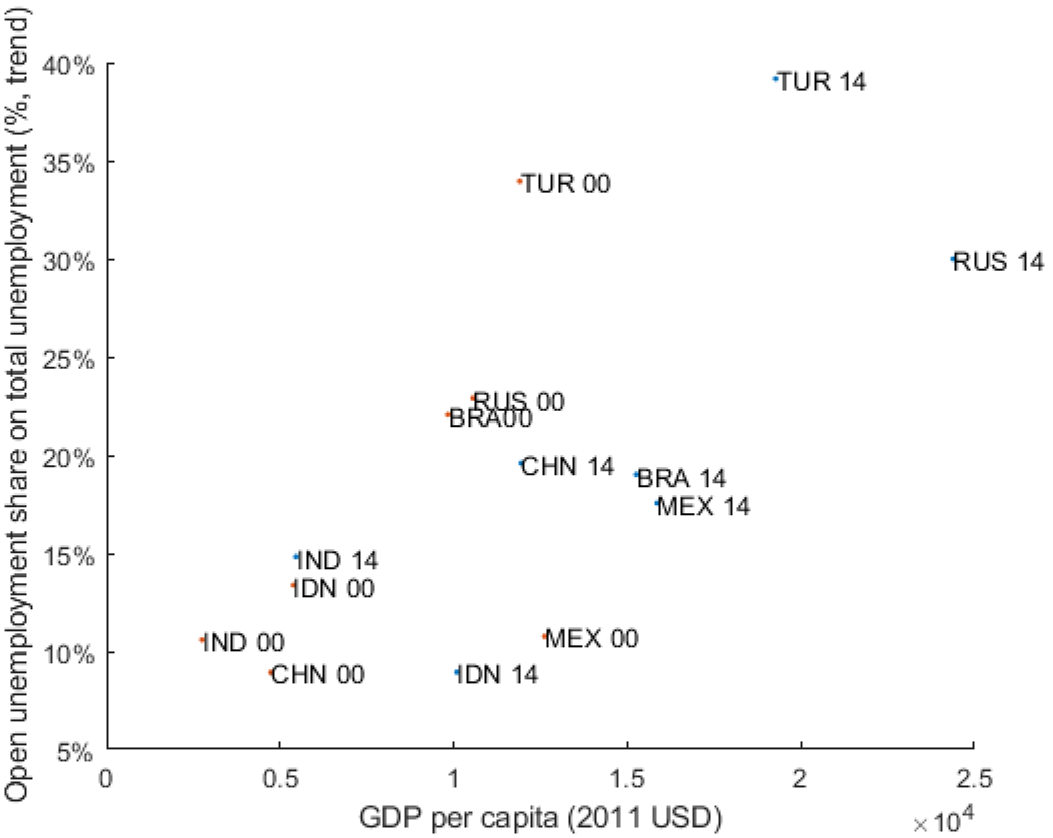


So, as economic growth accelerates, disguised unemployment decreases as differences in the marginal product of labour employed in different industries diminish. In this way, according to the disguised-unemployment hypothesis, as demand for the product of large-scale industries increases due to investment or exports, more labour is employed at the prevailing wage of such industries, so that labour available for the remaining occupations decreases, thereby raising wages and reducing the difference in the marginal product of labour. This fact is reminiscent of some predictions implied by the Lewis-type models of economic development (Lewis, 1954; Ranis & Fei, 1961; Chiswick, 2018). According to that theoretical approach, as capital per head increases and modern production techniques spread, more and more labour can be employed by modern, large-scale businesses and, therefore, less and less labour is available to be employed in the remaining occupations, so that differences in the marginal product of labour between industries decrease.

However, this is only part of the tale, as it is also the case that a part (albeit a small one) of the decrease in disguised unemployment can be explained by the increase in open unemployment. If the share of open unemployment in total unemployment is represented as a function of income per capita, a relationship does seem to present itself, as shown in Figure 7.

[14] Data for disguised-unemployment rates was taken from the estimated trends plotted in Figure 5, while data for GDP per capita was taken from the Maddison Project Database 2020.

Figure 7. Open unemployment share on total unemployment as a function of GDP per capita[15].

