WP/20/23

IMF Working Paper

The Minimum Wage Puzzle in Less Developed Countries: Reconciling Theory and Evidence

by Christopher Adam and Edward Buffie

INTERNATIONAL MONETARY FUND

 WP/20/23

IMF Working Paper

Research Department

The Minimum Wage Puzzle in Less Developed Countries: Reconciling Theory and Evidence[*]

Prepared by Christopher Adam and Edward Buffie

Authorized for distribution by Chris Papageorgiou

January 2020

Abstract

We show that a dynamic general equilibrium model with efficiency wages and endogenous capital accumulation in both the formal and (non-agricultural) informal sectors can explain the full range of confounding stylized facts associated with minimum wage laws in less developed countries.

JEL Classification Numbers: E24, JO8, J23

Keywords: minimum wage, employment elasticity, lighthouse effect

Author's E-Mail Address: christopher.adam@qeh.ox.ac.uk, ebuffie@indiana.edu

[*] This research was supported by funding from the United Kingdom's Department For International Development under the IMF-DFID Macro Research for Development Program and from the Macroeconomic Research Division of the African Development Bank. We thank Sterre Kuipers for excellent research assistance. All errors and omissions are solely ours.

Contents

1 Introduction

Minimum wage (MW) laws are now an important policy for combatting poverty in many LDCs, but, as in developed countries, there is considerable controversy about whether they achieve their stated objective. First-generation analyses of the MW relied on the canonical Segmented Labor Markets Model (SLMM). According to SLMM, a higher MW reduces employment and output in the formal sector. Some of the workers who lose their jobs then seek employment in the informal sector (where MW laws cannot be enforced). The influx of labor to the informal sector increases employment and output but also depresses the real wage. Underemployment worsens, total output declines, and any improvement in the overall distribution of income comes at the expense of the poorest group in the country, low-paid workers in the informal sector. For standard production functions and plausible parameter values, job losses in the formal sector and the redistributive effects are large. In short, MW laws derive from good intentions but are hard to recommend.

The data have not been kind to this narrative. Empirical evidence accumulated over the past twenty years casts doubt on, or strongly contradicts, every claim advanced by the SLMM. Sometimes employment increases in the informal sector; typically, however, it decreases more than employment in the formal sector (Betcherman, 2014). The real wage in the informal sector does not decline; reflecting the ubiquitous "lighthouse effect," it almost always increases: "No study has found that a higher minimum wage depresses wages for informal sector workers as a whole" (Gindling, 2014). Completing the rout, employment losses in the formal sector are often surprisingly small. The mean employment elasticities in the meta-analysis of Nataraj et al. (2014) and in surveys of the literature by Bhorat et al. (2017), the World Bank (2006), and this paper (Appendix C) are -.08, -.011, -.20, and -.23, respectively. In some countries, the evidence suggests a *positive* impact on formal sector employment.

These stylized facts represent a major challenge for theory. The lighthouse effect is consistent with employment decreasing in the informal sector. But what explains the effect in the first place? The usual explanation, that the MW serves as a norm for fairness in the informal sector, is incomplete and unconvincing.[1] Most informal sector capitalists are quite poor (La Porte and Shleifer, 2013). The notion that they feel a social obligation to respond to an increase in the MW by paying much higher wages strains belief; evidently some unspecified change in the economic environment, causally linked to the MW, makes it profitable for firm owners to raise wages.

The finding that employment losses are often very small in the formal sector – nil is a common descriptor – is perhaps the most perplexing result uncovered by empirical studies. For a CES production function with two inputs, capital and labor, the elasticity of employment with respect to the wage equals $-\sigma/\theta_K$, where σ is the elasticity of substitution and θ_K the cost share

[1]Kristensen and Cunningham emphasize this point: ". . enforcement mechanisms are weak, but for some reason employers, and particularly those in the informal sector who are not legally bound by the minimum, choose to adjuste wages when the legally mandated wage is changed."

of capital.[2] This yields an employment elasticity of $1.5 - 3$ when $\sigma = .5 - 1$ and $\theta_K = .33$. Yet .5 is at the high end of empirical estimates, and the literature surveys cited earlier place the mean elasticity between .08 and .20. The true employment elasticities may be higher (in absolute value) than those reported in the literature, and certainly the variation in outcomes among LDCs deserves more attention.[3] We return to these points later. If anything, however, they add to the list of unresolved empirical puzzles. A satisfactory theory should account for both high and very low employment elasticities. As Bhorat et al. (2017) observe: "There is a range of potential impacts of minimum wages on employment. The heterogeneity of outcomes in LMI countries, in particular, suggests that a variety of *context-specific factors* interact with the minimum wage." (Our emphasis.)

There are pros and cons to the approach taken by the existing literature. On the credit side of the ledger, the provocative stylized facts, amassed through decades of careful empirical research, are important in their own right and exceptionally informative about the right way to model the labor market in LDCs. This will be a recurrent theme in our paper.

But the literature's strength is also its weakness. From a policy standpoint, the lopsided emphasis on empirical investigation is troubling. Absent any substantive input from theory, the stylized facts are something of a black box: a set of potentially important, policy-relevant results that we do not understand and therefore cannot fully trust. The black box problem was noted thirty years ago in the developed country literature by Brown (1989) and has persisted largely unchanged to the present day. In the development literature, Eyraud and Saget (2005), Lemos (2009), Betcherman (2014), and Fields (2011) have called for research to "look for the factors behind [the] weak effect" on employment (Eyraud and Saget); to develop a "coherent theoretical framework" that makes sense of the "puzzling results" in Brazil and othe countries (Lemos); to help understand the long-run effects of MWs (Betcherman); and, more generally, to meet the "the need for empirically-grounded theoretical labor market models that can be used in the formulation of policy" (Fields). The appeals have yet to elicit a response. Writing in 2017, Bhorat et al. assert that "While work on minimum wages is fairly mature in many OECD countries, our understanding of minimum wage policy in SSA is not." To a lesser but still significant extent, the same assessment applies to Latin America and Asia.[4]

Our objective in this paper is to bridge the divide between theoretical and empirical research. Toward that end, we develop a dynamic general equilibrium model with efficiency wages (EW)

[2]This is the solution for the short run, where the capital stock is fixed.

[3]It is often asserted that failure to account for noncompliance biases estimates of the employment elasticity downward. This assertion is valid in the SLMM but dubious in our model. The informal sector in our model includes firms that do not comply with the MW law. But employment losses in the noncompliant sector are typically larger than in the compliant sector. Failure to account for noncompliance could therefore bias the estimated elasticity in the formal sector *upward*.

[4]Bhorat et al. attribute the problem to lack of data. We partly disagree. In the case of SSA, we favor a combination of Bhorat et al. and Fields' views: better policy analysis requires new, better theoretical models informed by better data.

and endogenous capital accumulation in both the formal and (non-agricultural) informal sectors. A large body of empirical work already attests that EW models can explain the most important characteristics of labor markets in developing countries. We show that they can also explain the full range of confounding stylized facts – those emphasized in the literature plus others that have flown below radar – associated with MWs in LDCs. This will not settle the debate on how to model the labor market in developing countries. It does, however, enhance the appeal of EW theory and strengthen the case for its general relevance.

The main body of the paper is organized into five sections. Section 2 takes two pages to review the empirical evidence bearing on EWs in LDCs. In Section 3 we derive analytical results in a stripped-down model that assumes constant employment and output in the informal sector. The analytical results elucidate many of the key mechanisms that limit employment losses in the formal sector. In a standard setup where firms operate a CES production function and worker effort depends only on the real wage, EW effects reduce the employment elasticity from $2 - 3$ to 1. This is substantial but inadequate progress: 1 is a long way from $.1 - .3$, the range that brackets the majority of empirical estimates. The solution to the problem is to strengthen fidelity to the stylized facts by incorporating two other effects: (i) the impact of the unemployment rate on work effort, as measured by wage curves estimated for LDCs, and (ii) the link between monitoring costs, effort, and the firm-size wage premium (much larger in LDCs than in developed countries). When these effects are added to the mix, the MW decreases the effective cost of labor, inducing firms to *increase* output and investment.[5] The increase in output lowers the employment elasticity to $.2 - .6$ in the short run. Moreover, as the capital stock grows, labor demand recovers and output continues to rise. In the limiting case where the goods produced by the formal and informal sectors are perfect substitutes, labor demand recovers fully – the employment elasticity equals zero across steady states.

In Section 4 we present the full model that features EWs in both the formal and informal sectors. Following this, we calibrate the model and explore the sensitivity of the lighthouse effect and sectoral employment to alternative empirically-relevant values of key parameters. The variation in the numerical results mirrors the variation in outcomes documented in empirical studies. Four "context-specific factors" condition the impact of an increase in the MW: (i) the relative size of the formal sector; (ii) the degree of substitutability between formal and informal sector output; (iii) the absolute and relative degree of wage flexibility embodied in the sectoral wage curves; and (iv) the tradability of formal sector output. For certain configurations of the context-specific factors, employment losses are large overall and in the formal sector. But these outcomes are a minority. Consistent with the majority of empirical estimates, small employment elasticities of $.1 - .3$ predominate in the relevant parameter space at *all* time horizons. While this is encouraging, it does not mean that increasing the MW is a good bet in all LDCs. Our

[5] Investment increases provided the elasticity of substitution in consumption between the formal and informal good is not implausibly low.

results suggest a well-defined heirarchy of MW effectiveness. Moving up the development ladder from LICs to MICs to EMEs brings progressively larger increases in GDP and real wages in the informal sector and progressively smaller employment losses. Disturbingly, at the lowest rung of the ladder, there is a small but tangible risk of harm: in the case of LICs – and only LICs – the MW may reduce output and welfare.

Our paper is only a first pass at solving the MW puzzle. As such, it ignores a number of important issues. The final section discusses this and some of the topics that should be addressed in future research.

2 The Case for Efficiency Wages

Efficiency wages are rarely seen in development macromodels. This is perplexing, for evidence in support of EW theory is broad, deep, and compelling across the development spectrum. Over the past twenty years, empirical studies have amassed abundant, compelling evidence that efficiency wages operate throughout the non-agricultural sector in LDCs. Estimates of the impact of unemployment on real wages confirm the existence of wage curves in the formal and informal sectors in Argentina, Turkey, Colombia, Uruguay, Chile, S. Africa, Cote d'Ivoire, Mexico, China, S. Korea, and a host of other developing countries (Blanchflower and Oswald, 2005). There is also powerful, if indirect evidence supportive of efficiency wages in the stylized facts documented in microeconomic studies of LDC labor markets. In LICs, EMEs, and everything in between, wage and employment data exhibit the same patterns: (i) firm-size wage premiums that start at very small establishment size and are much larger than in developed countries; (ii) persistent, remarkably stable inter-industry wage differentials; (iii) high correlation of industry wage premiums across occupations; (iv) large wage premia for formal vs. informal sector employment and for informal non-agricultural employment vs. agricultural employment; (v) large cyclical flows into and out of unemployment in both the formal sector and the informal sector; (vi) virtually identical lists for low- and high-paying industries; (vii) large, stable wage differentials between firms in the same industry; and (viii) lower quit rates and longer job tenure in the formal sector. At present, only efficiency wage models can explain all of these stylized facts. We do not have the space here to survey the literature in greater depth or to discuss myriad estimation issues. References and capsule summaries of the results for 50+ studies are available, however, at http://mypage.iu.edu/~ebuffie/.

2.1 Efficiency Wages in the Informal Sector?

Admittedly, EWs are a harder sell for the informal sector than for the formal sector. We need to elaborate on some of the empirical evidence cited above:

- Appendix B collects estimates of wage curves that relate the level of the real wage to the unemployment rate in LDCs. Clearly, wage curves are *not* confined to the formal sector; they also operate in the informal sector. This does not mean that wages are equally rigid in the two sectors. The common perception that wages are more flexible in the informal sector is correct. Most studies find that wages in the informal sector are more responsive to the unemployment rate than wages in the formal sector. But a large gap separates more responsive from highly responsive. The informal sector does not approximate a frictionless buffer sector with flexible, market-clearing wages.

- The firm size effect kicks in very quickly, starting at micro enterprises with 2-5 employees (Velenchik, 1997; Schaffner, 1998; Badaoui et al., 2010).

- If wages are rigid in the informal sector, the data should show large movements into and out of unemployment during booms and recessions. This is precisely what Bosch and Maloney (2007) find in their study of labor market dynamics in Mexico, Argentina, and Brazil.[6] Salaried jobs in the informal sector showed high rates of separation toward unemployment and inactivity (i.e., dropping out of the labor force). In fact, in all three countries transitions out of informal sector employment contributed *much more* to unemployment than transitions out of formal sector employment. In Mexico, for example, transitions into unemployment from salaried informal employment were three times greater than transitions from formal employment; equally striking, *none* of the workers laid off in the formal sector found jobs in the informal sector – entry from the formal into the informal sector *declined* during downturns.

- For at least one important country, there is strong, direct evidence of job rationing in the informal sector. In labor force surveys in S. Africa, eighty percent of the unemployed reported that they could not find *any* work; only three percent cited an inability to find "suitable work" as the reason for being unemployed (Heinz and Posel, 2008). Several other studies corroborate the survey findings. Nattras and Walker (2005) and Burgess and Schotte (2017) estimate that the reservation wage of the unemployed is far below their predicted earnings and link their results to data showing a shortage of job offers is the principal cause of unemployment; job refusals are rare. Kingdon and Knight (2004) present data affirming that the unemployed are substantially worse off than the employed in the informal sector in income, consumption, and various indicators of non-economic well-being.

[6] Berg and Contreras (2004) supply evidence for Chile. Neri (2002) and Ulyssea (2010) provide additional evidence for Brazil.

- Labor force participation rates are implausibly low in much of SSA (Falco et al., 2009; Teal, 2014). The most plausible explanation is that discouraged workers, who cannot find a job even in the informal sector, are misclassified as "out of the labor force."

3 Insights From a Simplified Model

The full model has a lot of moving parts. It is not a black box, however. To facilitate comprehension of the model and the numerical results presented in Sections 3 and 4, we first analyze a simplified model that abstracts from most of the general equilibrium interactions between the formal and informal sectors.

Variable names are familiar or at least mnemonic. K_i, L_i, Q_i, w_i, C_i, and P_i refer to capital, labor, output, wages, consumption, and prices, with subscript 1 for the formal sector and 2 for the informal sector. The informal good serves as the numeraire ($P_2 = 1$).

Technology

The simplified model fixes output and employment in the informal sector in order to focus on the response of the formal sector to a higher MW. The numerous complications associated with the lighthouse effect are on hold for the time being.

Firms in the formal sector operate a linearly homogeneous CES production function. The elasticity of substitution between capital and labor is $\sigma_1$and the supply of labor services depends on the amount of effort e_1 that workers expend:

$$Q_1 = a_f \left[a_1^{1/\sigma_1} (e_1 L_1)^{(\sigma_1 - 1)/\sigma_1} + (1 - a_1)^{1/\sigma_1} K_1^{(\sigma_1 - 1)/\sigma_1} \right]^{\sigma_1/(\sigma_1 - 1)} . \tag{1}$$

Factories are built by combining one unit of the informal good with f units of the formal good. The supply price of capital is thus

$$P_k = 1 + f P_1. \tag{2}$$

Preferences, Saving and Investment

All economic activity is undertaken by a single representative agent. Preferences of the agent qua consumer are given by

$$C = \left[(1 - \kappa)^{1/\epsilon} C_1^{(\epsilon - 1)/\epsilon} + \kappa^{1/\epsilon} C_2^{(\epsilon - 1)/\epsilon} \right]^{\epsilon/(\epsilon - 1)} . \tag{3}$$

C is a CES aggregate of C_1 and C_2, with substitution elasticity ϵ. The optimal choices for C_1 and C_2 minimize the cost of purchasing C. This yields the demand function

$$C_1 = (1-\kappa)\left(\frac{P_1}{P}\right)^{-\epsilon} C \tag{4}$$

and the exact consumer price index

$$P = [\kappa + (1-\kappa)P_1^{1-\epsilon}]^{1/(1-\epsilon)}. \tag{5}$$

After choosing the best mix of C_1 and C_2, the agent solves the problem

$$\underset{\{C\}}{Max}\, U = \frac{C^{1-1/\tau}}{1-1/\tau} e^{-\rho t} dt, \tag{6}$$

subject to

$$P_k \dot{K} = P_1 Q_1 + Q_2 - PC - P_k \delta K, \tag{7}$$

where δ, ρ, and τ denote, respectively, the depreciation rate, the pure time preference rate, and the intertemporal elasticity of substitution, and managers/supervisors.

On an optimal path, consumption satisfies the Euler equation

$$\dot{C} = \tau C \left(\frac{r_1}{P_k} - \rho - \delta\right), \tag{8}$$

where $r_1 = P_1 \partial Q_1 / \partial K_1$ is the capital rental and we have assumed that P_1 enters P_k and P with the same weight.[7]

The Effort Function

Work effort depends on the real wage, the unemployment rate u, and the number of managers/supervisors S who monitor employee performance. The supplies of production labor and managers/supervisors are fixed at unity. So

$$e_1 = g_o + g_1 \ln(w_1/P) + g_3 u - g_4 \ln L_1, \tag{9}$$

where

$$u = 1 - L_1 - L_2. \tag{10}$$

Naturally, workers exert more effort when they are paid a higher real wage and when high unemployment increases their gratitude for having a job. Effort also increases when L_1/S is low

[7] The general form of the Euler equation is $\dot{C} = \tau C[r_1/P_k - \rho - \delta - (\gamma - \alpha)\dot{P}_1/P_1]$, where $\alpha \equiv f P_1/P_k$ is the cost share of the formal good in production of the investment good and $\gamma \equiv P_1 C_1/PC$ is the share of the formal good in aggregate consumption. Equation (8) assumes $\alpha = \gamma$.

[$S = 1$ in (9)] and firms monitor work performance more closely and/or provide more input to workers about how to do their job properly. As will become apparent shortly, this gives rise to a firm-size wage premium.

The effort function in (9) may be derived either (i) in a more general version of the micro-theoretic model in Shapiro and Stiglitz (1984) where effort is a continuous variable, the intensity of monitoring depends on L_1/S, and the utility loss from being fired for shirking is increasing in the unemployment rate[8] or (ii) by appending a separable term in the utility function à la Collard and de la Croix (2000) and Danthine and Kurmann (2004, 2010) that captures the nonpecuniary loss from effort at the job. Neither method affects the other first-order conditions associated with the solution to the private agent's optimization problem here or in the full model developed in Section 4.

Labor Demand and the Wage Curve

Firms recognize the connection between labor productivity and the real wage. Hence they optimize over L_1 and w_1. The profit-maximizing choices satisfy

$$\begin{aligned} &P_1 \partial Q_1/\partial L_1 = w_1, \\ &\Longrightarrow L_1 = a_1 Q_1 (a_f e_1)^{(\sigma_1 - 1)} (1 - g_4/e_1)^{\sigma_1} \left(\tfrac{w_1}{P_1}\right)^{-\sigma_1} \end{aligned} \tag{11}$$

and

$$\begin{aligned} &\underbrace{a_f \left(\frac{Q_1}{a_f}\right)^{1/\sigma_1} \left(\frac{e_1 L_1}{a_1}\right)^{-1/\sigma_1}}_{w_1/P_1(e_1 - g_4)} \tfrac{\partial e_1}{\partial(w_1/P)} \tfrac{P_1}{P} = 1, \\ &\Longrightarrow \underbrace{\left(\frac{\partial e_1}{\partial(w_1/P)} \frac{w_1/P}{e_1}\right)}_{\text{Standard Solow Condition}} \tfrac{e_1}{e_1 - g_4} = 1. \end{aligned} \tag{12}$$

Equation (9) and the modified Solow condition in (12) imply[9]

$$\frac{g_1}{e_1 - g_4} = 1. \tag{13}$$

Without loss of generality, we set e_1 equal to unity at the initial equilibrium. The *wage curve* defined by (9) and (13) then reads

$$\ln(w_1/P) = \frac{1 - g_o - g_3 u + g_4 \ln L_1}{1 - g_4}. \tag{14}$$

[8] In the Shapiro-Stiglitz model where effort is either zero or one, L_1/S and the unemployment rate will enter the no-shirking condition.

[9] The Solow condition states that the wage maximizes profits when the elasticity of effort with respect to the real wage equals unity. The condition emerges whenever the first-order condition calls for w to minimize $w/e(w)$.

There is no "natural rate of unemployment," just a *curve* relating the equilibrium wage to the unemployment rate. Firm size shifts the wage curve in the manner shown in Figure 1. When employment rises, monitoring/managerial input per worker declines and effort decreases. The optimal response of the firm is to buy back the lost effort by paying a higher wage.

Raising the MW

An increase in a MW that is already binding misses the effects on output and employment of previous increases in the MW. Accordingly, we assume the MW initially equals the EW firms pay in equation (14). When the government announces a new, higher MW, equations (13) and (14) are suspended and effort is determined by (9) with the real minimum wage w_m replacing w_1/P:

$$e_1 = g_o + g_1 \ln w_m + g_3 u - g_4 \ln L_1. \tag{9'}$$

The nominal MW is indexed to the CPI to maintain the real MW. This makes the product wage in (11) a function of the real price of the formal good:

$$L_1 = a_1 Q_1 (a_f e_1)^{(\sigma_1 - 1)} (1 - g_4/e_1)^{\sigma_1} \left(w_m \frac{P}{P_1} \right)^{-\sigma_1}. \tag{11'}$$

Market-Clearing Conditions

Two market-clearing conditions close the model. Demand equals supply in the formal sector and in the rental market for capital goods when

$$Q_1 = (1-\kappa) \left(\frac{P_1}{P} \right)^{-\epsilon} C + f(\dot{K}_1 + \delta K_1) \tag{15}$$

$$K_1 = (1 - a_1) Q_1 {a_f}^{(\sigma_1 - 1)}. \tag{16}$$

3.1 The Short Run

Getting down to business, differentiate (9') and (11'). After slight manipulation,

$$\theta_{K1} \hat{L}_1 = \theta_{K1} \hat{K}_1 + \left(\frac{\sigma_1}{1 - g_4} - \theta_{K1} \right) \hat{e}_1 - \sigma_1 \left[\hat{w}_m - (1-\gamma) \hat{P}_1 \right], \tag{17}$$

$$\hat{e}_1 = g_1 \hat{w}_m - (g_3 L_1 + g_4) \hat{L}_1, \tag{18}$$

where θ_j is the cost share of factor$j$; a hat over a variable signifies a percentage change (i.e., $\hat{x} = dx/x$); and we made use of the adding-up condition $\theta_{K1} + \theta_{L1}/(1 - g_4) = 1$.[10] Although the capital stock is fixed in the short run, we carry it around in anticipation of future needs.

Without EW effects, the partial equilibrium solution for the employment elasticity (i.e., the solution with P_1 constant) is $\hat{L}_1/\hat{w}$ For $\theta_{K1} = .33$, textbook neoclassical economics cannot explain very small employment elasticities unless 100+ econometric estimates are badly wrong and the true value of σ_1 is less than .1.

EW effects reduce the employment elasticity, assuming $\sigma_1 > \theta_{K1}(1 - g_4)$. Substituting for $\hat{e}_1$ in (17) leads to

$$\hat{L}_1 = \frac{\theta_{K1}}{m_o}\hat{K}_1 + \frac{\sigma_1(1-\gamma)}{m_o}\hat{P}_1 - \frac{\theta_{K1}(1-g_4)}{m_o}\hat{w}_m, \tag{19}$$

where γ is the share of the formal good in aggregate consumption and

$$m_o \equiv \theta_{K1}(1 - g_3 L_1 - g_4) + \sigma_1 \frac{g_3 L_1 + g_4}{1 - g_4} > 0.$$

In the expression for m_o, the sign of $1 - g_3 L_1 - g_4$ determines whether the supply of labor services ($e_1 L_1$) rises or falls with L_1. For empirically-plausible values of g_3, g_4, and the share of formal sector employment in total employment, $1 - g_3 L_1 - g_4 > 0$ is likely, but not guaranteed, to hold.[11] We assume the condition always holds; none of the results in the paper depend on perverse general equilibrium effects (e.g., a downward-sloping supply curve).

The solution in (19) is involved but easy to break down. Three distinct effects operate. All are needed to bring the employment elasticity into the general vicinity of the elasticity estimates in empirical studies. To see this, consider the outcome in an overly simple model where effort depends only on the real wage ($g_3 = g_4 = 0$). The partial equilibrium employment elasticity then reduces to $\hat{L}_1/\hat{w}_m = -1$. The intuition for the result stems from the Solow condition and is quite general. For $P_1 = 1$ and $Q = F(e_1 L_1, K_1)$, the first-order condition for employment is $F_1(e_1 L_1, K_1) = w_1/e_1$. Starting from an equilibrium where firms pay the EW, the elasticity of effort with respect to the MW equals unity, per the standard Solow condition. It follows that $e_1 L_1$ is constant in partial equilibrium and hence that $\hat{L}_1/\hat{w}_m = -\hat{e}_1/\hat{w}_1 = -1$.

[10] Write the production function as $Q = F[e(w_1/P, L_1/S_1)L_1, K_1]$. With constant returns to scale,

$$\lambda Q = F[e(w_1/P, L_1/S_1)\lambda L_1, \lambda K_1].$$

Differentiating with respect to λ gives

$$\begin{aligned} &Q = F_1 e L_1 + F_K K_1 \\ &\Longrightarrow Q = w_1 L_1/P_1(1 - g_4) + r_1 K_1/P_1 \\ &1 \Longrightarrow= \theta_{L1}/(1 - g_4) + \theta_{K1}. \end{aligned}$$

[11] L_1 and the unemployment rate determine the employment share of the formal sector: $L_1/(L_1 + L_2) = L_1/(1 - u)$.

Return now to the solution in (19) and incorporate the firm-size wage premium ($g_4 > 0$) and the impact of higher unemployment on work effort ($g_3 > 0$). The empirical evidence discussed later in Section 3.1 places g_3 between .4 and 1.2, g_4 between .14 and .33, and L_1 between .30 and .75. For our base case calibration where $\theta_{K1} = .40$, $\sigma_1 = .75$, $g_3 = .80$, and $g_4 = .20$, the partial equilibrium employment elasticity equals .332.[12] This is not the complete solution, of course. (P_1 is endogenous.) It is clear, however, that a *fully-loaded* EW model has the potential to explain why big increases in the MW seldom result in big employment losses.

3.1.1 The Impact on Real Output

The results for employment strengthen the case for raising the MW. Surprisingly, so also do the results for real output and investment. Equations (1), (18), and (19) give

$$\hat{Q}_1 = \theta_{K1}\left[1 + \tfrac{\theta_{L1}}{m_o(1-g_4)}(1 - g_3L_1 - g_4)\right]\hat{K}_1 + \tfrac{\sigma_1(1-\gamma)}{m_o(1-g_4)}(1 - g_3L_1 - g_4)\hat{P}_1 + \tfrac{\sigma_1\theta_{L1}}{m_o(1-g_4)}(g_3L_1 + g_4)\hat{w}_m. \tag{20}$$

Real output *increases* in the short run. (P_1 decreases, but only in response to output rising.) This strong result is inherent in the logic of the EW model. Figure 2 depicts the solution for labor services e_1L_1 when there is no firm-size wage premium ($g_4 = 0$) and $P_1 = 1$. As before, $Q = F(e_1L_1, K_1)$ and firms maximize profits by hiring labor up to the point where $F_1(e_1L_1, K_1) = w_1/e_1$. In partial equilibrium, nothing happens: $\hat{e}_1/\hat{w}_m = 1$, so there is no change in the effective cost of labor (ECL) or the supply of labor services. In general equilibrium, however, a coordination externality comes into play: when each firm reduces employment, the increase in the unemployment rate induces workers to put out more effort. The combined effect of the higher wage and higher unemployment shifts the ECL schedule downward, increasing the supply of labor services and output.

The coordination externality is sufficient but not necessary for output to increase. The firm-size wage premium ($g_4 > 0$) also figures in the positive output response. If a larger workforce is more difficult to manage/supervise, then effort decreases with employment at the level of the firm. Thus the marginal ECL increases with employment. Turning this around, when a higher MW increases effort, the average ECL rises but the marginal ECL declines. Since $\hat{L}_1 = -\hat{e}_1$ when $g_3 = g_4 = 0$, the firm-size wage premium implies $\hat{L}_1 + \hat{e}_1 > 0$; again, the total supply of labor services increases. There are clear parallels with impact of a MW on labor demand at

[12] L_1 is backed out from the values of other parameters and variables. It equals .49 in the base case calibration.

firms that exercise monopsony power.[13] But while both output and employment increase under monopsony, employment declines in the EW case.[14]

3.1.2 The Full General Equilibrium Solution

Finally, we bring demand-side parameters into the solution. To minimize algebraic clutter, we assume the cost share of the formal good in production of investment goods is the same as its share in aggregate consumption. Solving (15) forP_1 then yields

$$\hat{P}_1 = -\frac{\theta_{K1}}{V}\left[1 + \frac{\theta_{L1}}{m_o(1-g_4)}(1 - g_3L_1 - g_4)\right]\hat{K}_1 - \frac{\sigma_1\theta_{L1}}{m_o(1-g_4)V}(g_3L_1 + g_4)\hat{w}_m, \tag{21}$$

where

$$V \equiv \frac{\sigma_1(1-\gamma)\theta_{L1}}{m_o(1-g_4)}(1 - g_3L_1 - g_4) + \epsilon\frac{C_1}{Q_1}.$$

Higher output in the formal sector depresses P_1. Consequently, employment decreases more in the full general equilibrium solution than in the partial equilibrium solution that holds P_1 constant. Exactly how much more depends on ϵ, the elasticity of substitution between the formal and informal goods. When the two goods are (not) close substitutes, ϵ is large (small) and the partial equilibrium solution is a good (poor) approximation to the general equilibrium solution. We will be more precise about what "close substitutes" means and about the value of ϵ compatible with small employment losses when we present numerical results for the full model in Section 5.

3.2 The Long Run

Across steady states,

$$r_1 = (\rho + \delta)P_k. \tag{22}$$

We rewrite (22) as

$$MPK = RCC, \tag{23}$$

where MPK and $RCK = (\rho+\delta)P_k/P_1 = (\rho+\delta)(1/P_1 + f)$ are the marginal product of capital and the real cost of capital in the formal sector.

When the government raises the MW, the supply of labor services increases and P_1 falls. Both the MPK and RCC schedules shift upward therefore in Figure 3. The relative strength of the competing effects depends on the size of the informal sector and the elasticities of substitution

[13] When MW increases, e_1 inreases and the marginal product of e_1 decreases. This reduces the marginal ECL.

[14] Rebitzer and Taylor (1995) develop a similar idea. They demonstrate in a variant of the Shapiro and Stiglitz model (1984) that a higher MW increases employment. The result depends, however, on the strong assumption that effort is constant once the no-shirking condition is satisfied.

in consumption and production. Equations (16) and (19) – (21) deliver

$$\frac{\hat{K}_1}{\hat{w}_m} = \frac{\sigma_1\theta_{L1}(g_3L_1+g_4)}{m_o(1-g_4)S}[\epsilon C_1/Q_1 - \sigma_1(1-\gamma)], \tag{24}$$

$$\frac{\hat{L}_1}{\hat{w}_m} = \frac{\theta_{K1}}{m_oV}[\epsilon C_1/Q_1 - \sigma_1(1-\gamma)]\frac{\hat{K}_1}{\hat{w}_m} - \underbrace{\left[\frac{\theta_{K1}(1-g_4)}{m_o} + \frac{\sigma_1^2(1-\gamma)\theta_{L1}}{m_o^2(1-g_4)V}(g_3L_1+g_4)\right]}_{\text{Short-run outcome}}, \tag{25}$$

$$\frac{\hat{Q}_1}{\hat{w}_m} = \frac{\theta_{K1}(1+\theta_{L1}\Delta)}{V}\epsilon\frac{C_1}{Q_1}\frac{\hat{K}_1}{\hat{w}_m} + \underbrace{\frac{\sigma_1\theta_{L1}}{m_o(1-g_4)}(g_3L_1+g_4)\epsilon\frac{C_1}{Q_1}}_{\text{Short-run outcome}}, \tag{26}$$

where

$$\Delta \equiv \frac{1-g_3L_1-g_4}{m_o(1-g_4)} > 0, \tag{27}$$

$$S = \sigma_1\left[\frac{\theta_{L1}(g_3L_1+g_4)}{m_o(1-g_4)}V + \theta_{K1}(1-\gamma)(1+\theta_{L1}\Delta)^2\right] > 0. \tag{28}$$

The equilibrium capital stock increases *iff*

$$\epsilon > \epsilon^* = \sigma_1(1-\gamma)\frac{Q_1}{C_1}. \tag{29}$$

In our base case calibration, $\gamma = .65$, $\sigma_1 = .75$, and $Q_1/C_1 = 1.095$.[15] For these values, ϵ^* is only .287. Sensible alternative calibrations produce higher (and lower) values for ϵ^*, but there remains a general presumption that macroeconomic life is better in the long run than in the short run. Employment always decreases less in the long run. In addition, when $\epsilon > \epsilon^*$, the capital stock and real output increase continuously on the path to the new steady state.

Could employment in the formal sector increase in the long run? This is asking too much of the current simplified model. It is possible, however, to get very close to a positive result. In the limiting case where the formal and informal goods are perfect substitutes (in consumption),

$$\left.\frac{\hat{K}_1}{\hat{w}_m}\right|_{\epsilon=\infty} = 1 - g_4, \tag{30}$$

$$\left.\frac{\hat{L}_1}{\hat{w}_m}\right|_{\epsilon=\infty} = 0. \tag{31}$$

Eventually, employment fully recovers.

[15] Q_1/C_1 is backed out from other values.

The full model includes additional general equilibrium effects that reduce employment losses relative to the losses in the simplified model. These effects can flip the sign of the employment elasticity in the formal sector from negative in the short run to positive in the long run for large but believable values of ϵ.

3.3 The Transition Path

The transition path is governed by the two differential equations for C and K in (7) and (8). Linearizing these two equations around the stationary equilibrium (C^*, K_1^*) gives

$$\dot{C} = \tau C(\rho + \delta)(\hat{r}_1 - \hat{P}_k), \tag{32}$$

$$P_k \dot{K}_1 = P_1 Q_1 \hat{Q}_1 - PdC - P_k \delta dK_1. \tag{33}$$

Equations (2), (16), (20), and (21) link the paths of P_k, r_1, Q_1 and P_1 to the path of K_1. The solutions for Q_1, r_1,and P_k are

$$\hat{Q}_1 = \frac{\theta_{K1}(1 + \theta_{L1}\Delta)}{V} \epsilon \frac{}{Q_1} \hat{K}_1, \tag{34}$$

$$\hat{r}_1 = -\frac{1}{V}\left[(1-\gamma)\theta_{L1}\Delta + \theta_{K1}(1 + \theta_{L1}\Delta) + \epsilon \frac{}{Q_1}\theta_{L1}\frac{g_3 L_1 + g_4}{m_o(1-g_4)^2}\right], \tag{35}$$

$$\hat{P}_k = \gamma \hat{P}_1 = -\gamma \frac{\theta_{K1}}{V}\left[1 + \frac{\theta_{L1}}{m_o(1-g_4)}(1 - g_3 L_1 - g_4)\right]\hat{K}_1. \tag{36}$$

Feeding the above solutions into (32) and (33) produces

$$\begin{bmatrix} \dot{C} \\ \dot{K} \end{bmatrix} = \begin{bmatrix} 0 & u_1 \\ -1/P_k & u_2 \end{bmatrix} \begin{bmatrix} C - C^* \\ K - K^* \end{bmatrix}, \tag{37}$$

where

$$u_1 \equiv -\tau \frac{C}{K_1}\frac{\rho + \delta}{\sigma_1 V}\left\{\epsilon \frac{C_1}{Q_1}\frac{\sigma_1 \theta_{L1}(g_3 L_1 + g_4)}{m_o(1-g_4)^2} + \sigma_1(1-\gamma)[\theta_{K1} + \theta_{L1}\Delta(1 + \theta_{K1})]\right\} < 0,$$

$$u_2 \equiv \frac{1}{V}\left\{\epsilon \frac{C_1}{Q_1}[\rho(1 + \theta_{L1}\Delta) + \delta\theta_{L1}\Delta] - \delta\sigma_1(1-\gamma)\theta_{L1}\Delta\right\}.$$

The stationary equilibrium is saddle-point stable. On the convergent path,

$$C - C^* = (K_{1,o} - K_1^*)\frac{u_1}{\lambda}e^{\lambda t}, \tag{38}$$

$$K_1 - K_1^* = (K_{1,o} - K_1^*)e^{\lambda t} \tag{39}$$

where

$$\lambda = \frac{u_2 - \sqrt{u_2^2 - 4u_1/P_k}}{2} < 0.$$

Figures 4 and 5 depict the transition paths of K_1, C, and L_1. The saddle path is positively sloped and the capital stock increases or decreases monotonically depending on whether $\epsilon \gtrless \epsilon^* = \sigma_1(1-\gamma)Q_1/C_1$. In the fourth quadrant, the slope of the LL schedule takes the same sign as $\epsilon - \epsilon^*$. Thus, after decreasing at $t = 0$, employment rises continuously. From (25) and (39),

$$\frac{\dot{L}_1}{L_1} = -\frac{\theta_{K1}}{m_o V}\underbrace{[\epsilon C_1/Q_1 - \sigma_1(1-\gamma)]}_{\text{Sign of } K_1^*\text{-}K_{1,o}}\lambda\frac{K_1^* - K_{1,o}}{K_{1,o}}e^{\lambda t} > 0. \tag{40}$$

Consumption increases in the short run when $\epsilon < \epsilon^*$ but not necessarily for $\epsilon > \epsilon^*$. Two conflicting effects operate when $\epsilon > \epsilon^*$. The increase in the equilibrium capital stock creates an incentive to temporarily reduce consumption, while the rise in output at $t = 0$ and the agent's desire for a smooth consumption path pull in the opposite direction. In the case shown in Figure 4, the intertemporal elasticity of substitution (τ) is relatively low and the consumption-smoothing motive wins out. The private sector allocates some of the increase in real income at $t = 0$ to investment and some to consumption. The counterintuitive outcome where consumption decreases in the short run obtains only when the intertemporal elasticity of substitution is implausibly large. In our base case calibration, for example, τ must exceed 1.27.

3.3.1 Welfare

Although we are primarily interested in positive analysis, we take the opportunity in passing to comment on the welfare implications of the results. The punchline is easy to guess: the MW increases welfare, subject to the caveat that a model with a representative agent ignores distributional concerns or assumes, optimistically, that the newly unemployed are compensated enough for their lost wage income. This is obvious in Figure 4, where the path of consumption is continuously higher. Other paths are possible. Consumption may be lower either in the short/medium run or in the long run (Figure 5). In every case, however, welfare improves. In Appendix A we show that the percentage equivalent variation (EV) welfare gain is

$$EV = \frac{(1 - g_3L_1 - g_4)\theta_{K1}\gamma}{m_o(1-g_4)V}(\epsilon - \epsilon^*)\underbrace{\frac{K_1^* - K_{1,o}}{K_{1,o}}}_{\text{Sign of } \epsilon\text{-}\epsilon^*}\frac{\lambda\rho}{\lambda - \rho} + \underbrace{\frac{\epsilon\gamma\sigma_1\theta_{L1}(g_3L_1 + g_4)}{m_o(1-g_4)V}}_{\text{Direct effect of } w_m \uparrow}. \tag{41}$$

The welfare arithmetic in (41) is straightforward. Both employment and the real wage are suboptimal at the initial equilibrium. Raising the MW ameliorates the coordination externality. It also reduces employment. But since the total supply of labor services increases, the net welfare effect is positive. This gain is captured by the second term in (41). The first term measures the additional welfare gain generated by changes in the capital stock. Variations in K_1 have no direct effect on welfare. Indirectly, however, changes in K_1 increase welfare by increasing the supply of labor services. The sign of $\epsilon - \epsilon^*$ determines *both* the change in the equilibrium capital stock and the impact of increases in the capital stock on employment. Thus, regardless of whether the equilibrium capital stock rises or falls, the supply of labor services continues to increase as some of the workers laid off at $t = 0$ get rehired on the transition path to the new steady state. The MW always increases welfare because it always moves the supply of labor services closer to its social optimum.

4 The Full Model

The full model assumes an open economy where production in the export sector is constant at Q_x and imports comprise machinery and equipment as well as consumer goods. The export good is not consumed domestically and all world prices equal unity (i.e., the country is small in world markets).

Many elements of the full model will be familiar from the exposition of the simplified model. To save space, we present the model with minimum commentary.