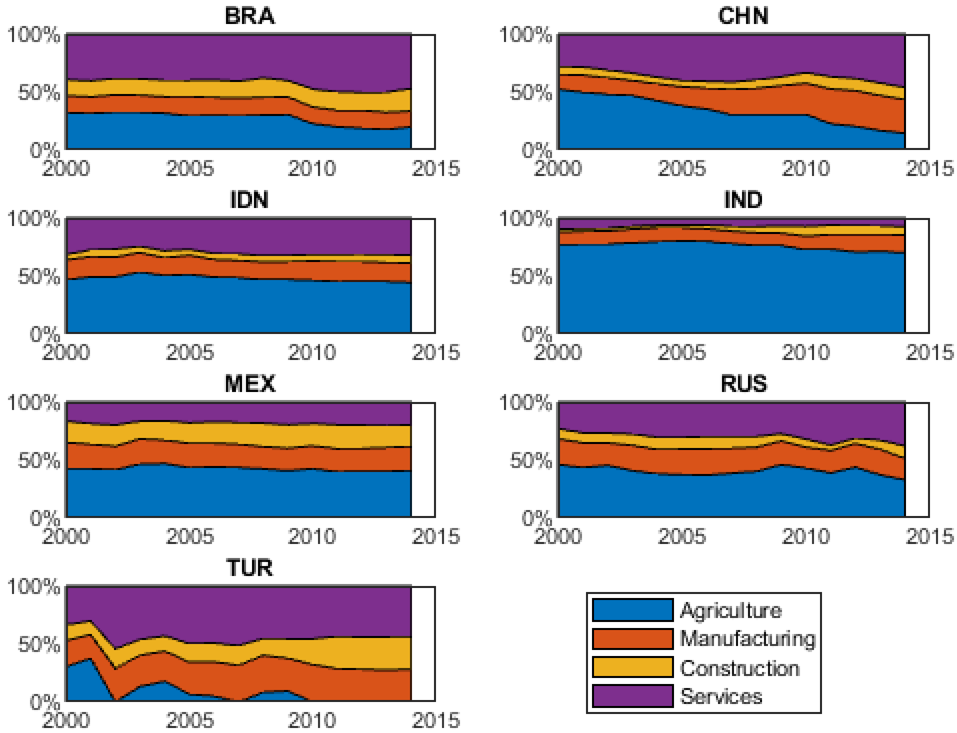


Thus, it seems that in lower-middle-income countries such as Indonesia, India, or China at the beginning of the period, a large part of unemployment appears to be mainly disguised unemployment, while in higher-middle-income countries such as Turkey or Russia, open unemployment seems to account for more than a third of total unemployment. Likewise, it is also observed that, with the exception of Brazil and Indonesia, the share of open unemployment in total unemployment increases as countries grow. This result is also consistent with the disguised-unemployment hypothesis because, as countries develop, incentives for a labourer who cannot find a regular job to engage in 'hand-to-mouth occupations' are expected to be less and less. This is due to institutional factors like a more restrictive labour legislation and a more generous system of unemployment benefits, but it can also be due to the growing scarcity of uncultivated land and the meagre opportunities for small-scale business in many sectors where large-scale firms have begun to prevail (Robinson, 1936; Fields, 2004).

Another interesting relationship between a country's economic development and the information provided by the estimate of disguised unemployment can be observed if attention is focused on the sector distribution of disguised unemployment, as shown in Figure 8.

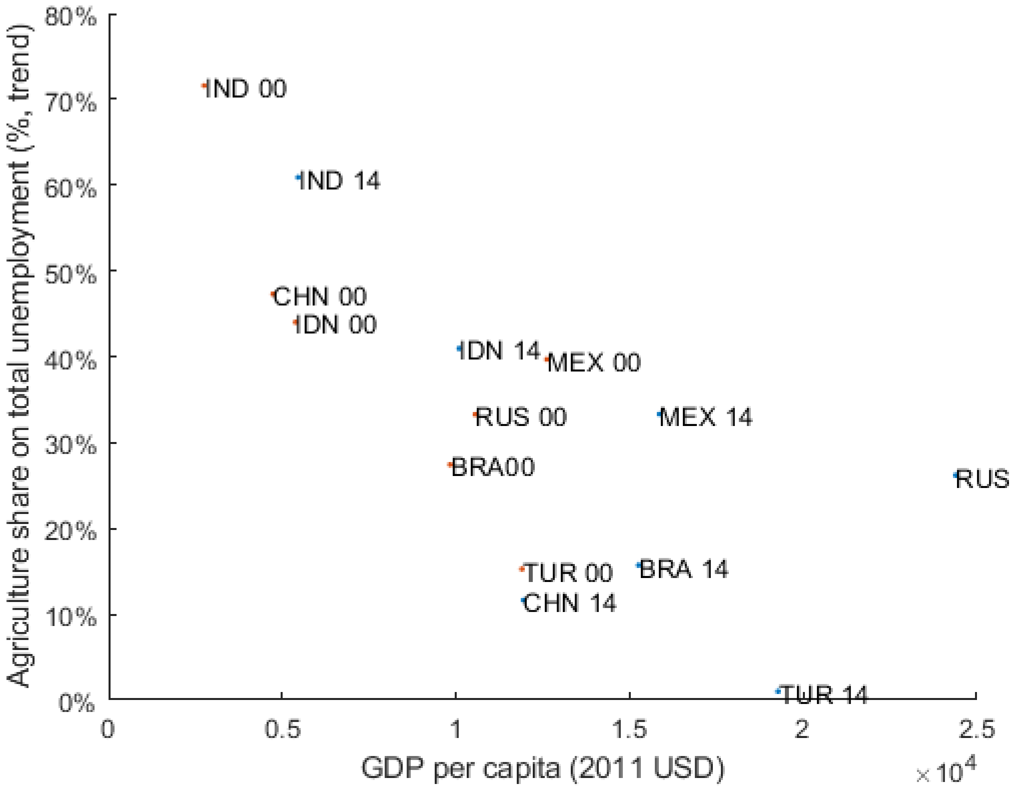
[15] Shares data result from the estimated trend of the series plotted in Figure 5 using ordinary least squares. Data for GDP per capita was taken from the Maddison Project Database 2020.

Figure 8. Sector distribution of disguised unemployment.



As illustrated in Figure 8, there seem to be significant differences in the sector distribution of unemployment between the countries and years considered. Again, if the differences in level and trend are considered, some stylized facts may be observed. Regarding the average sector distribution, it seems that in lower-middle-income countries such as Indonesia or India, agriculture is the main reservoir of disguised unemployment, while in higher-middle-income countries such as Brazil or Turkey, urban-based occupations and mainly services fulfil that role. Moreover, if differences in trend are regarded, the share of agricultural disguised unemployment within total unemployment decreases more in the countries that grew most during the period, such as China or Russia. If both observations are put together, the share of agriculture on total unemployment (both disguised and open) can be related to the level of income per capita, as Figure 9 shows.

Figure 9. Disguised agricultural unemployment share on total unemployment as a function of GPD per capita[16].



Thus, as seen in Figure 9, countries in which the main part of unemployment is disguised agricultural unemployment are lower-middle-income countries like China at the beginning of the period, India, and Indonesia, while that share is less than half in higher-middle-income countries like China at the end of the period, Brazil, Russia, or Turkey. Thus, as income per capita increases, the share of disguised agricultural unemployment to total unemployment decreases. This result is coherent with the well-observed fact that, as a country grows, its rural labourers migrate to urban environments where some find regular jobs while others become part of urban disguised or open unemployment (Todaro, 1969; Ravallion, Chen & Sangraula, 2009). This is also consistent with the dualistic-labour-market assumption, since high wages of modern, formal industries attract rural labourers, but not all labourers can be employed by these industries because wages in this sector are set by institutional or internal-efficiency criteria above market-clearing prices. As a result, a portion of rural-to-urban emigration leads to higher disguised unemployment in urban-based sectors such as services or construction (or even higher open unemployment).

4 Brief discussion of results

Having presented the main results of the estimate as well as some stylized facts that seem to derive from them, it is worth wondering about the plausibility of the estimate itself. Given that the numerical method of solving the system of equations converges, the estimation errors can come from either the data used or the model and its assumptions.

In relation to the overall data, little can be added because there is no other source reporting on these characteristics for the major middle-income countries. However, in terms of the plausibility shown by individual country data, it should be noted that data for Indonesia show an overly extreme relative-

[16] Shares data result from the estimated trend of the series plotted in Figure 8 using ordinary least squares. Data for GDP per capita was taken, again, from the Maddison Project Database 2020.

wage structure for all years of the sample, even in consideration of characteristics when compared, for example, to that of India. This is why Indonesia's disguised unemployment figures (as in Figure 4) are so high and do not seem to show a clear trend, despite the high growth figures experienced by that country during the sample period. Nonetheless, Indonesia's disguised-unemployment rate appears to be coherent with its open-unemployment rate (as shown in Figure 5) and with some scholars' observations (Felipe & Hasan, 2006; Williams & Lansky, 2013). Regarding the remaining countries, no large or striking anomalies have been observed, except for some possible outliers in the relative-wage series that explain some irregularities in the estimates for China in 2000, Mexico in 2003, or Turkey in 2002, as can be seen in Figures 1 and 4.