Technology

CES production functions convert inputs into output. Scarce entrepreneurial talent H is a fixed factor in the informal sector:

$$Q_1 = a_f \left[a_1^{1/\sigma_1} (e_1 L_1)^{(\sigma_1 - 1)/\sigma_1} + (1 - a_1)^{1/\sigma_1} K_1^{(\sigma_1 - 1)/\sigma_1} \right]^{\sigma_1/(\sigma_1 - 1)}, \tag{42}$$

$$Q_2 = a_i \left[a_2^{1/\sigma_2} (e_2 L_2)^{(\sigma_2 - 1)/\sigma_2} + a_3{}^{1/\sigma_3} K_2^{(\sigma_2 - 1)/\sigma_2} + (1 - a_2 - a_3)^{1/\sigma_2} H^{(\sigma_2 - 1)/\sigma_2} \right]^{\sigma_2/(\sigma_2 - 1)} \tag{43}$$

Factories are assembled by combining one imported machine with f_1 and f_2 units of formal and informal sector capital inputs. In both sectors,

$$P_k = 1 + f_1 P_1 + f_2 P_2. \tag{44}$$

Preferences, Saving, and Investment

Preferences are given by

$$C = \left[\kappa_2{}^{1/\epsilon_2} C_j^{(\epsilon_2 - 1)/\epsilon_2} + (1 - \kappa_2)^{1/\epsilon_2} C_2^{(\epsilon_2 - 1)/\epsilon_2} \right]^{\epsilon_2/(\epsilon_2 - 1)},$$

$$C_j = \left[(1-\kappa_3)^{1/\epsilon_3} C_m^{(\epsilon_3-1)/\epsilon_3} + \kappa_3^{1/\epsilon_3} C_1^{(\epsilon_3-1)/\epsilon_3}\right]^{\epsilon_3/(\epsilon_3-1)}.$$

The lower tier defines C_j as a CES aggregate of C_1 and consumption C_m of an imported consumer good. At the upper tier, C_j combines with C_2 in another CES function.

The optimal choices for C_m, C_1, and C_2 yield

$$C_1 = \kappa_3 \left(\frac{P_1}{P_j}\right)^{-\epsilon_3} \kappa_2 \left(\frac{P_j}{P}\right)^{-\epsilon_2} C, \tag{45}$$

$$C_2 = (1-\kappa_2)\left(\frac{P_2}{P}\right)^{-\epsilon_2} C, \tag{46}$$

and the associated price indices

$$P = \left[\kappa_2 P_j{}^{1-\epsilon_2} + (1-\kappa_2) P_2^{1-\epsilon_2}\right]^{1/(1-\epsilon_2)}, \tag{47}$$

$$P_j = \left[\kappa_3 P_1{}^{1-\epsilon_3} + 1 - \kappa_3\right]^{1/(1-\epsilon_3)}. \tag{48}$$

The representative agent solves the more elaborate Ramsey problem

$$\underset{\{C,I_1,I_2,g,h\}}{Max} U = \int_0^\infty \frac{}{1-1/\tau} e^{-\rho t} dt, \tag{49}$$

subject to

$$PC = P_1 Q_1 + P_2 Q_2 + Q_x - P_k \left[I_1 + I_2 + \frac{v_1}{2}\left(\frac{I_1}{K_1} - \delta\right)^2 K_1 + \frac{v_2}{2}\left(\frac{I_2}{K_2} - \delta\right)^2 K_2\right]$$

$$-w_1 L_1 - w_2 L_2 - P_2 v_3 \frac{g^2}{2} - P_1 \frac{v_4}{2} h^2 + R \tag{50}$$

$$\dot{K}_1 = I_1 - \delta K_1, \tag{51}$$

$$\dot{K}_2 = I_2 - \delta K_2, \tag{52}$$

$$\dot{L}_1 = h L_1, \tag{53}$$

$$\dot{L}_2 = g L_2. \tag{54}$$

where $R \equiv w_1 L_1 + w_2 L_2$; I_j is investment in sector j (j = 1, 2); and the terms $v_1(\bullet)^2 K_1/2$, $v_2(\bullet)^2 K_2/2$, $v_3 g^2/2$, and$v_4 h^2/2$ capture adjustment costs incurred in changing the capital stocks and employment.[16]

[16]Adjustment costs are required to support the assumption that capital is sector specific. The representative agent qua firm owner treats R as exogenous when optimizing over g and h.

The first-order conditions for an optimum can be compressed into a set of four Euler equations for I_1, I_2, g, and h. On an optimal path, investment adjusts so that the return on capital, net of adjustment costs and depreciation, continuously equals the real interest rate. Similarly, adjustment costs to changing employment drive a wedge between the marginal product of labor (Q_{iL}) and the product wage:

$$\frac{v_1}{K_1}\dot{I}_1 = \left[1 + v_1\left(\frac{I_1}{K_1} - \delta\right)\right]\left[\frac{\dot{C}}{C\tau} + \rho + \delta - (\alpha_1 - \gamma_1)\frac{\dot{P}_1}{P_1} - (\alpha_2 - \gamma_2)\frac{\dot{P}_2}{P_2}\right] + \frac{v_1}{2}\left(\frac{I_1}{K_1} - \delta\right)^2 - \frac{r_1}{P_k}, \tag{55}$$

$$\frac{v_2}{K_2}\dot{I}_2 = \left[1 + v_2\left(\frac{I_2}{K_2} - \delta\right)\right]\left[\frac{\dot{C}}{C\tau} + \rho + \delta - (\alpha_1 - \gamma_1)\frac{\dot{P}_1}{P_1} - (\alpha_2 - \gamma_2)\frac{\dot{P}_2}{P_2}\right] + \frac{v_2}{2}\left(\frac{I_2}{K_2} - \delta\right)^2 - \frac{r_2}{P_k}, \tag{56}$$

$$\dot{h} = (w_1/P_1 - Q_{1L})\frac{L_1}{v_4} + \rho h + h\left[\frac{\dot{C}}{C\tau} + (1 - \gamma_1)\frac{\dot{P}_1}{P_1} + \gamma_2\frac{\dot{P}_2}{P_2}\right], \tag{57}$$

$$\dot{g} = (w_2/P_2 - Q_{2L})\frac{L_2}{v_3} + \rho g + gt\left[\frac{\dot{C}}{C\tau} + (1 - \gamma_1)\frac{\dot{P}_1}{P_1} + \gamma_2\frac{\dot{P}_2}{P_2}\right], . \tag{58}$$

where $\alpha_i \equiv P_i f_i / P_k$ is the cost share of the good i in the production of a factory and $\gamma_i \equiv P_i C_i / PC$ is the consumption share of good i.

The Effort Functions

EW effects operate in both sectors:

$$e_1 = g_o + g_1 \ln w_m + g_3 u - g_4 \ln L_1, \tag{59}$$

$$e_2 = b_o + b_1 \ln(w_2/P) - b_2 \ln w_m + b_3 u. \tag{60}$$

The effort function in the informal sector differs from its counterpart in the formal sector in two ways. First, effort is independent of employment on the assumption that supervision of the small workforce at micro firms is not a problem. Second, and more importantly, the MW shifts the norm for fairness among workers. When w_m increases, workers perceive their current real wage as less fair than before; disgruntled, they express their dissatisfaction with the status quo by reducing effort.

Labor Demand and the Wage Curve in the Informal Sector

The sectoral demands for labor are

$$L_1 = a_1 Q_1 (a_f e_1)^{(\sigma_1 - 1)} (1 - g_4/e_1)^{\sigma_1} \left(w_m \frac{P}{P_1} \right)^{-\sigma_1}, \tag{11'}$$

$$L_2 = a_2 Q_2 (a_i e_2)^{(\sigma_2 - 1)} w_2^{-\sigma_2}. \tag{61}$$

Enforcement of the MW law is confined to the formal sector. In the informal sector, firms pay an EW well below w_m. Equation (60) and the Solow condition

$$\frac{\partial e_2}{\partial (w_2/P)} \frac{w_2/P}{e_2} = 1 \tag{62}$$

yield

$$e_2 = b_1. \tag{63}$$

Conveniently, effort is constant in general equilibrium. We set e_2 equal to unity, the initial level of effort in the formal sector. The resulting wage curve is

$$\ln(w_2/P) = 1 - b_o + b_2 \ln w_m - b_3 u. \tag{64}$$

At first glance, equation (64) delivers a lighthouse effect. This is not necessarily the case, however. Layoffs in the formal sector exert downward pressure on the real wage by increasing the unemployment rate. Moreover, estimates of wage curves find, as expected, that real wages are considerably more responsive to unemployment in the informal sector than in the formal sector. A significant lighthouse effect requires not only b_2 sufficiently large, but also relatively small employment losses in the formal sector. The MW puzzle is multifaceted, but the three most important stylized facts – small employment losses in the formal sector, larger employment losses in the informal sector, and the lighthouse effect – are all of a piece.

Raising the MW

The policy experiment is the same as in the simplified model. Initially the MW is a penny below the EW firms pay in the formal sector. The announcement of a higher MW thus increases the wage in the formal sector dollar-for-dollar.

Market-Clearing Conditions

Four market-clearing conditions close the model. Demand equals supply in the formal sector, the informal sector, and the rental markets for the two capital stocks when[17]

$$Q_1 = C_1 + f_1 \left[I_1 + I_2 + \frac{v_1}{2} \left(\frac{I_1}{K_1} - \delta \right)^2 K_1 + \frac{v_2}{2} \left(\frac{I_2}{K_2} - \delta \right)^2 K_2 \right] + v_4 \frac{h^2}{2}, \tag{65}$$

$$Q_2 = C_2 + f_2 \left[I_1 + I_2 + \frac{v_1}{2} \left(\frac{I_1}{K_1} - \delta \right)^2 K_1 + \frac{v_2}{2} \left(\frac{I_2}{K_2} - \delta \right)^2 K_2 \right] + v_3 \frac{g^2}{2}, \tag{66}$$

$$K_1 = (1 - a_1) Q_1 {a_f}^{(\sigma_1 - 1)} \left(\frac{r_1}{P_1} \right)^{-\sigma_1}, \tag{67}$$

$$K_2 = a_3 Q_2 {a_i}^{(\sigma_2 - 1)} \left(\frac{r_2}{P_2} \right)^{-\sigma_2}. \tag{68}$$

4.1 Model Calibration

Table 1 shows the values assigned to various deep parameters, to the formal sector wage premium, and to factor shares and expenditure shares at the initial equilibrium. We chose ordinary values for the depreciation rate (δ), the intertemporal elasticity of substitution (τ), the urban unemployment rate (u), and the cost share of capital in the formal sector (θ_{K1}). With respect to the other choices (save one):

- *Pure time preference rate* (ρ) *and the real return on private capital.* Across steady states, the real return on private capital (net of depreciation) equals ρ. We set ρ at 10%. This is line with estimates of the return to private investment in Isham and Kaufmann (1999), Dalgaard and Hanson (2005), and Marshall (2012), and with hard data on real loan rates in LDCs.[18]

- *Elasticity of substitution between capital and labor services* (σ_1, σ_2). Estimates of σ in LDCs range from .5 to 1.2.[19] Overall, there is more support for $\sigma < 1$ than for $\sigma \geq 1$.

[17] We omit the market-clearing condition for H, which tracks the quasi-rent earned by entrepreneurial talent in the informal sector (a variable irrelevant to the issues under examination).

[18] To give a few examples, the real loan rate in 2014 was 8.9% in Colombia,9.7% in Costa Rica, 10.3% in Guatemala, 8.4% in Kenya, and 11.1% in Tanzania (World Development Indicators, 2014). The estimates of the return on private capital cited in the text range from 12% to 16% and presumably incorporate a risk premium. Karabarbounis and Neiman (2013) assume a time preference rate of 10% in estimating a global (59-country) model of labor shares.

[19]

▷ See Briguglio (1998), Duffy and Papageorgiou (2000), Claro (2002), Wang (2012), Shankar and Rao (2012), Martinez (2012), Shen and Whalley (2013), Goldar et al.\thinspace (2014), Oberfeld and Raval (2014), and Helali and Kalai (2015).

Since separate estimates do not exist for the informal sector, we fix both σ_1 and σ_2 at .75. The results do not change significantly when σ equals .5 or 1.

- *Adjustment costs to changing the capital stock* (v_1, v_2) *and the q-elasticity of investment spending* (Ω). The first-order condition for investment in the formal sector is $[1+v_1(I_1/K_1-\delta)] = \phi_1/\phi_2 P_k$, where ϕ_1 and ϕ_2 are multipliers attached to the private agent's budget constraint and to the law of motion for the capital stock [the constraints in (50) $-$ (52)]. To link the adjustment cost parameter v_1 to an observable elasticity, note that ϕ_1/ϕ_2 is the shadow price of capital measured in dollars. Thus $\phi_1/\phi_2 P_k$ is effectively Tobin's q, the ratio of the demand price to the supply price of capital. Let $\Omega_1 \equiv \hat{I}_1/\hat{q}$ denote the q-elasticity of investment spending. Evaluated at a stationary equilbrium, the first-order condition for investment then gives $v_1 = 1/\delta\Omega_1$. There are only a couple of reliable estimates of Ω for LDCs. The estimates for Egypt in Shafik (1992) and for Korea in Hong (1998) and Kim et al. (2015) are 2.11 $-$ 2.56, 3.1, and 2.08 $-$ 2.36, respectively. The assigned value is consistent with these estimates and with high-end estimates for developed countries. A sensible case can be made for both higher and lower numbers. Fortunately, the results are highly insensitive to Ω. The impulse responses presented in Sections 4 and 5 change very little when Ω equals .5 or 5.

- *Adjustment costs to changing employment* (v_3, v_4). The empirical literature on adjustment costs for employment is frustrating to read. Some estimates find that adjustment costs are quite small, others suggest that they are much larger than adjustment costs for the capital stock.[20] Taking a conservative position, we assume adjustment costs are 50% as large as adjustment costs for the capital stock in the formal sector. This implies $v_4 = .5 v_1 P_k K_1/P_1$.[21] Not much is known about adjustment costs in the informal sector, but they are probably a small fraction of adjustment costs in the formal sector.[22] Our poorly educated guess is that $v_3 = .1 v_4$.

- *Firm-size wage premium* $[g_4/(1-g_4)]$. Velenchik (1997), Soderbom and Teal (2004),Falco et al. (2011), Aigbokhan (2011), and Rand and Torm (2012) report elasticities of the real wage with respect to employment of .16 in Zimbabwe, .15 in Ghana, .38 $-$.50 in Tanzania, .26 in Nigeria, and .24 in Vietnam. This elasticity pins down g_4 in the formal sector wage curve in (14). Our choice, .25, equals the average of the five estimates. The associated value of g_4 is .20 $[g_4/(1-g_4) = sizepremium \Longrightarrow g_4 = sizepremium/(1+sizepremium)]$.

[20] See, for example, Shapiro (1986), Merz and Yashiv (2007), Mumtaz and Zanetti (2015), and Mizobata (2015). Eslava et al. (2005) and Gonzaga (2009) estimate that adjustment costs for labor are comparable to or larger than adjustment costs for capital in Colombia and Brazil.

[21] The ratio of both total and marginal adjustment costs for labor relative to capital is $v_4 P_1/v_1 P_k K_1$ when$\dot{K}_1/K_1 = \dot{L}$.

[22] See the estimates in Gonzaga (2009) for large vs. small firms in Brazil.

- *Formal sector wage premium* ($\psi = w_1/w_2$). The formal sector wage premium is large in LDCs. Numerous empirical studies find, after controlling for observable human capital characteristics, unobservable heterogeneity, self-selection, and workplace conditions, that workers in the formal sector earn $20 - 120\%$ more than workers in the informal sector.[23] A wage premium of 50% is representative, if slightly conservative. As explained later, the wage premium should be set jointly with the sectoral factor cost shares and the consumption share of the formal good to be consistent with the observed share of the formal sector in total employment.

- *Consumption shares* (γ_1, γ_2, γ_m). There is considerable variation in the size of the formal sector across LDCs. To accommodate this, we set γ_m at .14 and let γ_1 take low, average, and high values of .39, .56, and .69. The average value, together with the values assigned to other parameters, generates an output share of the formal sector in non-agricultural GDP equal to the average share in the World Bank Enterprise Surveys (La Porte and Shleifer, 2014).

- *Elasticity of substitution in consumption between the composite formal good* (C_j) *and the informal good* (ϵ_2). Estimates of demand systems do not distinguish between goods produced by formal and informal firms. The right value for ϵ_2 is a judgment call therefore that depends on whether firms in the formal and informal sectors sell in similar or distinct product markets. Variation across countries in the sectoral overlap between formal and informal firms suggests that both high and low values of ϵ_2 are defensible. Lacking a strong prior, we carry out runs for $\epsilon_2 = .5 - 5$.

- *Elasticity of substitution between imported consumer goods and the formal good* (ϵ_3). The law of one price does not hold for manufactured goods or services like tourism, which, unlike primary products, are highly heterogeneous. The characterization of the formal sector as tradable or nontradable depends therefore on the value assigned to ϵ_3. When $\epsilon_3 = 1$, formal sector output is either nontradable or a poor substitute for imports. In runs where $\epsilon_3 = 10$, the sector produces manufactured goods competitive with imported varieties. $\epsilon_3 = 3$ is an in between case (e.g., the formal sector produces a mix of nontradable services and highly tradable manufactured goods).

- *Cost share of the formal/informal good in production of investment goods* (α_1, α_2). The base case in the full model maintains the assumption of the simplified model that $\alpha_i = \gamma_i$.

- *Lighthouse effect* (b_2). There are no empirical estimates on which to base the value of b_2. In these circumstances we set $b_2 = 1$ in which case effort in the formal sector depends on the ratio of the wage to the MW. The simulation results discussed below suggest this

[23]Summary results for 36 case studies may be found at http://mypage.iu.edu/~ebuffie/.

represents a plausible calibration, although we also investigate the consequence of a weaker lighthouse effect.

- *Real wage flexibility in the formal and informal sectors* $[g_3/(1-g_4), b_3]$. Most estimates of wage curves in LDCs find that $b_3 >> g_3/(1-g_4)$ (see Table 2). In other words, the common perception that real wages are much more flexible in the informal sector than in the formal sector is correct. But much more flexible does not always mean highly flexible. In both the formal and informal sector, the sensitivity of the real wage to the unemployment rate varies considerably across countries, time periods, and states of the economy. Aiming for generality with minimum taxonomy, we examine low, average, and high wage flexibility scenarios, but impose $b_3 = 2g_3/(1-g_4)$ in all runs.

4.1.1 The Problem Child: Cost Shares in the Informal Sector

One important part of the model proved difficult to calibrate. Good, sensible data are not readily available for factor cost shares in the informal sector. National Income Accounts data are especially unreliable (Gollin, 2002).

We calibrate the labor share in informal sector value added directly from the 19 *Informal Enterprise Surveys* collected by the World Bank.[24] We focus exclusively on manufactured firms and compute the labor share at the level of the firm as $\theta_{Li} = (wL/VA)_i$. The denominator, value added, is defined as $VA_i = PY_i - P_M M_i - P_E E_i$, where PY_i denotes the total value of sales, $P_M M_i$ is the cost of material inputs, and $P_E E_i$ is the value of energy and transport costs. We consider two measures of the numerator, labor costs. The first is simply the firm's self-reported "labor costs" and the second ("wage bill") is computed as the product of the (reported) average wage times reported employment. As noted by Gollin (2002), in many low-income countries payments to informal labor, including family employees, are treated as residual payments to capital; to control for this, we impute the average wage for "unpaid" family members working in the firm.

Both labor measures ("labor costs" and "wage bill") are computed on a country-by-country basis where the usable sample of manufacturing firms ranges from 50 to 250 informal firms. Missing and clearly mis-reported data are endemic in the informal surveys and we therefore censor the firm-level data, excluding firms with labor shares in value added that exceed 100% or fall below 15%. Table 2 and the associated kernel densities in Figure 6 summarize the information in the 19 surveys. Mean employment in informal firms is approximately four (of which 1.75 are unpaid family/other employees) and the labor share in informal sector value added is approximately .50. Since production is less capital intensive in the informal sector than

[24] Afghanistan (2008, 2009), Burkina Faso (2009), Cape Verde (2009), Cameron (2009), Cote d'Ivoire (2009), Madagascar (2009), Mauritius (2009), Angola (2010), Botswana (2010), DRC (2010, 2013), Mali (2010), Argentina (2010), Ghana (2013), Guatamala (2010), Kenya (2013), Myanmar (2014), Peru (2010) and Rwanda (2011).

in the formal sector, we set $\theta_{K2} = .25$. This and the value of .50 for θ_{L2} imply a cost share for entrepreneurial skill of .25.

The initial distribution of non-agricultural employment between the formal and informal sectors is tied down by the formal sector's share in consumption and investment expenditure, $\gamma = \alpha$; the initial formal sector wage premium, $\psi = w_1/w_2$; and factor cost shares in the two sectors. If the values assigned to these variables are reasonable, the employment share of the formal sector should lie between .35 and .75, the range observed in the data (Terrell and Almeida, 2008; Gasparini and Tornarolli, 2009). The base case and alternative calibrations of the model satisfy this consistency check. In the baseline calibration where $\gamma_1 = \alpha_1 = .56$, formal labour accounts for 54% of total (non-agricultural) employment. Increasing the expenditure share of the formal sector to .69 implies that formal sector labour accounts for 72% of the total, which aligns with non-agricultural employment shares in higher-income countries in Latin America, while for $\gamma_1 = \alpha_1 = .39$, the share of formal employment in non-agricultural employment falls to 34%, consistent with that observed in low-income countries.

4.1.2 Solution Technique

There are a variety of ways to approximate the stable manifold. Given the substantial non-linearities present in the model, we judged the method in Novales et al.\thinspace (1999) to offer the best tradeoff between solution speed and minimization of approximation error. The method derives stability conditions from a linear approximation around the steady state, but incorporates the nonlinear structure of the model when tracking the transition path.

5 Numerical Results

Different calibrations of the model are appropriate for countries at different stages of development. To keep the taxonomy sparse, we limit the analysis in this section to a comparison between two archetypes: a middle-income developing country (MIC), corresponding roughly to the middle two quartiles of per capita income of the countries analysed by La Porta and Shleifer (2008, Table 1), in which the formal sector accounts for approximately 65 percent of non-agricultural output, and a high-income, Emerging Market (EM) economy where the formal sector share is around 80 percent (La Porta and Shleifer's top quartile of countries). These archetypes reflect the broad structural characteristics of the countries that dominate the empirical evidence reviewed in Appendix B. In Section 6 we report the results of solving the model calibrated for a representative low-income country (LIC) where the formal sector accounts for only 35% of non-agricultural output. In each case we report the long-run consequences of an increase in the real minimum wage in the formal sector for key macroeconomic indicators: the percentage change across steady states in sectoral and total employment; sectoral capital stocks; sectoral and aggregate output; and the real consumption wage in the informal sector. Reading from top to bottom of each table, the panels summarize the solution results under alternative characterizations of the structure of consumption, defined by the elasticities of substitution between formal and informal goods (ε_2) and between the domestic formal good and the imported good (ε_3), while reading left to right within each panel shows variations in outcomes as the slope of the wage curves in both sectors increases. The central settings for the unemployment semi-elasticity of wages are $g_3/(1-g_4) = 1$ in the formal sector and $b_3 = 2$ in the informal sector, against which we consider a relatively flat wage curve ($g_3/(1-g_4) = .5$ and $b_3 = 1$) and a relatively steep curve ($g_3/(1-g_4) = 1.5$ and $b_3 = 3$).[25] In each case we consider a permanent 10% increase in the formal sector real minimum wage: to compare these results with the elasticities typically reported in the empirical literature, simply divide our results through by 10.

5.1 Middle Income and Emerging Market calibrations

5.1.1 The long-run

The first two panels of Table 3 show the effects of reducing the elasticity of substitution in consumption between the formal and informal good (from $\epsilon_2 = 3$ to $\epsilon_2 = 1.5$) holding the corresponding elasticity of substitution between the formal and imported good constant at $\epsilon_3 = 3$. In the remaining panels we assume the domestically produced formal good and the imported good are close substitutes in consumption ($\epsilon_3 = 10$) and then progressively reduce the substitutability between the formal good and the informal good.

Focusing first on the central spine of Table 3, three main results stand out. First, in the long run the aggregate economy adds capital, expands output and sheds labor.[26] The output and capital elasticities both lie between 0.31 and 0.38, and the employment elasticities are around -0.25. These long-run changes strongly favor the formal sector but informal sector wages also rise and aggregate welfare increases in all cases (see below). The mechanics of these outcomes are consistent with the intuition developed in Section 3, and can be traced through panel [a] in the first instance. A higher minimum wage leads to a modest contraction in long-run employment in the formal sector, but this is offset by increased capital accumulation and output in this sector. These changes are accompanied in the informal sector by a proportionately larger contraction in employment (so that aggregate employment falls) and by a mild contraction of the capital stock and a modest contraction in output. Specifically, total employment contracts by 2.8%, comprising a contraction of 1.9% in formal sector employment and a 3.9% reduction in employment in the informal sector. Total output expands by 3.9%, but also in an unbalanced fashion; formal sector output expands by 7.2% while informal sector output contracts by 2.1%.

[25] The wage curve has the real wage on the vertical axis. A steeper wage curve therefore exhibits a more elastic response of the wage to the unemployment rate.

[26] The initial capital stock in the formal sector is approximately three times as large as that in the informal sector so that in all cases the expansion in formal sector capital substantially outweighs any contraction in capital in the informal sector.

The strong growth in formal output reflects large increases in both the capital stock and labor services. Because of EW effects, effective labor input in the formal sector (e_1L_1) rises by 7.9% as increased effort outweighs the contraction in formal sector employment. This growth, in turn, increases the marginal product of capital and stimulates investment; capital in the formal sector thus grows by 6.1% across steady states. By contrast, the decrease in employment in the informal sector leads to a modest net disinvestment so that output contracts. Because aggregate employment losses are small, however, the unemployment effect in the informal wage curve is relatively weak so that the lighthouse effect is observed with the informal real wage rising by just under 5%.

Second, higher substitutability (between formal and informal goods and between the formal good and the imported good) means higher aggregate gains to the economy, leveraged in favor of factors employed in the formal sector (compare column 2 of panels [a] and [c] in Table 3). Total output growth increases from 3.9% to 4.8%, while the contraction in overall employment is slightly lower (-2.5% as opposed to -2.8%). These aggregate effects, however, conceal highly asymmetric sectoral effects: in panel [c], formal sector employment marginally *increases*, while contraction in the informal sector increases sharply and likewise in the responses of sectoral capital accumulation and output.

The final three panels of Table 3 explore these changes further by considering cases where the formal and informal sectors are progressively less substitutable in demand (with the formal and import goods remaining highly substitutable). As this occurs, aggregate outcomes are attenuated and the net gains shift back in favor of the informal sector, although the principal driver of GDP growth remains the expansion of formal sector output, irrespective of the level of wage flexibility. Moreover, as substitutability falls, employment losses in the formal sector increase and eventually exceed those in the informal sector, to the point where, if formal and informal goods are very poor substitutes, employment in the informal sector may increase, especially when the wage curves are relatively steep (panel [f]). Whilst this movement in employment is consistent with the standard segmented labor market model, the associated increase in output and the informal sector wage is not.

Third, the steeper the wage curves, the stronger are the positive effects on output and employment in both sectors. Per the analysis in Section 3, the larger the unemployment semi-elasticity in the formal and informal sector wage curves, the more rising unemployment leverages effort, minimizing employment losses in both sectors. The extra boost to effective labor spurs greater capital accumulation, further reducing employment losses. Indeed, in combination with high general substitutability in consumption, formal sector employment may actually *increase* in the long run. This paradoxical result stems from general equilibrium interactions associated with the lighthouse effect. Indirectly, via its impact on the unemployment rate, the lighthouse effect increases work effort, labor productivity, and labor demand in the formal sector. We observe this in columns 2 and 3 of panel [c], but it follows that for any plausible slope to the wage curve there exists critical values of ϵ_2 and ϵ_3 for which formal sector employment increases across steady states. Naturally, the critical value of ϵ_2 is smaller the steeper the wage curves. In the MIC calibration with $\epsilon_3 = 10$, for example, the borderline value of ϵ_2 declines from 7.5 when $g_3/g_1 = .5$ and $b_3 = 1$ to 3.4 for $g_3/g_1 = 1.5$ and $b_3 = 3$.

Table 4 replicates panels [a], [d] and [f] from Table 3 for the Emerging Market (EM) calibration where the informal economy accounts for only 20% of non-agriculture output. The qualitative nature of the results is broadly similar to the MIC calibration with the key quantitative difference being that the larger formal sector leverages the aggregate gains to the economy, again with the employment and output gains accruing primarily to the formal sector. For example, in the case of $\epsilon_2 = 3$ and $\epsilon_3 = 10$, long run output is between 1.4 and 1.9 percentage points higher than in the MIC case, although in this case the effect on informal wages is significantly stronger.

5.1.2 Coherence With Empirical Estimates

Our simulation results are generated for a range of plausible model calibration choices that are themselves disciplined by the relevant research evidence. Nonetheless, the range of results displayed in Tables 3 and 4 displays a pleasingly high degree of fidelity with the empirical evidence discussed in the Introduction. Much the largest share of this evidence focuses on the short- to medium-run employment consequences of changes in minimum wages and, to a lesser extent, on the impact on wages in the uncovered sectors; there is much less empirical evidence on sectoral or aggregate output effects. Figure 7 presents a stylized summary of our simulated employment elasticities for the MIC calibration (the results from Table 3 shown in red) and the EM calibration (from Table 4, shown in green), against a range of estimates from the empirical literature (from Appendix B). The distribution of the simulated results is statistically indistinguishable from that of the empirical estimates: the mean of the former is -0.24 with a standard deviation of 0.18 against a mean of $-.22$ and standard deviation of 0.20.

As noted, the evidence on other variables is less complete but nonetheless our simulations are consistent with the key results emerging from the literature. The bulk of the empirical evidence suggests that wages in informal/uncovered sectors rise – or at least do not fall – following increases in the formal-sector minimum wage. Gindling and Terrell (2005) estimate an elasticity of .15 for urban informal workers and .40 for rural informal workers (Costa Rica); Neumark et al. (2006) estimate an elasticity of .43 (Brazil); and Rani and Ranjbar's (2015) estimated elasticities vary from .45 (for India) to around $.80 - .90$ (for Indonesia and South Africa). See also Bhorat et al (2016), Andalon and Pages (2009), Lemos (2009), Gindling and Terrell (2007). The results from Tables 3 and 4 return uniformly positive informal wage elasticities that range from .41 to .71. Finally, while only a few empirical papers attempt to measure the impact on macro variables other than employment, those that do strongly support the predictions of our model that big positive effects on GDP, labor productivity, and investment are the norm.

Rama (2001), Azam (1997), Kertesi and Kollo (2003), Bhorate et al.(2014), and Mayneris et al. (2014) report very large increases in labor productivity in Indonesia, Morocco, Hungary, South Africa, and China (Table C1, Appendix C).[27,28] Mayneris et al. (2014), for example, estimate the elasticity of labor productivity with respect to the MW in China to be .38 for the private sector and .19 for the state sector. By way of comparison, in simulations for our base case, the mean elasticity is approximately .41 across steady states and .20 to .40 in the short/medium run.

5.1.3 Transition Paths and Welfare

We conclude our analysis of these results by examining the transitional dynamics for employment, capital, output and consumption along with the welfare implications of raising the minimum wage. Figures 8 and 9 report the first 50 periods of the transition paths for the MIC and EM calibrations respectively. Consider first the MIC calibration in Figure 8, which displays the transition path for the case analysed in column 2 of Table 3, panel [d]. As per Figure 4, consumption and output jump on impact – reflecting the instantaneous adjustment in effort – before converging on their long-run values as capital stocks adjust. Given the calibrated adjustment costs in capital, the latter converge relatively slowly towards their long-run values (K_1 achieves half its long-run value after approximately 25 periods). The path for employment is highly sensitive to adjustment costs. When these are absent, as shown in the final panel of Figure 8, formal employment substantially overshoots its long-run value (the short-run elasticity is -0.48 compared to the long-run elasticity -0.10) and informal employment undershoots its long-run value. Allowing for small adjustment costs in employment, as shown in the penultimate panel of Figure 8, recognizing these are likely to be substantially higher in the formal sector than the informal sector, generates a more modest degree of overshooting and smoother and more realistic paths for employment.[29]

These patterns are broadly replicated in Figure 9 for the EM calibration, corresponding to column 3 of Table 4, panel [c]. Recall that in this case the low substitutability in consumption between the formal and informal goods means that employment and capital accumulation both increase in the informal sector. In this case, for the same parameterisation of adjustment costs, the degree of overshooting in formal sector employment is substantially reduced and the short-run overshoot of consumption and output witnessed in Figure 8 is eliminated.

[27] Bhorat et al. (2014) also present evidence that an investment boom accompanied the sharp increase in the MW for agricultural workers in South Africa. Mayneris et al. (2014) do not discuss the impact on investment in China; they emphasize, however, that unit labor costs fell and firm profits held up nicely.

[28] Kertesi and Kollo (2003) find the large increase in labor productivity "puzzling." After noting the 57% increase in the real MW was associated with a sudden increase in labor productivity, they remark: "The question of how labor productivity was raised in many hard-hit low-wage enterprises seems a hard nut to crack."

[29] Note that the transition paths displayed for the other variables in Figure 8 are based on the adjustment costs and paths for employment shown in the penultimate panel.

Figures 10 to 13 pick out panels from Tables 3 and 4 to explore how the transition dynamics for employment vary with changes in the calibration of the wage curves and economic structure. Two features emerge. First, except when the elasticity of substitution between formal and informal goods is low (for example Figure 11c and Figure 12), the notion that the formal sector employment elasticity may be greater in the short- to medium-run than in the long-run is quite general: to the extent that much of the empirical literature is concerned with short-run evidence, these results suggest that this evidence may overstate the true long-run formal sector employment effects of MW increases. The second and related feature is that when the elasticity of substitution is low, employment losses in the informal sector may initially exceed those in the formal sector, even though the long run outcome for informal sector employment is more favorable.

Finally turning to welfare considerations, recall the striking result in the simplified model that the MW *always* increases welfare, at least in the simple case of a single representative agent. This result, which does not generalize to the full model (see Section 6), is highly robust in the relevant parameter space considered here.[30] In all 27 runs reported in Tables 3 and 4, the path of consumption is qualitatively similar to the path shown in Figures 8 & 9: aggregate consumption jumps upward at $t = 0$ and then converges smoothly to its steady-state level, closely tracking the path of GDP.

5.1.4 Coherence with empirical estimates revisited

Although we noted the close fidelity of the of our simulated *long run* employment elasticities with the empirical estimates, we need to recognize that the latter tend to be measure short- to medium-term employment effects. A more relevant test of fidelity, therefore,is whether our simulated *short-run* elasticities are consistent with the empirical evidence. Comparing the transition paths with Figure 7 suggests they are: while the over-shooting of employment necessarily means the short-run simulated elasticities are substantially larger, the reported values along the transition paths shown in Figures 8-13, still remain within the range of empirical estimates reported in Figure 7.

Even so, there are a number of reasons why our simulated (long-run and short-run) estimates from our model may still be 'too high' relative to those derived from empirical studies. Three in particular are worth mentioning. First, we assume that coverage of and compliance with MW legislation is complete in the formal/covered sector. Second, our simulations are generated from a starting point where the initial (efficiency) wage in the formal sector is equal to the MW prior to its increase and that firms have optimized employment and output to this MW. Both assumptions will tend to leverage up our simulated elasticities relative to estimates from environments where coverage and compliance is incomplete and wages may initially be substantially below the

[30] To repeat an earlier disclaimer, a representative agent model of the form used here necessarily ignores distributional concerns. Positive results are therefore only suggestive of potential welfare gains.

prevailing MW. Third, the calibrated unemployment elasticities we use in our model wage curves are defined in terms of the aggregate, economy-wide unemployment rate rather than an arguably more salient skill- or sector-specific unemployment rate, with the consequence of weakening the employment effect of minimum wage effects.

6 The Low-Income Country Case

The results in Tables 3 and 4 sit comfortably with the rich evidence from those middle-income developing countries whose MW programs have been studied extensively in the empirical literature (e.g., Brazil, Costa Rica, Honduras, Mexico, Indonesia, and South Africa). By contrast, however, there is very little robust empirical evidence on low-income economies, such as those of Sub-Saharan Africa, and hence nothing with which to discipline the results of solving the full model for a LIC calibration. It is nonetheless of interest to consider the implications of our model for a stylized low-income country where the informal sector is much more dominant and where coverage and compliance of MW regulations is very significantly lower. Table 5 reports a set of runs for a calibration where the informal/non-compliant sector accounts for a large share (65%) of the non-agricultural economy and whose output, arguably, is less substitutable in consumption with output of the formal sector. To reflect the lower substitutability with formal sector output and with imports, we concentrate on runs where $\epsilon_2 = 1, \epsilon_3 = 3$ (panel [b]) and $\epsilon_2 = \epsilon_3 = 1$ (panel [c]), although for comparison with Tables 3 and 4 we retain the $\epsilon_2 = \epsilon_3 = 3$case. Compared to Table 3, the aggregate response and response in the formal sector are significantly attenuated. For $\epsilon_2 = \epsilon_3 = 3$ and the wage curve parameters at their central values (Panel [a], column 2), aggregate output growth collapses from 3.9% to 0.7%, while the contraction in aggregate employment increases from 2.8% to 3.6% between steady states. Outcomes for the formal sector are correspondingly less favorable, with employment elasticities much closer to the high end estimates reported in Figure 7. If we combine these low-income country structural characteristics with a relatively flat wage curve, as in Column 1, employment losses increase even further, to 5.9% for aggregate employment and 5% for the formal sector. And it is here where the kicker comes in: aggregate output and investment stagnates or contracts slightly, with the minimal output gains in the (now relatively small) formal sector failing to offset the contraction in informal sector output. This has an unfortunate corollary. While consumption is continuously higher in the six runs where $g_3/g_1 = 1 - 1.5$ and $b_3 = 2 - 3$, it is short-lived when wage curves are relatively flat. This is shown in Figure 14. After an upward jump at $t = 0$, consumption decreases monotonically, dropping below its initial level at year four. The end result is an equivalent variation welfare loss equal to $.10 - .15\%$ of consumption when the social discount rate is 10% (the private rate) and $.43 - .50\%$ when the discount rate is 5%.[31] If

[31] See Sen (1967) and Feldstein (1964) for cogent arguments why the social time preference rate should be less than the private discount rate.

our LIC calibration is broadly plausible, this suggests that the favorable aggregate effects from MW policies documented for Middle Income and Emerging Market countries are much less likely to emerge in LICs where the formal sector is small and produces goods that are relatively poor substitutes for imports and for informal sector goods and where wage curves are flat.

7 Concluding Remarks

We have shown that a dynamic general equilibrium model with efficiency wages in both the formal and informal sectors can explain the salient features of the empirical evidence on how binding MW regulations affect employment, wages, and output in middle-income and emerging market developing countries. Calibrated to conventional values for structural parameters, to micro-level data for informal firms, and to consensus estimates of sectoral wage curves, the "fully-loaded" model has considerable leverage, generating results for the short- and long-term that are capable of replicating the full range of empirical estimates in the existing literature. Building on this platform, we extend the model to consider the implications for a stylized low-income country and identify the channels through which MW regulations may have distinctly inferior and possibly adverse aggregate output and welfare effects in LICs compared to MICs.

This is, however, only a first pass. There are a number of areas in design and application that require to be addressed in future research. On the modelling side, we have already hinted at modifications, including the explicit treatment of coverage and compliance,[32] that may be required to further strengthen our ability to match the key characteristics of the empirical evidence, but there are some others. These include allowing for efficiency wage effects to operate in the public sector as well as the private sector, and to allow for habit formation or adjustment costs in effort so as to remove the rather unrealistic impact effects we observed on the transition paths. Our priority, however, is to engage more directly with welfare considerations since the results presented here are merely suggestive. They show only that welfare often increases when the MW is slightly above the equilibrium wage in the formal sector, but more importantly they are necessarily silent on distributional concerns. The latter qualification is obviously important. A proper analysis requires welfare comparisons in a more elaborate model with heterogeneous households.

[32] Analysis of the macroeconomic effects of greater enforcement of the MW is another promising area for future work. See Gindling *et al.* (2015) for empirical evidence on the impact of stronger enforcement in Costa Rica and Basu *et al.* (2010) for a detailed micro-theoretic model of how enforcement and the mandated MW interact with credibility and the structure of the labor market.

References

[1] Aigbokhan, B., 2011, "Efficiency Wage, Rent-Sharing Theories and Wage Determination in the Manufacturing Sector in Nigeria." AERC Research Paper 222 (African Economic Research Consortium; Nairobi, Kenya).

[2] Alaniz, E., Gindling, T., and K. Terrell, 2011, "The Impact of Minimum Wages on Wages, Work and Poverty in Nicaragua." Labour Economics 18, S45-S59.

[3] Almeida, R. and K. Terrell, 2008, "Minimum Wages in Developing Countries: Helping or Hurting Workers?" World Bank Employment Policy Primer (Washington, D.C.)

[4] Alatas, V. and L. Cameron, 2003, "The Impact of Minimum Wages on Employment in a Low-Income Country: An Evaluation Using the Difference-in-Differences Approach." Working Paper 2985, Policy Research Department, World Bank (Washington, D.C.).

[5] Andalon, M. and C. Pages, 2009, "Minimum Wages in Kenya." In, eds., R. Kanbur and J. Svegnar, *Labour Markets and Economic Development* (Routledge; Abingdon, U.K.)

[6] Azam, J., 1997, "Efficiency Wage and the Family: An Explanation for the Impact of the Agricultural Minimum Wage in Morocco." Kyklos 50(3), 369-382.

[7] Badaoui, E., Strobl, E.m, and F. Walsh, 2010, "The Formal Sector Wage Premium and Firm Size." Journal of Development Economics 91, 37-47.