In relation to the model and its assumptions, several issues should be noted with regard to both the characterization of the production function and the characterization of demand. As both are arbitrary, they inevitably introduce certain biases in the estimation.

So, concerning the characterization of the production function, it should be noted that the assumptions about elasticities regarding the use of inputs introduce a bias into the estimate. Thus, insofar as such assumptions imply that the elasticity of substitution between inputs is null, any effect that a change in relative prices could have on the use-intensity of inputs other than labour is ignored. This makes the commodities supply relatively rigid, which could explain part of the fact that disguised unemployment seems relatively large in all countries. Furthermore, since it has been assumed that decreasing returns-to-scale occur only for labour usage, it is possible that the effect that a change in employment has on output has been overestimated. Despite all this, there is some evidence in favour of the assumptions that characterize the production function, as noted (Fernández-Vázquez, 2015).

Moreover, about the characterization of demand, it should be noted that this also introduces a bias into the estimate. Since it is assumed that all the components of demand except consumption are independent of income, any induced effect that a change in wages may have on any of these components is disregarded. Likewise, as long as the marginal propensity to consume is considered constant, the effects that may derive from a change in the income distribution are underestimated. Furthermore, the assumption that consumer demand behaves as a nested Cobb-Douglas function also introduces a bias into the estimation, which can make the demand for some products more or less elastic than it actually is. This bias affects the estimate of disguised unemployment, although not in a specific sense. However, dispensing with all these assumptions regarding the characterization of demand would make the numerical resolution of the system of equations very difficult.

Considering all these biases, it is worthwhile to wonder about the scope of the highlighted results and the stylized facts derived from the estimate.

With the results plotted in Figures 1 to 3, it must be recognized that these are the sole consequence of the model assumed and the biases that it implies. However, it can be considered that, under a broad set of assumptions, a change in relative wages such as the one simulated here implies a decline in the volume of employment and output, a loss of purchasing power for social classes other than low-wage labourers, and an increase in the labour share, all else being constant in terms of the wage-unit. These results may be indicative of a bias in policymaking towards largely-urban mobilized groups (stock-owners, unionized workers, white-collar workers) in the sample countries. Indeed, many scholars highlighted that, as a result of institutional constraints and biased policies, distortions in factor prices arise, leading to greater inequality and lower efficiency in less-developed countries (Balassa, 1988; Lin & Li, 2009). In this way, the question about the policy implications of disguised unemployment seems to lead to the question about the impact of factor-price distortions on economic efficiency and welfare. Nevertheless, to properly assess such implications, it would be necessary to consider truly counterfactual scenarios in which many of the elements that were assumed to be constant in terms of the wage-unit can plausibly change and in which the role of policy may be explicitly considered.

On the other hand, a wider set of assumptions can be considered in relation to the stylized facts arising from Figures 5, 6, 7, and 9. Many of these stylized facts are simply due to the relative-wage structure of the different countries of the sample. Once this is considered to be suggestive of dual labour markets and therefore capable of disguising some amount of unemployment, any estimate similar to that carried out in the present study will lead to similar results. In this sense, the present study should be seen as an estimate of disguised unemployment under the assumptions of the hypothesis but not as a test of the hypothesis itself.

5 Conclusions

Substantial wage differentials between sectors and businesses observed in less-developed countries can be explained by the disguised-unemployment hypothesis. According to this hypothesis, the labour market in less-developed countries is segmented into two sections: one for large-scale, modern business, in which wages are set according to institutional criteria, and another for small-scale, traditional business, in which wages are set according to market-clearing prices. Thus, sizeable wage differentials are assumed to be due to overcrowding of the latter segment of the labour market, and this situation is regarded as reflective of disguised unemployment. So stated, the disguised-unemployment hypothesis implies a way to measure assumed non-open unemployment -by the amount of labour that must be withdrawn from the labour market for relative wages to change until they reflect differences in disutility and skills.