[8] Basu, A., Chau, N., and R. Kanbur, 2010, "Turning a Blind Eye: Costly Enforcement, Credible Commitment and Minimum Wage Laws." Economic Journal 120, 244-269.

[9] Bell, L., 1997, "The Impact of Minimum Wages in Mexico and Colombia." Journal of Labor Economics 15, S102-S135.

[10] Berg, J. and D. Contreras, 2004, "Political-Economic Regime and the Wage Curve: Evidence from Chile, 1957-1996." International Review of Applied Economics 18, 151-165.

[11] Betcherman, G., 2014, "Labor Market Regulations: What Do We Know About Their Impacts in Developing Countries?" World Bank Research Observer 30, 124-153.

[12] Bhorat, H., Kanbur, R., and B. Stanwix, 2014, "Estimating the Impact of Minimum Wages on Employment, Wages, and Non-Wage Benefits: The Case of Agriculture in South Africa." American Journal of Agricultural Economics 96(5), 1402-1419.

[13] Bhorat, H., Cassim, A., Kanbur, R., Stanwix, B., and D. Yu, 2016, "Minimum Wages and Youth: The Case of South Africa." Journal of African Economies 25, AERC Supplement 1, i61-i102.

[14] Bhorat, H., Kanbur, R., and B. Stanwix, 2017, "Minimum Wages in Sub-Saharan Africa: A Primer." World Bank Research Observer 32, 21-74.

[15] Blanchflower, D. and A. Oswald, 2005, "The Wage Curve Reloaded." IZA Discussion Paper, No. 1665.

[16] Bosch, M. and W. Maloney, 2007, "Comparative Analysis of Labor Market Dynamics Using Markov Processes: An Application to Informality." IZA Discussion Paper No. 3038 (Institute for the Study of Labor Economics; Bonn, Germany).

[17] Bosch, M. and M. Manacorda, 2010, "Minimum Wages and Earnings Inequality in Urban Mexico." American Economic Journal: Applied Economics 2 (4), 128-149.

[18] Briguglio, L., 1998, "Small Country and Returns to Scale in Manufacturing." World Development 26, 507-515.

[19] Burger, C. and S. Schotte, 2017, "A Structural Approach to Modelling Employment Transitioning in South Africa." Mimeo (University of Stellenbosch, S. Africa; University of Gottingen and German Institute of Global and Area Studies).

[20] Claro, S., 2002, "A Cross-Country Estimation of the Elasticity of Substitution Between Labor and Capital in Manufacturing Industries." Mimeo (Universidad Catolica de Chile).

[21] Collard, F. and D. de la Croix, 2000, "Gift Exchange and the Business Cycle: The Fair Wage Strikes Back." Review of Economic Dynamics 3, 166-193.

[22] Comola, M. and L. de Mello, 2011, "How Does Decentralized Minimum Wage Setting Affect Employment and Informality? The Case of Indonesia." Review of Income and Wealth 57 (Special Issue), S79-S99.

[23] Conradie, B., 2004, "Wages and Wage Elasticities for Wine and Table Grapes in South Africa." Working Paper No. 90, Centre for Social Science Research, University of Cape Town.

[24] Dalgaard, C. and H. Hansen, 2005, "The Return to Foreign Aid." Discussion Paper No. 05-04, Institute of Economics, University of Copenhagen.

[25] Danthine, J. and A. Kurmann, 2004, "Fair Wages in a New Keynesian Model of the Business Cycle." Review of Economic Dynamics 7, 107-142.

[26] Danthine, J. and A. Kurmann, 2010, "The Business Cycle Implications of Reciprocity in Labor Relations." Journal of Monetary Economics 57, 837-850.

[27] Del Carpio, X. and C. Liang, 2013, "The Impacts of Minimum Wages on Employment, Wages and Welfare: The Case of Vietnam." Working Paper, East Asia and Pacific Social Protection and Labor Unit, World Bank (Washington, D.C.).

[28] Del Carpio, X., Nguyen, H., Pabon, L., and L. Wang, 2015, "Do Minimum Wages Affect Employment? Evidence From the Manufacturing Sector in Indonesia." IZA Journal of Labor and Development 4:17, 1-30.

[29] Del Carpio, X., Messina, J., and A. Sans-de-Galdeano, 2019, "Minimum Wage: Does It Improve Welfare in Thailand." Review of Income and Wealth 65, 358-382.

[30] Dinkelman, T. and V. Ranchhod, 2012, "Evidence on the Impact of Minimum Wage Laws in an Informal Sector: Domestic Workers in South Africa. Journal of Development Economics 99 (1), 27-45.

[31] Duffy, J. and C. Papageorgiou, 2000, "A Cross-Country Empirical Investigation of the Aggregate Production Function Specification." Journal of Economic Growth 5, 87-120.

[32] El Hamidi, F. and K. Terrell, 2002, "The Impact of Minimum Wages on Wage Inequality and Employment in the Formal and Informal Sector in Costa Rica." In, R. Freeman, ed., *Inequality Around the World* (International Association Economic Series).

[33] Eslava, M., Haltiwanger, J., Kugler, A., and M. Kugler, 2005, "Employment and Capital Adjustments After Factor Market Deregulation: Panel Evidence from Colombian Plants." Mimeo.

[34] Eyraud, F. and C. Saget, 2005, "The Fundamentls of Minimum Wage Fixing." Mimeo, Internation Labour Office (Geneva, Switzerland).

[35] Falco, P., Kerr, A., Rankin, N., Sandefur, J. and F. Teal, 2011, "The Returns to Formality and Informality in Urban Africa." Labour Economics 18 (Supplement 1), S23-S31.

[36] Fang, T. and C. Lin, 2013, "Minimum Wages and Employment in China." Discussion Paper 7813, Institute for the Study of Labor (Bonn, Germany).

[37] Fajnzylber, P., 2001, "Minimum Wage Effects Throughout the Wage Distribution: Evidence from Brazil's Formal and Informal Sectors." Mimeo, Department of Economics, Universidade Federal de Minas Gerais.

[38] Feldstein, M., 1964, "The Social Time Preference Discount Rate in Cost Benefit Analysis." Economic Journal 74, 360-379.

[39] Feliciano, Z., 1998, "Does the Minimum Wage Affect Employment in Mexico?" Eastern Economic Journal 24(2), 165-180.

[40] Fields, G., 2011, "Labor Market Analysis for Developing Countries." Labour Economics 18, S16-S22.

[41] Gasparini, L. and L. Tornarolli, 2009, "Labor Informality in Latin America and the Caribbean: Patterns and Trends From Household Survey Microdata." Revista Desarrollo y Sociedad 63(1), 13-80.

[42] Gindling, T., 2014, "Does Increasing the Minimum Wage Reduce Poverty in Developing Countries?" IZA Wrold of Labor 30, 1-10.

[43] Gindling, T. and K. Terrell, 2005, "The Effect of Minimum Wages on Actual Wages in Formal and Informal Sectors in Costa Rica." World Development 33 (11), 1905-1921.

[44] Gindling, T. and K. Terrell, 2007, "The Effects of Multiple Minimum Wages Throughout the Labor Market: The Case of Costa Rica." Labour Economics 14, 485-511.

[45] Gindling, T. and K. Terrell, 2009, "Minimum Wages, Wages and Employment in Various Sectors in Honduras." Labour Economics 16, 291-303.

[46] Gindling, T., Mossaud, N. and J. Trejos, 2015, "The Consequences of Increased Enforcement of Legal Minimum Wages in a Developing Country: An Evaluation of the Impact of the Campana Nacional de Salarios Minimos in Costa Rica." ILR Review 68, 666-707.

[47] Goldar, B., Basanta, P. and A. Sharma, 2014, "Elasticity of Substitution Between Capital and Labor in Major Sectors of the Indian Economy." Working Paper No. 335, Institute of Economic Growth (IEG).

[48] Gollin, D., 2002, "Getting Income Shares Right." Journal of Political Economy 110, 458-474.

[49] Gonzaga, G., 2009, "Labor Adjustment Dynamics in Brazilian Manufacturing." Brazilian Review of Econometrics 29, 251-284.

[50] Ham, A., 2018, "The Consequences of Legal Minimum Wages in Honduras." World Development 102, 135-137.

[51] Harrison, A. and J. Scorse, 2010, "Multinationals and Anti-Sweatshop Activism." American Economic Review 100, 247-273.

[52] Heinz, J. and D. Posel, 2008, "Revisiting Informal Employment and Segmentation in the South African Labour Market." South African Journal of Economics 76, 26-44.

[53] Helali, K. and M. Kalai, 2005, Estimate of the Elasticities of the CES and Translog Production Functions in Tunisia." International Journal of Economics and Business Research 9, 245-253.

[54] Hertz, T., 2005, "The Effect of Minimum Wages on the Employment and Earning of South Africa's Domestic Service Workers." Working Paper 05-120, Upjohn Institute (Kalamazoo, MI).

[55] Hohberg, M. and J. Lay, 2015, "The Impact of Minimum Wages on Informal and Formal Labor Market Outcomes." IZA Journal of Labor and Development 4:14, 1-25.

[56] Isham, J. and D. Kaufmann, 1999, "The Forgotten Rationale for Policy Reform: The Productivity of Investment Projects." Quarterly Journal of Economics 114, 149-184.

[57] Islam, I. and S. Nazara, 2000, "Minimum Wage and the Welfare of Indonesian Workers." Occasional Discussion Paper Series No.3, ILO (Jakarta Office).

[58] Jones, P., 1998, "The Impact of the Minimum Wage Legislation in Developing Countries Where Coverage is Incomplete." Working Paper No. WPS 98-2, Centre for the Study of African Economies (University of Oxford).

[59] Karabarbounis, L. and B. Neiman, 2013, "The Global Decline of the Labor Share." NBER Working Paper No. 19136 (National Bureau of Economic Research; Cambridge, MA).

[60] Kertesi, G. and J. Kollo, 2003, "Fighting 'Low Equilibria' by Doubling the Minimum Wage? Hungary's Experiment." IZA Discussion Paper No.\thinspace 970 (Bonn, Germany).

[61] Khamis, M., 2013, "Does the Minimum Wage Have a Higher Impact on the Informal Than on the Formal Labour Market? Evidence From Quasi-Experiments." Applied Economics 45(4), 477-495.

[62] Kingdon, G. and J. Knight, 2004, "Unemployment in South Africa: The Nature of the Beast." World Development 32, 391-408

[63] Kristensen, N. and W. Cunningham, 2006, "Do Minimum Wages in Latin America and the Caribbean Matter? Evidence From 19 Countries." Policy Research Working paper Series 3870, The World Bank.

[64] La Porta, R. and A. Shleifer, 2008, "The Unofficial Economy and Economic Development." Brookings Papers on Economic Activity, Fall, 275-352.

[65] La Porta, R. and A. Shleifer, 2014, "Informality and Development." Journal of Economic Perspectives 28 (Summer), 109-126.

[66] Lathipipat, D. and C. Poggi, 2016, "From Many to One: Minimum Wage Effects in Thailand." Pier Discussion Paper.

[67] Lemos, S., 2004, "Minimum Wage Policy and Employment Effects: Evidence from Brazil." Economia 5, 219-266.

[68] Lemos, S., 2009, "Minimum Wage Effects in a Developing Country." Labour Economics 16(2), 224-237.

[69] Magruder, J., 2013, "Can Minimum Wages Cause a Big Push? Evidence from Indonesia." Journal of Development Economics 100, 48-62.

[70] Marshall, K., 2012, "Factor Payment Shares in a Large Cross-Section of Countries." Mimeo, California Polytechnic State University.

[71] Martinez, R., 2012, "Bayesian MC\$^{2}\$ Estimation of the Capital-Labor Substitution Elasticity in Developing Countries." Mimeo, Unidad de Analisis de Politicas Sociales y Economicas de Bolivia (UDAPE).

[72] Mayneris, F., Poncet, F., and T. Zhang, 2018, "Improving or Disappearing: Firm-level Adjustments to Minimum Wages in China." Journal of Development Economics 135, 20-42.

[73] Merz, M. and E. Yashiv, 2007, "Labor and the Market Value of the Firm." American Economic Review 97, 1419-1431.

[74] Mizobata, H., 2016, "Differing Factor Adjustment Costs Across Industries: Evidence from Japan." Economic Modelling 54, 382-391.

[75] Mumtaz, H. and F. Zanetti, 2015, "Factor Adjustment Costs: A Structural Investigation." Journal of Economic Dynamics and Control 51, 341-355.

[76] Murray, J. and C. van Walbeek, 2007, "Impact of the Sectoral Determination for Farm Workers on the South African Sugar Industry: Case Study of the KwaZulu-Natal North and South Coasts." Agrekon 46(1), 1216-134.

[77] Nataraj, S., Perez-Arce, F., and K. Kumar, 2014, "The Impact of Labor Market Regulation on Employment in Low-Income Countries: A Meta-Analysis." Journal of Economic Surveys 28(3), 551-572.

[78] Nattrass, N. and R. Walker, 2005, "Unemployment and Reservation Wages in Working-Class Cape Town." South African Journal of Economics 73, 498-509.

[79] Neri, M., 2002, "Decent Work and the Informal Sector in Brazil." Ensaios Economicos No.\thinspace 461 (Fundacao Getulio Vargas).

[80] Neri, M., Gonzaga, G., and J. Camargo, 2001, "Minimum Wage, 'Lighthouse Effect' and Poverty." Revista de Economia Politica 21(2), 68-90.

[81] Neumark, D., Cunningham, W., and L. Siga, 2006, "The Effects of the Minimum Wage in Brazil on the Distribution of Family Incomes: 1996-2001." Journal of Development Economics 80 (1), 136-159.

[82] Novales, A., Dominguez, E., Perez, J. and J. Ruiz, 1999, "Solving Nonlinear Rational Expectations Models by Eigenvalue-Eigenvector Decompositions." In, R. Marimon and A. Scott, eds., *Computational Methods for the Study of Dynamic Economies* (Oxford University Press, New York).

[83] Oberfeld, E. and D. Raval, 2014, "Micro Data and Macro Technology." NBER Working Paper No.\thinspace 20452.

[84] Papps, K., 2012, "The Effects of Social Security Taxes and Minimum Wages on Employment: Evidence from Turkey." Industrial and Labor Relations Review 65, 686-707.

[85] Rama, M., 2001, "Consequences of Doubling the Minimum Wage: The Case of Indonesia." Industrial and Labor Relations Review 54 (4) , 864-886.

[86] Rand, J. and N. Torm, 2012, "The Informal Wage Gap Among Vietnamese Micro Firms." Journal of the Asia Pacific Economy 17, 560-577.

[87] Rani, U. and S. Ranjbar, 2015, "Impact of Minimum Wages on Wage Quantiles: Evidence from Developing Countries." Mimeo, Interantional Labour Office and University of Geneva.

[88] Rebitzer, J. and L. Taylor, 1995, "The Consequences of Minimum Wage Laws: Some New Theoretical Ideas." Journal of Public Economics 56, 245-255.

[89] Schaffner, J., 1998, "Premiums to Employment in Larger Establishments: Evidence from Peru." Journal of Development Economics 55, 81-113.

[90] Sen, A., 1967, "Isolation, Assurance and the Social Rate of Discount." Quarterly Journal of Economics 81, 112-124.

[91] Shankar, S. and B. Bhaskara Rao, 2012, "Estimates of the Long-Run Growth Rate of Singapore With a CES Production Function." Applied Economics Letters 19, 1525-1530.

[92] Shapiro, M., 1986, "The Dynamic Demand for Labor and Capital." Quarterly Journal of Economics 101, 513-542.

[93] Shapiro, C. and J. Stiglitz, 1984, "Equilibrium Unemployment as a Worker Discipline Device." American Economic Review 74, 433-444.

[94] Shen, K. and S. Whalley, 2013, "Capital-Labor-Energy Substitution in Nested CES Production Functions for China." NBER Working Paper No.\thinspace 19104.

[95] SMERU Research Institute, 2001, "Wage and Employment Effects of Minimum Wage Policy in the Indonesian Urban Labor Market." SMERU Research Report (Jakarta, Indonesia).

[96] Soderbom, M. and F. Teal, 2004, "Size and Efficiency in African Manufacturing Firms: Evidence from Firm-Level Panel Data." Journal of Development Economics 73, 369-394.

[97] Strobl, E. and F. Walsh, 2003, "Minimum Wage and Compliance: The Case of Trinidad and Tobago." Economic Development and Cultural Change 51 (2), 427-450.

[98] Suryahadi, A., W. Widyanti, D. Perwira, and S. Sumarto, 2003, "Minimum Wage Policy and Its Impact of Employment in the Urban Formal Sector." Bulletin of Indonesian Economic Studies 39 (1), 29-50.

[99] Teal, F., 2014, "Employment Creation, Poverty, and the Structure of the Job Market in Nigeria." CSAE Working Paper WPS/2014-18.

[100] Terrell, K. and R. Almeida, 2008, "Minimum Wages in Developing Countries: Helping or Hurting Workers?" World Bank Employment Policy Primer (December 2008, No.10).

[101] Ulyssea, 2010, "Regulation of Entry, Labor Market Institutions and the Informal Sector." Journal of Development Economics 91, 87-99.

[102] Velenchik, A., 1997, "Government Intervention, Efficiency Wages, and the Employer Size Wage Effect in Zimbabwe." Journal of Development Economics 53, 305-338.

[103] Wang, Y., 2012, "Estimating CES Aggregate Production Functions of China and India." Recent Researches in Business and Economics (City University of Hong Kong).

[104] Wang, J. and M. Gunderson, 2011, "Minimum Wage Impacts in China: Estimates From a Prescribed Research Design, 2000-2007." Contemporary Economic Policy 29(3), 392-406.

[105] World Bank, 2006, "Minimum Wages in Latin America and the Caribbean: The Impact on Employment, Inequality, and Poverty." Office of the Chief Economist.

Appendix A

For small changes,

$$\frac{U - U_o}{C_o^{-1/\tau}} = \int_0^\infty (C - C_o)e^{-\rho t}dt. \tag{A1}$$

Linearizing the private agent's budget constraint gives

$$C - C_o = \rho P_k(K_1 - K_{1,o}) - P_k\dot{K}_1 + Q_1\theta_{L1}\left[\frac{1 - g_3L_1 - g_4}{1 - g_4}(m_1\hat{K}_1 + m_2\hat{P}_1 + \frac{m_5}{\theta_{L1}}\hat{w}_m\right], \tag{A2}$$

where

$$m_1 = \theta_{K1}/m_o,$$

$$m_2 = \sigma_1(1 - \gamma)/m_o,$$

$$m_5 = \frac{\sigma_1\theta_{L1}(g_3L_1 + g_4)}{m_o(1 - g_4)},$$

and we have chosen units to that $P_1 = P = 1$ at the initial steady state.

The envelope theorem tells us that there is no first-order impact on welfare of changes in the capital stock, holding the supply of labor services constant. Hence the sum of the first two terms in (A2) equals zero. Formally, substitute

$$K_1 - K_{1,o} = (K_1^* - K_{1,o})(1 - e^{\lambda t}) \tag{A3}$$

$$\dot{K}_1 = -\lambda(K_1^* - K_{1,o})e^{\lambda t} \tag{A4}$$

into (A2) and then substitute the resulting expression for $C - C_o$ into (A1):

$$\frac{U - U_o}{C_o^{-1/\tau}} = P_k(K_1^* - K_{1,o})\left[\int_0^\infty \rho e^{-\rho t}dt + \int_0^\infty (\lambda - \rho)e^{(\lambda-\rho)t}dt\right]$$

$$+\int_0^\infty Q_1\theta_{L1}\left[\frac{1 - g_3L_1 - g_4}{1 - g_4}(m_1\hat{K}_1 + m_2\hat{P}_1 + \frac{m_5}{\theta_{L1}}\hat{w}_m\right]e^{-\rho t}dt. \tag{A5}$$

The two integrals enclosed by [•] sum to zero. Thus the welfare gain/loss depends only on how the MW affects the present value of the total supply of labor services (e_1L_1):

$$\frac{U - U_o}{C_o^{-1/\tau}} = Q_1\theta_{L1}\int_0^\infty \left[\frac{1 - g_3L_1 - g_4}{1 - g_4}(m_1\hat{K}_1 + m_2\hat{P}_1 + \frac{m_5}{\theta_{L1}}\hat{w}_m\right]e^{-\rho t}dt. \tag{A6}$$

Write the solution for $\hat{P}_1$ in equation (21) as

$$\hat{P}_1 = -\frac{m_3}{V}\hat{K}_1 - \frac{m_5}{V}\hat{w}_m, \tag{21'}$$

where

$$m_3 \equiv \theta_{K1}\left[1 + \frac{\theta_{L1}(1-g_3L_1-g_4)}{m_0(1-g_4)}\right]$$

Substituting for P_1 in (A6) and collecting terms yields

$$\frac{U-U_o}{C_o^{-1/\tau}\hat{w}_m} = Q_1\theta_{L1}\int_0^\infty \left[\frac{1-g_3L_1-g_4}{1-g_4}(m_1 - m_2m_3/V)\frac{\hat{K}_1}{\hat{w}_m}\right. \tag{A7}$$

$$\left. + m_5\left(\frac{1}{\theta_{L1}} - \frac{m_2}{V}\frac{1-g_3L_1-g_4}{1-g_4}\right)\right] e^{-\rho t}dt.$$

Now

$$m_1 - \frac{m_2m_3}{V} = \frac{m_1}{V}[\epsilon C_1/Q_1 - \sigma_1(1-\gamma)],$$

$$m_5\left(\frac{1}{\theta_{L1}} - \frac{m_2}{V}\frac{1-g_3L_1-g_4}{1-g_4}\right) = \frac{m_5}{\theta_{L1}V}\epsilon\frac{C_1}{Q_1}.$$

So the solution in (A7) may be rewritten as

$$\frac{U-U_o}{C_o^{-1/\tau}\hat{w}_m} = \frac{Q_1\theta_{L1}(1-g_3L_1-g_4)}{(1-g_4)V}\frac{m_1}{K_1}[\epsilon C_1/Q_1 - \sigma_1(1-\gamma)]\int_0^\infty (K_1^* - K_{1,o})(1-e^{\lambda t})e^{-\rho t}dt$$

$$+\frac{Q_1m_5}{V}\epsilon\frac{C_1}{Q_1}\int_0^\infty e^{-\rho t}dt. \tag{A8}$$

$(U-U_o)/C_o^{-1/\tau}$ is the welfare gain measured in units of consumption. To express the equivalent variation (EV) gain as a percentage of consumption, multiply by ρ/C. Doing this and substituting for $m_1$and $m_5$produces the solution stated in equation (41) in the text:

$$EV = \frac{(1-g_3L_1-g_4)\theta_{K1}\gamma}{m_o(1-g_4)V}(\epsilon-\epsilon^*)\underbrace{\frac{K_1^*-K_{1,o}}{K_{1,o}}}_{\text{Sign of } \epsilon\text{-}\epsilon^*}\frac{\lambda\rho}{\lambda-\rho} + \underbrace{\frac{\epsilon\gamma\sigma_1\theta_{L1}(g_3L_1+g_4)}{m_o(1-g_4)V}}_{\text{Direct effect of } w_m \uparrow}. \tag{69}$$

Appendix B

Wage Curves and Unemployment

Study, Country	Elasticity of the real wage with respect to the unemployment rate
Berg and Contreras, 2004. Chile, Greater Santiago Area, 1974-1996.	Aggregate = -.076 University education = -.08, No university education = -.11 Formal Sector = -.08, Informal Sector = -.03 (insignificant) Estimate for informal sector is restricted to self-employed workers.
Baltagi et al., 2012. Turkey, 2005-2009. Excludes agricultural workers.	Aggregate = -.105 Formal Sector = -.069, Informal Sector = -.264 High Education: Aggregate = -.089, Formal = -.073, Informal = -.139 Low Education: Aggregate = -.098, Formal = -.037, Informal = -.288
Ramos et al., 2009. Colombia, 2002-2006. Covers 13 metropolitan areas and 45.2% of the population.	Aggregate = -.071 Formal Sector = -.060 (insignificant), Informal Sector = -.179
Bucheli and Gonzalez, 2007. Uruguay, 1991-2005. National sample, but under-coverage of agriculture.	Aggregate (private sector) = -.132 Formal Sector = -.058, Informal Sector = -.241 Education: 0-8 years = -.158; 9-11 = -.144; 12+ = -.04 (insignificant)
Lugo, 2006. Chile, 1992-2002. Sample covers only the urban sector.	Aggregate (private sector): Male = -.039, Female = -.048 Formal: Male = -.031, Female = -.040 Informal: Male = -.040, Female = -.057 High Education: Male = 0, -.045, Female = insignificant

Study, Country	**Elasticity of the real wage with respect to the unemployment rate**
Alcaraz, 2009. Mexico, 1995-2001	Formal Sector = 0, Informal Sector = -.138.
Arango et al., 2010. Colombia, different data sources for 2001-2009.	Local (city) unemployment rate: -.009 to -.167; cell mean = 0 to -.103 Group unemployment rate: -.086 to - .108; cell mean = -.044 to -.097
Garcia and Granados, 2005. Chile? Three different national surveys for 1990-2003.	Regional unemployment rate: -.04 Sectoral unemployment rate: -.13.
Hoddinott, 1996. Cote d'Ivoire, 1985-1987, males in urban areas.	Aggregate = -.119 Education: Primary or less = -.215, More than primary = -.111 Professional = 0, Non-professional = -.127
Ilkaracan et al., 2003 Turkey, firms with 10+ employees.	Aggregate private sector = -.135 Primary education or less = -.23 Primary-high school education = -.172 College graduates = -.029 (insignificant) Non-agricultural labor = -.15-.43
Kingdon and Knight, 1999 S. Africa, 1993	All workers = -.108 Private sector = -.141 at mean unemployment rate; Urban = -.135 (evaluated at mean unemployment rate) Rural = -.122 (evaluated at mean unemployment rate)

Study, Country	**Elasticity of the real wage with respect to the unemployment rate**
Mudiriza and Edwards, 2018 S. Africa, 2011	Aggregate = -.091 Private sector = -.052
Von Fintel (2015) S. Africa, 2000-2004	Close to zero in the short run and approximately -.1 in the long run
Baltagi et al., 2017 Brazil, 2002-2009	Aggregate = -.107 Formal = -.039 (insig), Informal = -.246 Age 15-29 = -.154, Age 30-44 = -.030 (insig) Tenure < 1 = -.180, 1 < Tenure < 5 = -.137, Tenure > 5 = insig Low skill = -.048 (insig), Medium skill = -.110
Castro (2006) Mexico, urban workers, 1993-2002	Aggregate = -.037, -.039 Male Female Private Sector -.039 -.048 Formal Sector -.031 -.040 Informal Sector -.058 -.057 High education -.045 insig Low education -.044, -.065 -.041, -.057 Age < 26 -.063, -.068 -.063, -.070 Age 26-45 -.017, -.067 -.023, -.031

Study, Country	Elasticity of the real wage with respect to the unemployment rate
Lopez and Mendoza (2017) Mexico, manufacturing sector, 2007-2015	Aggregate = -.023, -.045 Period of greater stability (07/2009 – 12/2015) = -.092, -.131
Galiani (1999) Argentina, urban areas, 1990-1997	Aggregate: short run = -.04, long run = -.082 Males: short run = -.057, long run = -.119
Galindo and Catalan (2010) Mexico, 1989-2008	Aggregate = -.032
Baltagi et al. (2012) Turkey, 2005-2008	Aggregate = -.099 Young (< 34) = -.108 (-.243), Old = -.081 (-.177) Male = -.069, Female = -.237 Urban = -.101, Rural = -.105 (insig) Tenure: Low (< 6.9 years) = -.175 (-.309), High = -.011 (insig) Education: Low (< 8 years) = -.086 (-.632), High = -.067 (-.088, insig) Note: Figures in parentheses are for women.
Wu (2004) China, urban youth, 1989-1999	Aggregate = -.224
Park and Shin (2008) Korea, 1998-2002	Aggregate = -.075, -.098

Appendix C

Minimum Wage Studies and Episodes

Notation: F = formal sector; I = informal sector; EE = employment elasticity; Overall = combined effect in formal and informal sectors; LE = lighthouse effect. Unless otherwise noted, employment elasticities are negative in the formal sector.

Study/Country	Employment	Real Wages and Productivity
Bhorat et al. (2016), S. Africa.	F: Small *positive* effect in retail and taxi sectors. I: Small *negative* effect in agriculture. No significant effect in the other three sectors. Significant decrease in hours in agriculture (I), but longer hours in the taxi industry (F). Overall: No significant impact.	F: increases 11% (retail). Alternative estimate = 26.3%. I: Increases 11.3-14.6% (agriculture, domestic workers). Alternative estimate = 15.8-58.2%. LE: Yes.
Bell (1997). Colombia.	F: EE = .15-.33 for unskilled labor and .55-1.22 for target group (firms where the wage is ≤ 1.5 MW).	MW has a stronger impact the wage in I than F. LE: Yes.
Gindling and Terrell (2009). Honduras, 1990-2004.	F: EE = .46-.55 in the short run and 1.22 in the long run. I: Positive EE; range = .39-.51.[1] Overall: Elasticity of unemployment = .96 for fixed effects, but insignificant for 2SLS and GMM.	I: No effect (small, insignificant coefficients) on wage workers or the self-employed. LE: Unclear.

Study/Country	Employment	Real Wages and Productivity
Lemos (2009). Brazil, 1982-2004.	No discernable impact on employment in F or I (including self-employment in I).	Strong evidence from kernel densities that MW affects wages in the both F and I. LE: Yes.
Gindling and Terrell (2007). Costa Rica, 1988-2000.	F: EE = .11-.55. (F = all salaried employees in the private sector.)	Evidence of LE in kernel densities. LE: Yes.
Ham (2018). Honduras, 2006-2012.	F: EE = .8-1. (F = the *covered* sector — all salaried employees in the private sector .) I: Positive EE = .5-.7 (I = only employers, self-employed workers, and unpaid family members.) Overall: -.10.	NA
Andalon and Pages (2008). Kenya, 1998-1999.	F: .11-.55 I: Positive EE for self-employed ranges from .27 to .59; no significant effect on employment of salaried workers.	Strong effect on average real wage in non-agriculture. Elasticity with respect to the MW equals 1.02. No separate data for F and I. LE: Probably.
Rama (2001). Indonesia, 1988-1994.	F: Estimates suggest *positive* impact, but effects are not statistically significant. I (small manufacturing): Average of three EE = -.96; highest EE = -1.30. Overall: Small negative, statistically insignificant effect.	95% increase in real MW that increased average real wages 5-15% was associated with an increase in labor productivity of 14.4-22.6%. The increase in labor productivity in small-firm manufacturing was 38.7%. LE: NA.

Study/Country	Employment	Real Wages and Productivity
Kertesi and Kollo (2003). Hungary, 2001-2002.	F: No evidence of effect at large firms. I: Significant decrease in employment (3% in first year); EE with respect to the weighted average real wage ranges from -.27 to -.32.	MW enforced across all firm sizes. Widespread compliance. 57% increase in the real MW in 2001. Large increase in labor productivity in the small firm sector. No direct evidence for large firms. Aggregate labor productivity increased ≈ 7%. LE: Unclear (MW enforced across all firms.)
Jones (1998). Ghana, 1970-1991.	I: No effect of private sector MW. Total: *Positive* EE = .53; probably captures mainly the large firm response.	Kernel densities suggest a significant positive effect of MW in I. LE: Yes.
Azam (1997). Morocco, 1978-1991, agricultural MW.	NA	Strong positive effect on agricultural output. Elasticity on output with respect to the real MW = 1.18 for the largest crop (barley).
Gindling and Terrell (2005). Costa Rica, 1988-1999.	NA	Impact of MW much stronger in I than F. Reflects the bigger bite of MW in I. Elasticities of average wage with respect to MW: Urban F = .108; Urban I = .152; Rural F = .164; Rural I = .398. No impact on wages of the self-employed (not covered by MW). LE: Yes.
Strobl and Walsh (2003). Trinidad and Tobago, 1996-1998.	Total: Probability of job loss for those directly affected by the MW = 9% for males; statistically insignificant for females.	I (small firms): No effect for males; some evidence of a positive effect for females. LE: Unclear.

Study/Country	Employment	Real Wages and Productivity
Dinkelman and Ranchbod (2012). S. Africa, 2001-2004, domestic workers	No statistically significant effect on employment on either the intensive or extensive margins.	Despite no monitoring or active enforcement of the MW in this part of the informal sector, wages increased 19-22%. Work conditions also improved. LE: Yes.
Bosch and Manacorda (2010). Mexico, 1989-2001.	NA	F: Kernel densities show pronounced spikes at exact multiples and fractions of the MW. I: No discernible impact. LE: Yes for the formal sector; No for the informal sector.
Neumark et al. (2006). Brazil, 1996-2001, six largest metropolitan areas.	Total: EE = .07 for total employment (not the target group most directly affected by the MW).	I: Strong evidence that the MW serves as a reference wage; 11.4% of informal workers paid exactly the MW. Total: One dollar increase in MW increases the average wage 43 cents. LE: Yes.
Suryahadi et al. (2003). Indonesia, 1988-1999.	Urban F: EE = .112 for all workers, .196 for less-educated workers, and .140 for blue-collar workers.	NA
Comola and De Mello (2011). Indonesia, 1996-2004.	F: Employment decreases. I: Employment increases. Total: Employment increases.	I: Positive significant effect on earnings. LE: Yes.

Study/Country	Employment	Real Wages and Productivity
Murray and van Walbeek (2007). S. Africa, 2005, large sugar farms	F: No layoffs but total work hours reduced 10.1% in response to the MW introduced in agriculture in 2002.	NA
Khamis (2013). Argentina, 1993 and 2004.	NA	MW bites more and increases wages more in I than in F. Strong statistically significant effect. LE: Yes.
Conradie (2004). S. Africa, grape industry.	EE = .3-.6	NA
Kristensen and Cunningham (2006). 19 countries in Latin America and the Caribbean, 1998-2012.	NA	Kernel densities indicate the MW affects the wage distribution in I in 14 of 19 countries. Impact is stronger than in F. Numeraire effect suggested by spikes at exact multiples of the MW. LE: Yes.
Feliciano (1998). Mexico, 1970-1990.	Large decreases in the real MW had no effect on male employment, including employment of young males. EE = .43-1.25 for female employment, but the effect disappears when four states (out of 32) are excluded.	NA
Wang and Gunderson (2011). China, 2000-2007, rural migrants (target group).	Considerable heterogeneity. No effect in the eastern or western provinces. EE = -1.02 in central provinces. (Results for non-state enterprises.)	NA

Study/Country	Employment	Real Wages and Productivity
Rani and Ranjbar (2015). Brazil, India, Indonesia, S. Africa, and Mexico, 2005-2010.	NA	MW strong affects the wage distribution in all countries. In Brazil, Mexico, and India the impact in I is stronger than in F. Elasticity of real wage in I with respect to the effective MW (log of Kaitz index) at 20^{th} and 40^{th} quantiles in 2009-2010: .79, .64 in Brazil; .46, .48 in India; .82, .92 in Indonesia; .74, .66 in Mexico; .82, .82 in S. Africa. LE: Yes.
Nataraj et al. (2014). Survey and meta-regression analysis of nine studies of the impact of MW on F and I sector employment.	F: Meta-regression concludes that EE = .078. Based on only four studies. I: Share of total employment increases (four studies). Impact on self-employed is uncertain.	NA
Fang and Lin (2013). China, 2004-2009,	Young adults: EE = .156-.244. At-risk group: EE = .265-.553. Total: EE = .073-.086.	NA
Lemos (2004). Brazil, 1982-2000, six largest metropolitan areas, total public and private employment.	No significant effect on employment. If anything, the estimates suggest a positive effect (Table 40. Maximum possible EE = .16 in the short run and .05 in the long run. Adjustment occurs almost entirely through hours worked.	Strong evidence in kernel densities and estimated wage equations that the MW strongly compresses the wage distribution. Impact on F-sector wage is 2-3 times larger than the impact on I-sector wage. LE: Yes.

Study/Country	Employment	Real Wages and Productivity
Fajnzylber (2001). Brazil, 1982-1997, panel data for six major metropolitan areas.	F: EE = .16 for workers earning < 90% of the MW and .09 for those earning 90-110% of the MW. I, salaried: .35 for workers earning <90% of the MW and .25 for those earning 90-110% of the MW. Self-employed: .34 for workers earning <90% of the MW and .29 for those earning 90-110% of the MW.	Strong effects of the MW on the entire wage distribution in both the F and I sectors. Elasticity of real wage with respect to the real MW in F = 1.43 for workers earning 50-90% of the MW; 1.08 for workers earning 90-110% of the MW; and .89 for workers earning 110-150% of the MW. Corresponding elasticities = 1.18, 1.03, and .82 I-salaried and 1.18, 1.32, and .77 for self-employed workers. LE: Yes.
Hertz (2005). S. Africa, 2001-2004, domestic workers.	Significant disemployment effects. Average (median) EE = .42 (.46) for women and .48 (.33) for men. Employment losses greater in areas with a larger fraction of workers initially earning less than the new MW	Despite high levels of noncompliance, real wages increase 6.6-12.3% for men and 19-21.5%, for women. Larger increases seen in areas with a larger fraction of workers initially earning less than the new MW.
Alatas and Cameron (2003). Indonesia, 1990-1996, production workers in clothing, textiles, footwear and leather industries (formal sector).	No impact on employment at large firms. Baseline difference-in-differences estimate gives an average EE = .163 for small firms in 1990-1991. But estimates are statistically insignificant in sensitivity tests that utilize alternative control groups.	NA
SMERU (2001). Indonesia, urban formal sector, 1988-1999.	Baseline estimate of EE = .11 for all workers, .31 for youths and women, .20 for less-educated workers, and .14 for blue-collar workers. EE remain negative in sensitivity tests, but most become statistically insignificant.	NA

Study/Country	Employment	Real Wages and Productivity
Islam and Nazara (2000). Indonesia, 1990-1998.	With no controls, *positive* EEs of .136 for all employment and .395 for paid workers. With pre-crisis and area dummies and regional GDP as controls, EE = -.097.	NA
Del Carpio et al. (2013). Vietnam, 2006-2010.	F: *Positive* EE = .737. I: EE = 1.055. Total: EE = -.293.	Strong positive effect on the average real wage in combined F and I sectors; elasticity of real wage with respect to the real MW = .482. LE: Unclear (no separate estimate for I).
Mayneris et al. (2018). China, 2003-2005, industrial sector.	No impact.	Higher MW was binding. Elasticity of the average real wage with respect to the real MW = .361. Large increases in labor productivity. Elasticity of labor productivity with respect to the MW = .38 for private firms; elasticity of labor productivity was half as large in the state sector. Labor productivity increased 8.4% vs. average real wage increase of 7.9%. No decrease in firm profitability.
Gindling et al. (2015). Costa Rica, 2011-2012.	No evidence that an effective campaign to enforce the MW at small and medium-sized firms reduced full-time employment. Some weak evidence that part-time employment decreased.	No evidence of adverse an effect on GDP growth.

Study/Country	Employment	Real Wages and Productivity
Alaniz et al., 2011. Nicaragua, 1998-2006.	EE for large firms = -.615 (-1.197 for workers earning within 20% of the MW). Total EE = -.310 (-.522 for workers earning within 20% of the MW). No significant effect on employment at small firms.	Significant positive effect on wages at both large and small firms. (Compliance much lower at small firms.) For workers earning within 20% of the MW, the wage increase at small firms was 55-68% as large as at large firms. LE: Yes.
Bhorat et al., 2014. S. Africa, agricultural sector, 2001-2007.	MW increased farm workers 30% relative to control group. Employment decreased 13-18%, with an increase in full-time employment and large losses in part-time employment.[2]	Large increase in labor productivity: output growth stays on trend despite the large decrease in employment. Investment boom following the introduction of the agricultural MW.
Pappas, 2012. Turkey, 2002-2005.	F: EE = 0, -.26 I: No statistically significant effect.	High degree of compliance with MW, but no data reported for wages in the informal sector.
Lathinipat and Poggi (2016). Thailand, 2002-2013.	Employment losses concentrated among micro firms and small and medium enterprises. Six quarters out, EE = -.523 at micro firms and -.472 at small and medium enterprises. EE increases at large firms (EE = .287). Total EE = -.273 for working-age population and -.688 for low-skill youth, six quarters out.	Strong evidence of lighthouse effect. Elasticity of wage with respect to the MW equals .45-.55 at 15th - 25th percentile, .38-.47 at 30th - 35th percentile, and .32-.34 at 40th - 45th percentile of the wage distribution.