Assuming this hypothesis, it is possible to estimate disguised unemployment by means of a non-linear input-output model. This model involves ‘extended Leontief’ production functions, and it can be easily calibrated with actual input-output tables so that its solution can be reached by a Newton algorithm. Assuming the U.S. wage structure to be non-dualistic, it is possible to undertake the exercise of comparing the actual level and distribution of employment of a country with a simulated level and distribution that would result if its wage structure were similar to that of the U.S. Specifically, this simulation experiment has been carried out for seven middle-income countries (Brazil, China, Indonesia, India, Russia, Mexico, and Turkey) for the period 2000-2014 using data available from the 2016 Release of the World Input-Output Database.

The results of this simulation experiment are consistent with the disguised-unemployment hypothesis and related literature. It is observed that the disguised-unemployment rate series have short-term variations and even trends similar to the open-unemployment rate series in almost all the sample countries. In addition, the disguised-unemployment rate seems to be negatively correlated with income per capita, so as economic growth accelerates, disguised unemployment appears to decrease. Furthermore, this relationship also has to do with the distribution of unemployment since it seems that most of the unemployment in lower-middle-income countries is agricultural disguised unemployment. In contrast, in the higher-middle-income countries, unemployment is mostly disguised unemployment in urban-based occupations or else open unemployment.

These results may be relevant for policymaking in less-developed countries. The results of the estimate seem to show that a significant amount of the labour force of the sample countries is underemployed so that these countries do not seem to be even close to a situation of full employment. Likewise, the close relationship between income per capita and disguised unemployment seems to evince that economic development implies a tendency towards equalization in the marginal product of labour, which undoubtedly implies greater labour mobility. These results suggest that for many countries such as those in the sample, policies that allow taking advantage of the labour surplus seem appropriate, both through demand policies where possible (e.g., public works programs, promotion of foreign trade, etc.), as well as supply-side policies aimed at promoting labour mobility (e.g., household registration reform, removal of entry-barriers in certain trades, etc.).

Nevertheless, and despite their coherence, the specific results of this study should be considered highly dependent on the stated model and the biases that its assumptions imply. Thus, while it is true that the simulation results are such that they could be reached from a large number of disparate assumptions, it is no less true that the main disguised-unemployment-related variables are purely a by-product of the model stated in this study. However, the time change of the main simulated indicators is primarily due to changes in the relative-wage structure of the countries considered; hence, it is expected that many of the stylized facts highlighted here can be found by different means. Nevertheless, this must be proved, so questions around the scope and generality of the results obtained remain open, indicating that further studies will be needed.

References

Balassa, B. (1989). The interaction of factor and product market distortions in developing countries. *World Development*, 16(4), 449-463.

Chiswick, C. U. (2018). Modelling Economic Development: The Lewis Model Updated. *Institute for International Economic Policy Working Paper*, 2018-5.

Dickens, W. T., & Lang, K. (1985). A test of dual labor market theory. *The American Economic Review*, 75(4), 792-805.

Felipe, J., & Hasan, R. (2006). Labor Market Outcomes in Asia. In Felipe, J., & Hasan, R. (eds.) *Labor markets in Asia: Issues and perspectives*. Palgrave Macmillan, Basingstoke.

Fernández, A., & Meza, F. (2015). Informal employment and business cycles in emerging economies: The case of Mexico. *Review of Economic Dynamics*, 18(2), 381-405.

Fernández-Vázquez, E. (2015). Empirical estimation of non-linear input-output models: An entropy econometrics approach. *Economic Systems Research*, 27(4), 508-524.

Fields, G. S. (1975). Rural-urban migration, urban unemployment and underemployment, and job-search activity in LDCs. *Journal of development economics*, 2(2), 165-187.

Fields, G. S. (1990). Labour market modelling and the urban informal sector: Theory and evidence. In Turnham, D., et al., *The Informal Sector Revisited*, Development Centre of the OECD, Paris.

Fields, G. S. (2004). A guide to multisector labor market models. *ILR Working Papers*.

Fujimoto, T. (1986). Non-linear Leontief models in abstract spaces. *Journal of Mathematical Economics*, 15(2), 151-156.

Georgescu-Roegen, N. (1960). Economic theory and agrarian economics. *Oxford Economic Papers*, 12(1), 1-40.

Gindling, T. H. (1991). Labor market segmentation and the determination of wages in the public, private-formal, and informal sectors in San Jose, Costa Rica. *Economic development and cultural change*, 39(3), 585-605.

Gollás, M., & Fernández, O. (1993). El subempleo sectorial en México. *El Trimestre Económico*, 60(4), 157-215.