Study/Country	Employment	Real Wages and Productivity
Magruder, 2013. Indonesia, 1993-2000	EE *positive* .10 for full-time wage work. Mean EE *positive* .206 for large firms and -.437 for small firms. Nationally representative sample. Manufacturing census: strong positive effect on employment at registered firms and large negative effect on employment in unregistered firms.	NA
Del Carpio et al., 2019. Thailand, 2001-2011.	EE = .064. Adjusted for the limited bite of the MW, EE= .174. Employment losses concentrated among the less educated. No evidence that employment increased in the uncovered sector (self-employed and unpaid workers in family businesses).	NA
Del Carpio et al., 2015. Indonesia, 1993-2006.	EE = .034-.047 for production workers and .055-.062 for non-production workers. Employment losses concentrated among "small" firms (< 150 employees). No effect at large firms. EE greatest for the likely target groups. EE = .086 for production workers with primary education and .20 for those with junior/senior high school education. Corresponding EE for non-production workers = .29 and .155. Adjusting for limited bite of the MW, EE = .23-.31 for production workers.	NA

Study/Country	Employment	Real Wages and Productivity
Harrison and Scorse, 2010. Indonesia, manufacturing sector, 1990-1996.	EE = .123 - .179 for production workers. Employment losses larger at small firms: EE = .116 at large firms. Adjusting for limited bite of the MW, EE = .18-.27.	LE: Probably; elasticity of real wage for production workers with respect to the real MW at in textiles, footwear and apparel = 1 at large firms and .69 at small firms (more likely part of the informal, noncompliant sector).
Hobberg and Lay, 2015. Indonesia, 1997-2007.	Positive impact of MW on probability of employment in the formal sector and negative impact on probability of employment in the informal sector (self-employed and unpaid family workers).	LE: Weak evidence of an effect. Kernel density plots suggest an effect while estimates of the elasticity of the informal wage with respect to the MW are positive but not statistically significant.

[1] The authors caution that, due to the limitations of the data and a weak identification strategy, the positive EE is not strong evidence of an indirect of the MW on employment in the informal sector.

[2] The 13-18% figure is our estimate based on data in the paper.

Table 1: Calibration of the Model.

Parameter/Variable	Value in Base Case
Depreciation rate (δ)	.05
Intertemporal elasticity of substitution (τ)	.5
Urban unemployment rate (u)	.10
Cost share of capital in the formal sector (θ_{K1})	.40
Cost share of production labor in the formal sector (θ_{L1})[1]	.48
Pure time preference rate (ρ)	.10
Elasticity of substitution between capital and labor (σ_1, σ_2)	.75
q-elasticity of investment spending (Ω)	2
Adjustment costs to changing employment (ν_3, ν_4)	$\nu_4 = .5\nu_1 P_k K_1/P_1$, $\nu_3 = .1\nu_4$
Firm-size wage premium [$g_4/(1- g_4)$]	.25
Formal sector wage premium ($\psi = w_1/w_2$)	1.5
Consumption shares (γ_1, γ_2, γ_m)	$\gamma_1 = .56$, $\gamma_2 = .30$, $\gamma_m = .14$
Elasticity of substitution in consumption between the composite formal good and the informal good (ε_2)	.5-5
Elasticity of substitution between imported consumer goods and the formal good (ε_3)	3-10
Cost share of the formal/informal good in production of investment goods (α_1, α_2)	$\alpha_1 = .56$, $\alpha_2 = .30$
Lighthouse effect (b_2)	1
Real wage flexibility in the formal sector [$g_3/(1 - g_4)$]	1
Real wage flexibility in the informal sector (b_3)	2
Cost share of capital in the informal sector (θ_{K2})	.25
Cost share of labor in the informal sector (θ_{L2})	.50
Cost share of entrepreneurial talent in the informal sector (θ_H)	.25

[1] The cost shares for capital and production labor satisfy the adding-up constraint $\theta_{K1} + \theta_{L1}/(1 - g_4) = 1$. This and the value of g_4 backed out from the size premium imply $\theta_{L1} = .48$ and a cost share of .12 for managerial/supervisory labor

Table 2

Labour Share in value added [c]	Mean	Median	Std. dev	Max	Min
(Reported labour costs) / VA [a]	0.238	0.244	0.129	0.548	0.081
(Avg.wage*emp)/VA [b]	0.426	0.118	0.118	0.702	0.119
Labour Share in value added – trimmed [c]	Mean	Median	Std. dev	Max	Min
(Reported labour costs) / VA	0.494	0..482	0.093	0.706	0.354
(Avg.wage*emp)/VA	0.488	0.481	0.087	0.702	0.363

Employment	Mean	Median	Std. dev	Max	Min
Paid Employees	2.8	2.0	2.3	10.5	0.7
Unpaid Employees	0.7	0.7	0.5	1.6	0.0
Family	0.8	0.8	0.4	2.2	0.4

Source: Cross sectional means from 19 World Bank Informal Firms Survey (see Note 23)
Notes: [a] Total self-reported labour costs as a share of derived value added; **[b]** Average reported wage time total employment (including family members); **[c]** Labour share initially calculated excluding firms where measured labour share in excess of 1; trimmed calculation excludes firms with calculated labour share less than 0.15.

Table 3: Long-run outcome, MIC calibration.

	Panel [a] $\varepsilon_2 = \varepsilon_3 = 3$		
	$g_3/g_1 = .5$, $b_3 = 1$	$g_3/g_1 = 1$, $b_3 = 2$	$g_3/g_1 = 1.5$, $b_3 = 3$
w_2/P	5.6	4.6	4.1
L_1	-3.3	-1.9	-1.3
L_2	-6.0	-3.9	-3.0
$L_1 + L_2$	-4.5	-2.8	-2.0
K_1	4.6	6.1	6.8
K_2	-2.0	-.7	-.1
Q_1	5.6	7.2	7.9
Q_2	-3.3	-2.1	-1.5
GDP	2.4	3.9	4.6
	Panel [b] $\varepsilon_2 = 1.5$ and $\varepsilon_3 = 3$		
	$g_3/g_1 = .5$, $b_3 = 1$	$g_3/g_1 = 1$, $b_3 = 2$	$g_3/g_1 = 1.5$, $b_3 = 3$
w_2/P	5.7	4.6	4.1
L_1	-4.8	-3.4	-2.8
L_2	-4.1	-2.1	-1.1
$L_1 + L_2$	-4.5	-2.8	-2.0
K_1	3.0	4.5	5.2
K_2	0	1.3	1.9
Q_1	4.1	5.7	6.4
Q_2	-2.1	-.7	-.1
GDP	2.0	3.5	4.2
	Panel [c] $\varepsilon_2 = 5$ and $\varepsilon_3 = 10$		
	$g_3/g_1 = .5$, $b_3 = 1$	$g_3/g_1 = 1$, $b_3 = 2$	$g_3/g_1 = 1.5$, $b_3 = 3$
w_2/P	6.0	5.1	4.8
L_1	-1.0	.4	1.1
L_2	-7.7	-6.0	-5.2
$L_1 + L_2$	-4.1	-2.5	-1.8
K_1	7.0	8.5	9.2
K_2	-3.6	-2.4	-1.9
Q_1	7.7	9.3	10.0
Q_2	-4.9	-3.7	-3.1
GDP	3.3	4.8	5.4

Table 3 (cont).

	Panel [d] $\varepsilon_2 = 3$ and $\varepsilon_3 = 10$		
	$g_3/g_1 = .5$, $b_3 = 1$	$g_3/g_1 = 1$, $b_3 = 2$	$g_3/g_1 = 1.5$, $b_3 = 3$
w_2/P	6.0	5.1	4.7
L_1	-2.5	-1.0	-.4
L_2	-6.2	-4.4	-3.6
$L_1 + L_2$	-4.1	-2.5	-1.8
K_1	5.5	7.0	7.7
K_2	-2.0	-.8	-.2
Q_1	6.3	7.9	8.6
Q_2	-3.6	-2.4	-1.9
GDP	2.9	4.3	5.0
	Panel [e] $\varepsilon_2 = 1$ and $\varepsilon_3 = 10$		
	$g_3/g_1 = .5$, $b_3 = 1$	$g_3/g_1 = 1$, $b_3 = 2$	$g_3/g_1 = 1.5$, $b_3 = 3$
w_2/P	5.9	5.0	4.6
L_1	-5.2	-3.7	-3.1
L_2	-3.1	-1.2	-.4
$L_1 + L_2$	-4.2	-2.6	-1.9
K_1	2.5	4.1	4.8
K_2	1.2	2.4	3.0
Q_1	3.7	5.3	6.0
Q_2	-1.3	0	.5
GDP	2.0	3.5	4.1
	Panel [f] $\varepsilon_2 = .5$ and $\varepsilon_3 = 10$		
	$g_3/g_1 = .5$, $b_3 = 1$	$g_3/g_1 = 1$, $b_3 = 2$	$g_3/g_1 = 1.5$, $b_3 = 3$
w_2/P	5.9	4.9	4.5
L_1	-6.3	-4.9	-4.2
L_2	-1.8	.1	.9
$L_1 + L_2$	-4.3	-2.6	-1.9
K_1	1.3	2.9	3.6
K_2	2.5	3.8	4.3
Q_1	2.6	4.2	4.9
Q_2	-.3	1.0	1.5
GDP	1.6	3.1	3.7

Table 4: Long-run outcome, HIC/EME calibration.

	Panel [a] $\varepsilon_2 = \varepsilon_3 = 3$		
	$g_3/g_1 = .5, b_3 = 1$	$g_3/g_1 = 1, b_3 = 2$	$g_3/g_1 = 1.5, b_3 = 3$
w_2/P	6.6	5.7	5.3
L_1	-2.4	-1.3	-.8
L_2	-6.2	-4.5	-3.8
$L_1 + L_2$	-3.5	-2.2	-1.6
K_1	5.5	6.7	7.3
K_2	-1.6	-.5	0
Q_1	6.2	7.5	8.1
Q_2	3.5	-2.4	-1.9
GDP	4.3	5.5	6.1
	Panel[b] $\varepsilon_2 = 3$ and $\varepsilon_3 = 10$		
	$g_3/g_1 = .5, b_3 = 1$	$g_3/g_1 = 1, b_3 = 2$	$g_3/g_1 = 1.5, b_3 = 3$
w_2/P	7.1	6.4	6.1
L_1	-1.7	-.6	-.1
L_2	-6.5	-5.2	-4.6
$L_1 + L_2$	-3.0	-1.9	-1.3
K_1	6.3	7.4	8.0
K_2	-1.6	-.7	-.2
Q_1	6.8	8.0	8.6
Q_2	-3.7	-2.8	-2.4
GDP	4.8	5.9	6.4
	Panel [c] $\varepsilon_2 = .5$ and $\varepsilon_3 = 10$		
	$g_3/g_1 = .5, b_3 = 1$	$g_3/g_1 = 1, b_3 = 2$	$g_3/g_1 = 1.5, b_3 = 3$
w_2/P	6.9	6.2	5.9
L_1	-4.2	-3.1	-2.6
L_2	-.4	1.1	1.8
$L_1 + L_2$	-3.2	-2.0	-1.4
K_1	3.5	4.7	5.3
K_2	4.7	5.8	6.2
Q_1	4.4	5.6	6.2
Q_2	1.0	2.0	2.4
GDP	3.7	4.9	5.4

Table 5: Long-run outcome, LIC calibration.

	Panel [a] $\varepsilon_2 = \varepsilon_3 = 3$		
	$g_3/g_1 = .5, b_3 = 1$	$g_3/g_1 = 1, b_3 = 2$	$g_3/g_1 = 1.5, b_3 = 3$
w_2/P	4.4	3.1	2.5
L_1	-5.0	-3.4	-2.7
L_2	-6.1	-3.7	-2.6
$L_1 + L_2$	-5.9	-3.6	-2.6
K_1	2.8	4.5	5.3
K_2	-3.1	-1.5	-.8
Q_1	4.2	6.1	6.9
Q_2	-3.9	-2.2	-1.5
GDP	-1.1	.7	1.4
	Panel [b] $\varepsilon_2 = 1, \varepsilon_3 = 3$		
	$g_3/g_1 = .5, b_3 = 1$	$g_3/g_1 = 1, b_3 = 2$	$g_3/g_1 = 1.5, b_3 = 3$
w_2/P	4.5	3.3	2.7
L_1	-8.3	-6.6	-5.8
L_2	-4.8	-2.5	-1.4
$L_1 + L_2$	-5.7	-3.5	-2.5
K_1	-.7	1.1	2.0
K_2	-1.6	-.1	.5
Q_1	1.0	3.0	3.8
Q_2	-2.8	-1.3	-.6
GDP	-1.5	.2	1.0
	Panel [c] $\varepsilon_2 = 1$ and $\varepsilon_3 = 1$		
	$g_3/g_1 = .5, b_3 = 1$	$g_3/g_1 = 1, b_3 = 2$	$g_3/g_1 = 1.5, b_3 = 3$
w_2/P	4.4	2.9	2.3
L_1	-8.6	-7.3	-6.8
L_2	-4.8	-2.4	-1.3
$L_1 + L_2$	-5.8	-3.7	-2.7
K_1	-1.0	.3	1.0
K_2	-1.7	-.3	.4
Q_1	.7	2.3	3.0
Q_2	-2.8	-1.3	-.6
GDP	-1.6	0	.6

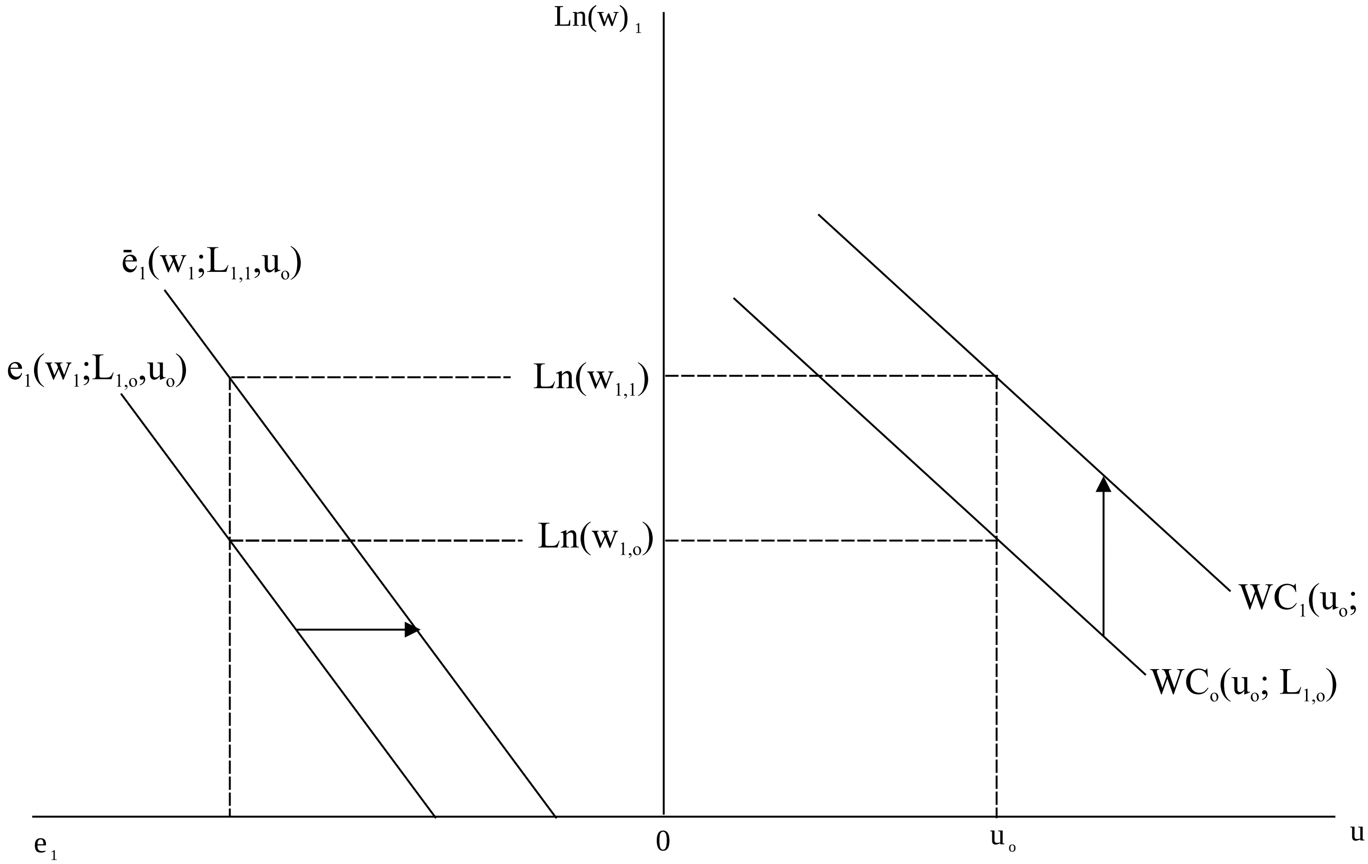


Figure 1: Impact of higher employment on the wage curve.
($P_1 = P = 1$, so w_1 equals the real wage.)

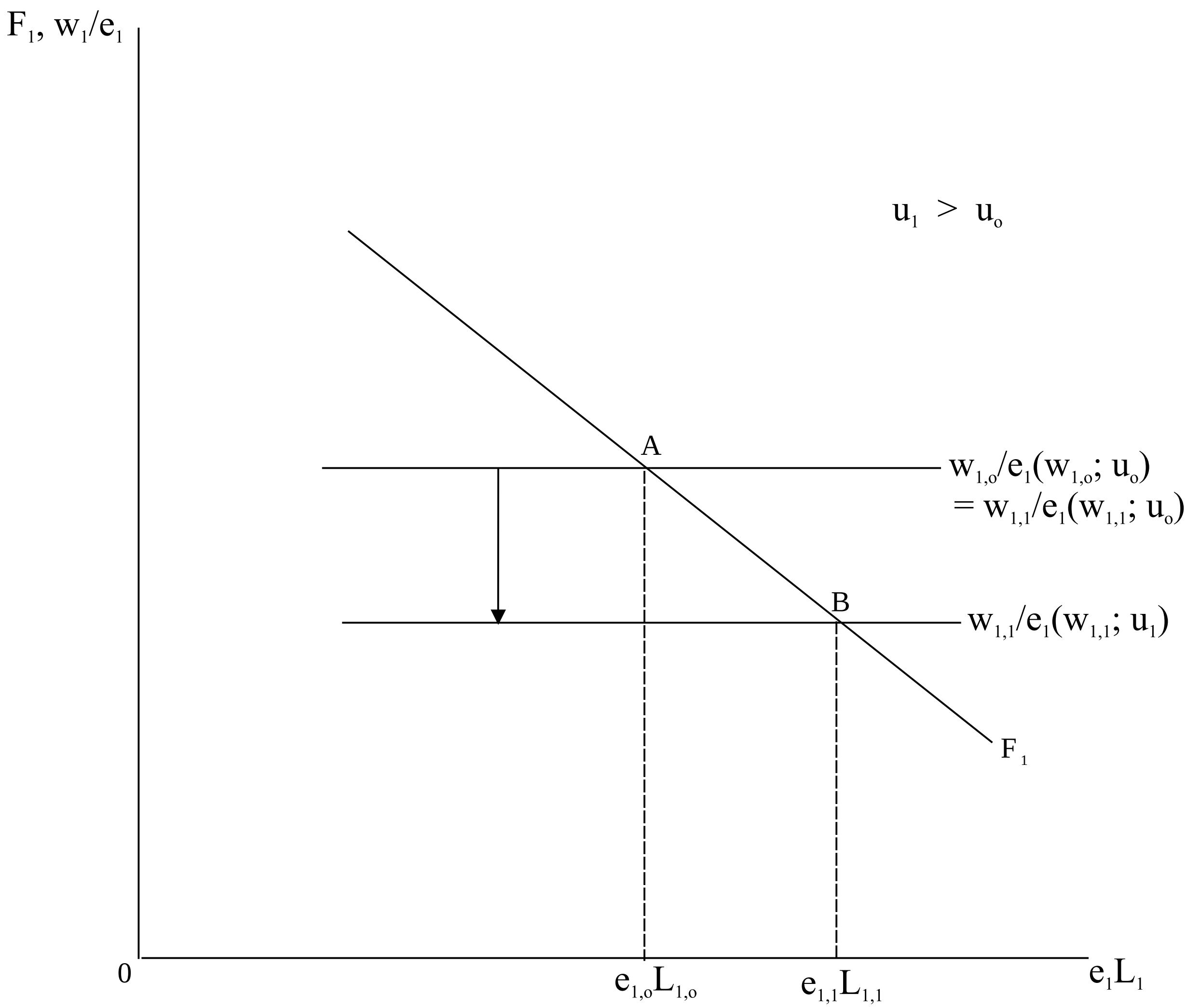


Figure 2: Impact on the total supply of labor services when the minimum wage increases the real wage in the formal sector from $w_{1,o}$ to $w_{1,1}$ ($P_1 = P = 1$).