Guerra, A. I., & Sancho, F. (2014). An operational, nonlinear input-output system. *Economic Modelling*, 41, 99-108.

Günther, I., & Launov, A. (2012). Informal employment in developing countries: Opportunity or last resort? *Journal of development economics*, 97(1), 88-98.

Harberler, G. (1957). Critical Observations on Some Current Notions in the Theory of Economic Development. *L'Industria*, II.

Heckman, J. J., & Hotz, V. J. (1986). An investigation of the labor market earnings of panamanian males evaluating the sources of inequality. *Journal of Human Resources*, 21(4), 507-542.

Hernández-Catá, E. (2015). Estimating Disguised Unemployment in Cuba. *Cuba in Transition*, 25, 199-209.

Hussain, M. A. (2003). Economic Measurement of Disguised Unemployment at Farm Level in Al-Jabal Al-Akhther, Libya. *Journal of Economic & Administrative Sciences*, 18(2), 127-141.

Jones, R. W. (1971). Distortions in factor markets and the general equilibrium model of production. *Journal of Political Economy,* 79(3), 437-459.

Kalirajan, K. P. (1995). Disguised unemployment of labour: a suggested methodology of measurement. *Applied Economics*, 27(9), 879-882.

Klein, L. R. (1952). On the interpretation of Professor Leontief's system. *The Review of Economic Studies*, 20(2), 131-136.

Lewis, W. A. (1954). Economic development with unlimited supplies of labour. *The Manchester School*, 22, 139-191.

Li, M. (2004). Aggregate demand, productivity, and 'disguised unemployment' in the Chinese industrial sector. *World development*, 32(3), 409-425.

Lin, J. Y., & Li, F. (2009). Development strategy, viability, and economic distortions in developing countries. *World Bank Policy Research Working Paper*, 2009-4906.

Magnac, T. (1991). Segmented or competitive labor markets. *Econometrica*, 59(1), 165-187.

Maloney, W. F. (1999). Does informality imply segmentation in urban labour markets? Evidence from sectoral transitions in Mexico. *The World Bank Economic Review*, 13(2), 275-302.

Maloney, W. F. (2004). Informality revisited. *World development*, 32(7), 1159-1178.

Mazumdar, D. (1977). Analysis of the dual labour market in LDCs. In Kannapan, S., (ed.) *Studies of urban labour market behavior in developing areas*. International Institute for Labor Studies, Geneva.

Mazumdar, D. (1999). Constraints to achieving full employment in Asia. *Employment and Training Papers,* No. 51, International Labour Office, Geneva.

Morishima, M., & Murata, Y., (1971). An input-output analysis of disguised unemployment in Japan, 1951-1965. In Morishima, M., Murata, Y., Nosse, T., & Saito, M., *The working of econometric models*. Cambridge University Press, New York.

Pratap, S., & Quintin, E. (2006). Are labour markets segmented in developing countries? A semiparametric approach. *European Economic Review*, 50(7), 1817-1841.

Ranis, G., & Fei, J. C. (1961). A theory of economic development. *The American Economic Review*, 51(4), 533-565.

Ravallion, M., Chen, S., & Sangraula, P. (2009). Dollar a day revisited. *The World Bank Economic Review*, 23(2), 163-184.

Robinson, J. (1936). Disguised unemployment. *The Economic Journal*, 46(182), 225-237.

Rosenstein-Rodan, P. N. (1943). Problems of industrialisation of eastern and south-eastern Europe. *The Economic Journal*, 53(210/211), 202-211.

Rosenzweig, M. R. (1988). Labour markets in low-income countries. *Handbook of development economics*, 1, 713-762.

Schultz, T. W. *Transforming Traditional Agriculture*. Yale University Press, New Haven.

Todaro, M. P. (1969). A model of labor migration and urban unemployment in less developed countries. *The American Economic Review*, 59(1), 138-148.

Viner, J. (1957). Some Reflections on the Concept of 'Disguised Unemployment'. *Contribuçoes a Analise do Desenvolvimento Economico*, Rio do Janeiro.

Williams, C. C., & Lansky, M. A. (2013). Informal employment in developed and developing economies: Perspectives and policy responses. *International Labour Review*, 152(3-4), 355-380.

Wu, Y. (1998). Redundancy and firm characteristics in Chinese state-owned enterprises. *The Asia Pacific Journal of Economics & Business*, 2(1), 33.