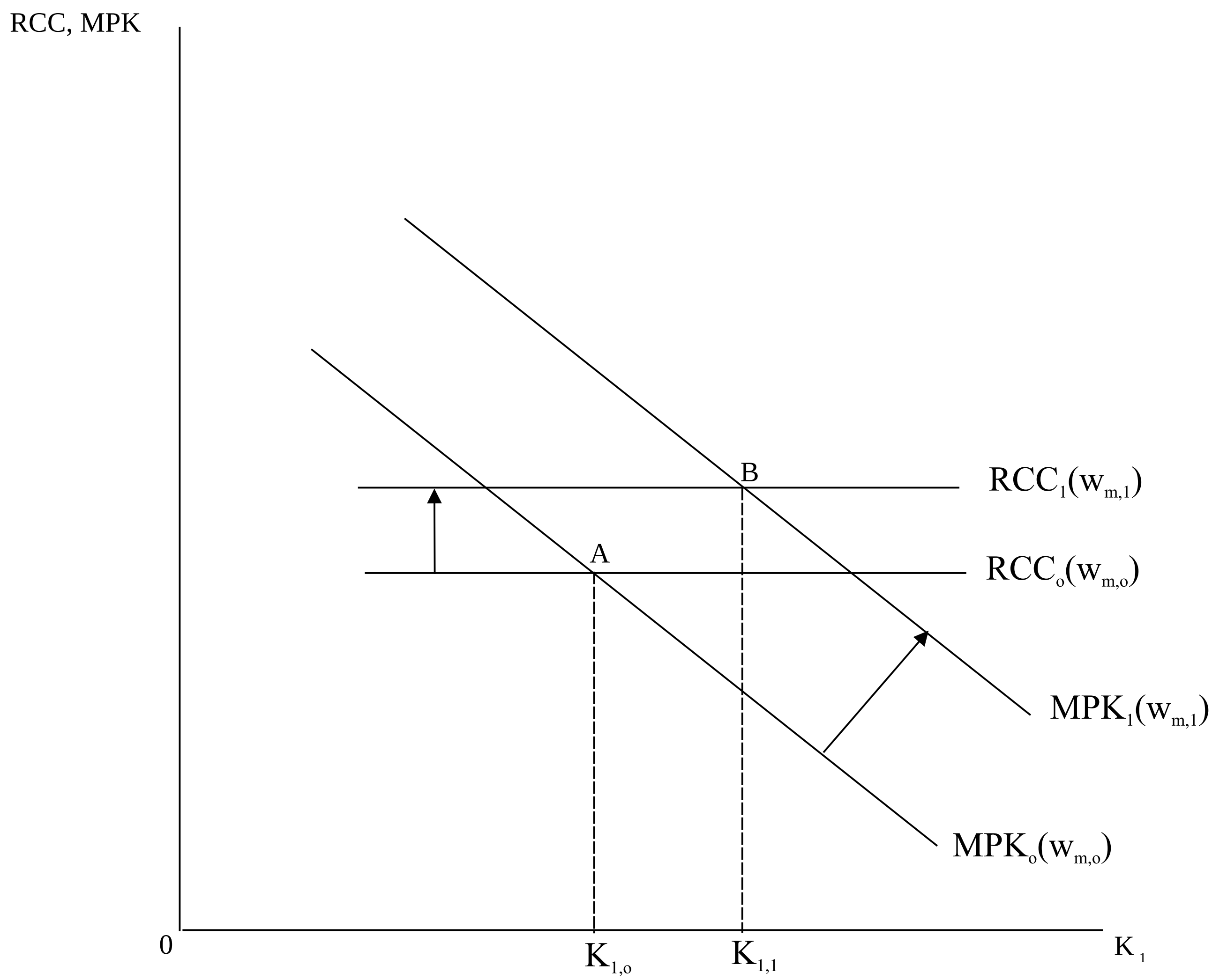


Figure 3: Impact on the capital stock in the formal sector when the real minimum wage increases and $\epsilon > \epsilon^*$.

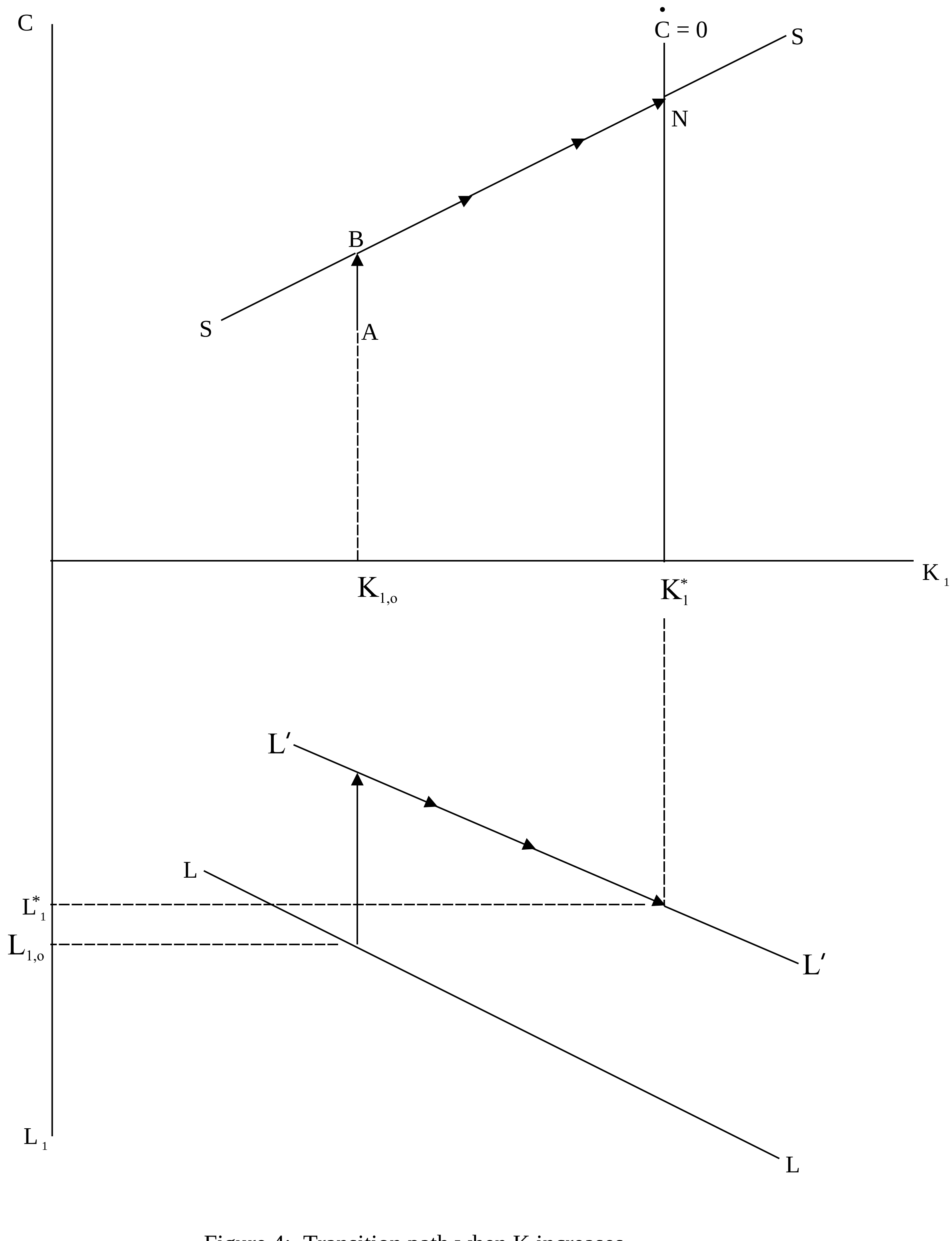


Figure 4: Transition path when K increases.

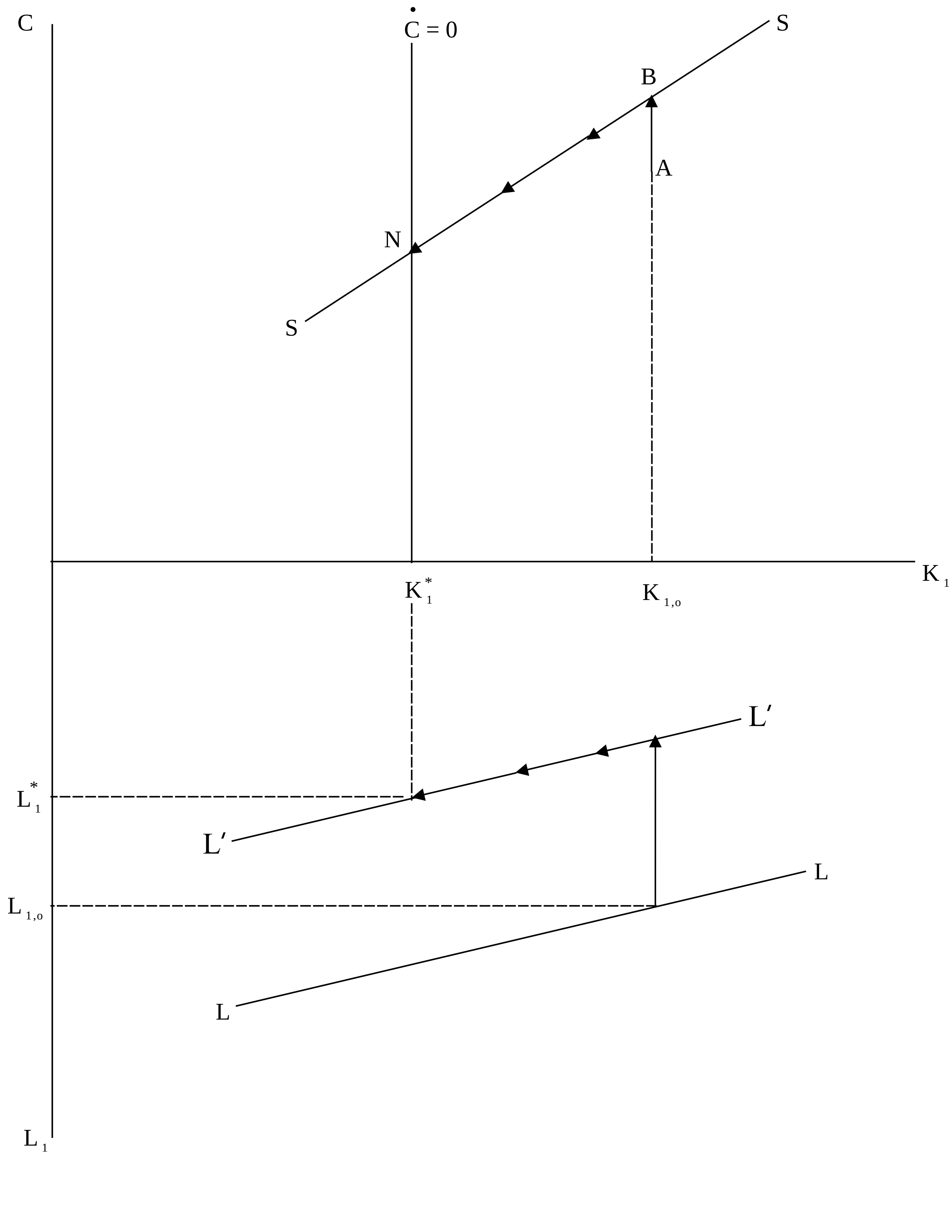
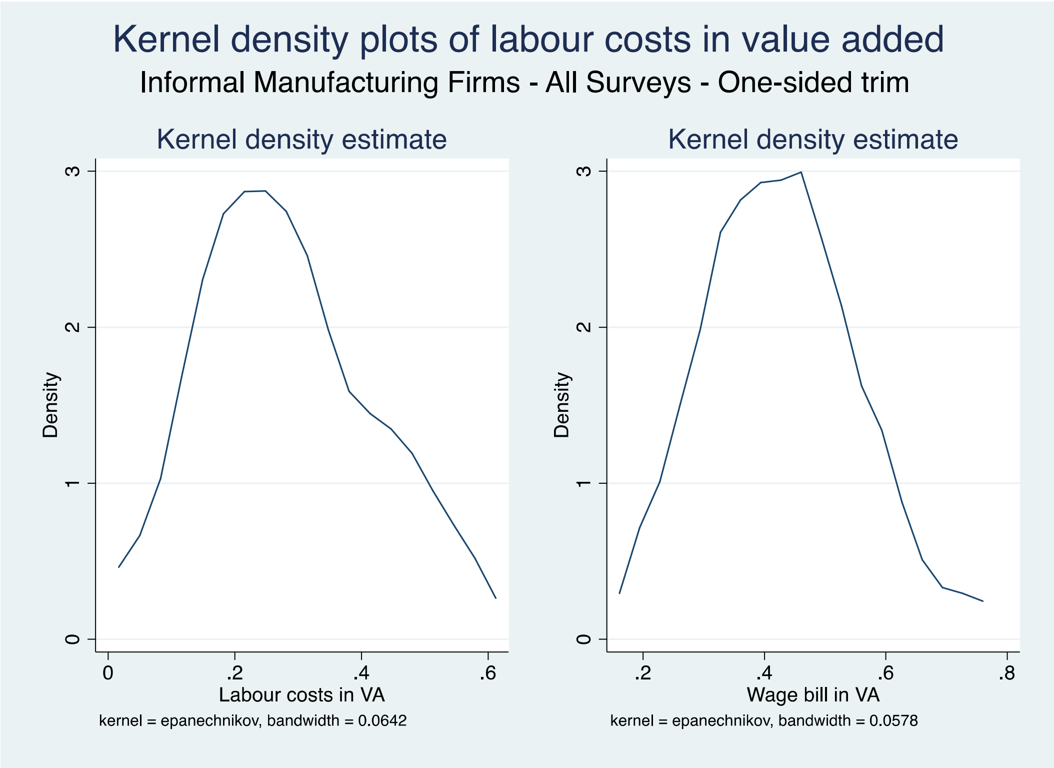


Figure 5: Transition path when K decreases.

Figure 6


Kernel density plots of labour costs in value added
Informal Manufacturing Firms - All Surveys - One-sided trim
Kernel density estimate
Density
0
1
2
3
0
.2
.4
.6
Labour costs in VA
kernel = epanechnikov, bandwidth = 0.0642
Kernel density estimate
Density
0
1
2
3
.2
.4
.6
.8
Wage bill in VA
kernel = epanechnikov, bandwidth = 0.0578

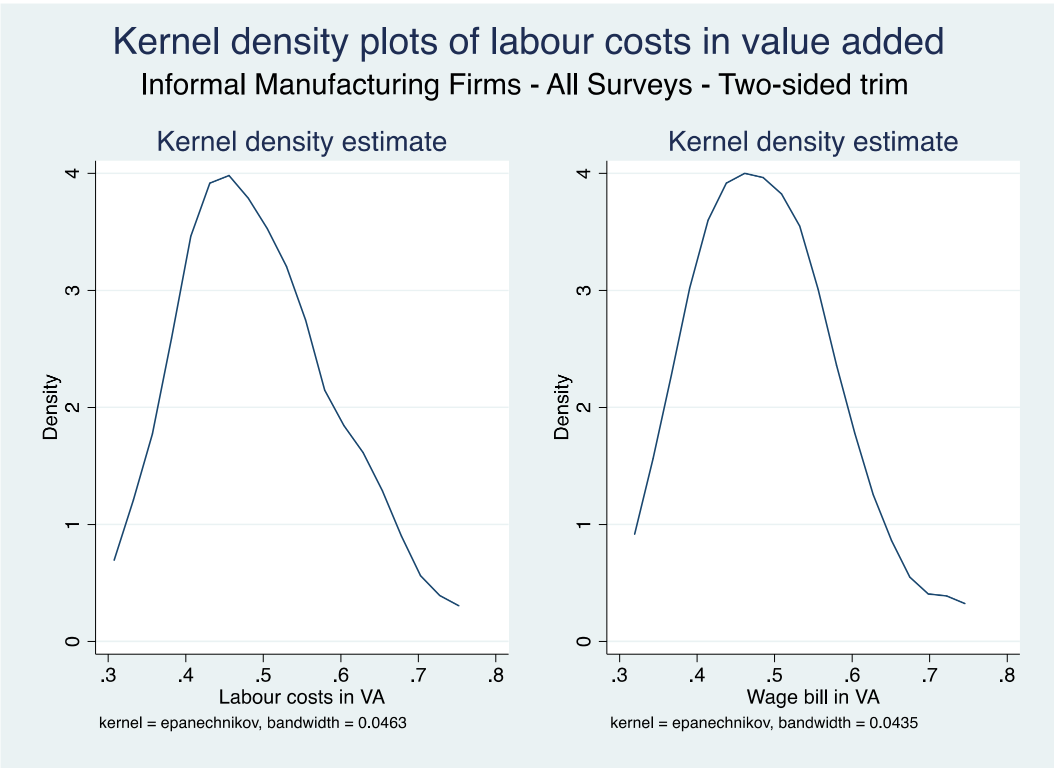

Kernel density plots of labour costs in value added
Informal Manufacturing Firms - All Surveys - Two-sided trim
Kernel density estimate
Density
0
1
2
3
4
.3
.4
.5
.6
.7
.8
Labour costs in VA
kernel = epanechnikov, bandwidth = 0.0463
Kernel density estimate
Density
0
1
2
3
4
.3
.4
.5
.6
.7
.8
Wage bill in VA
kernel = epanechnikov, bandwidth = 0.0435

Figure 7: Empirical and simulated employment elasticities

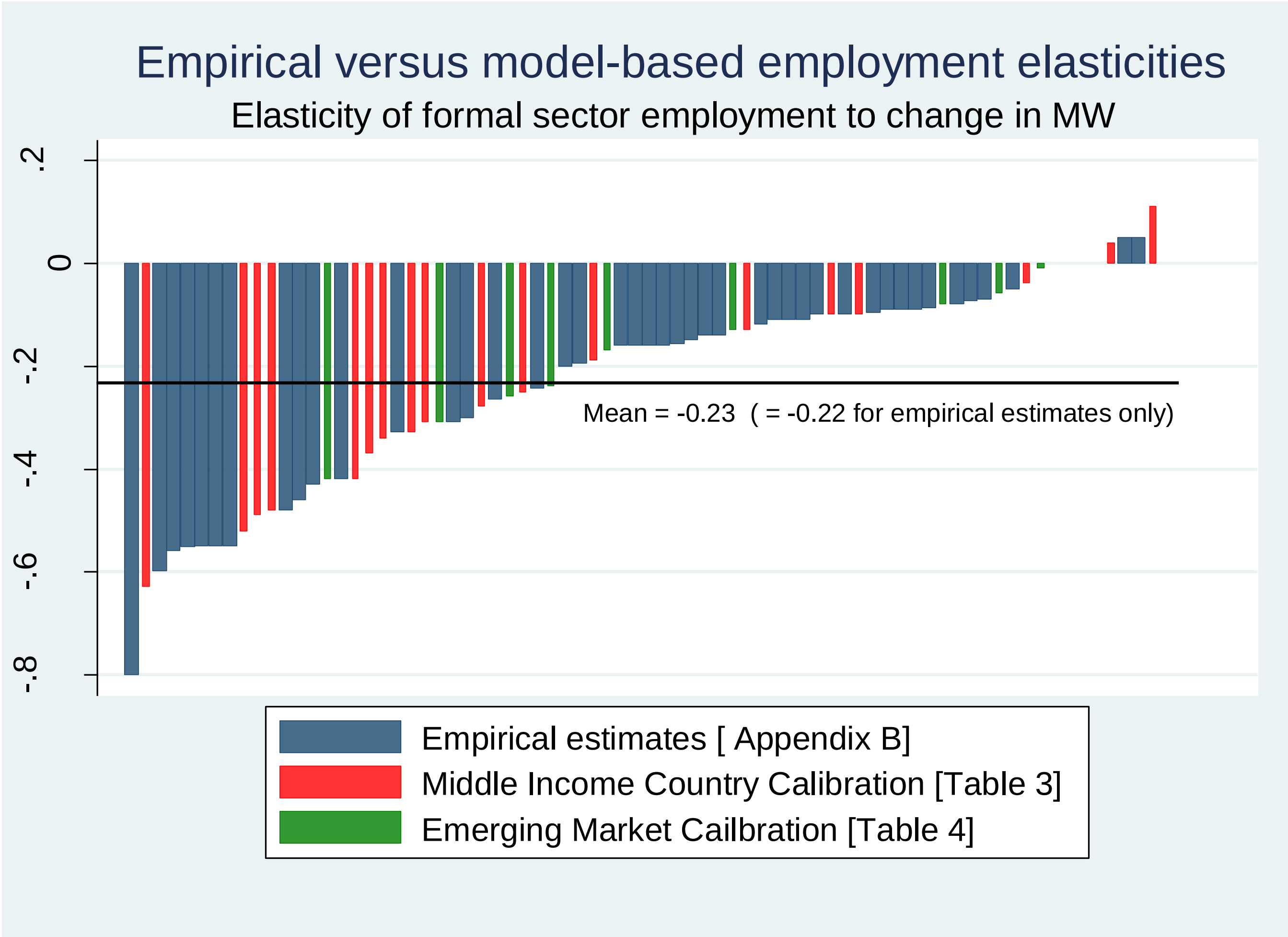
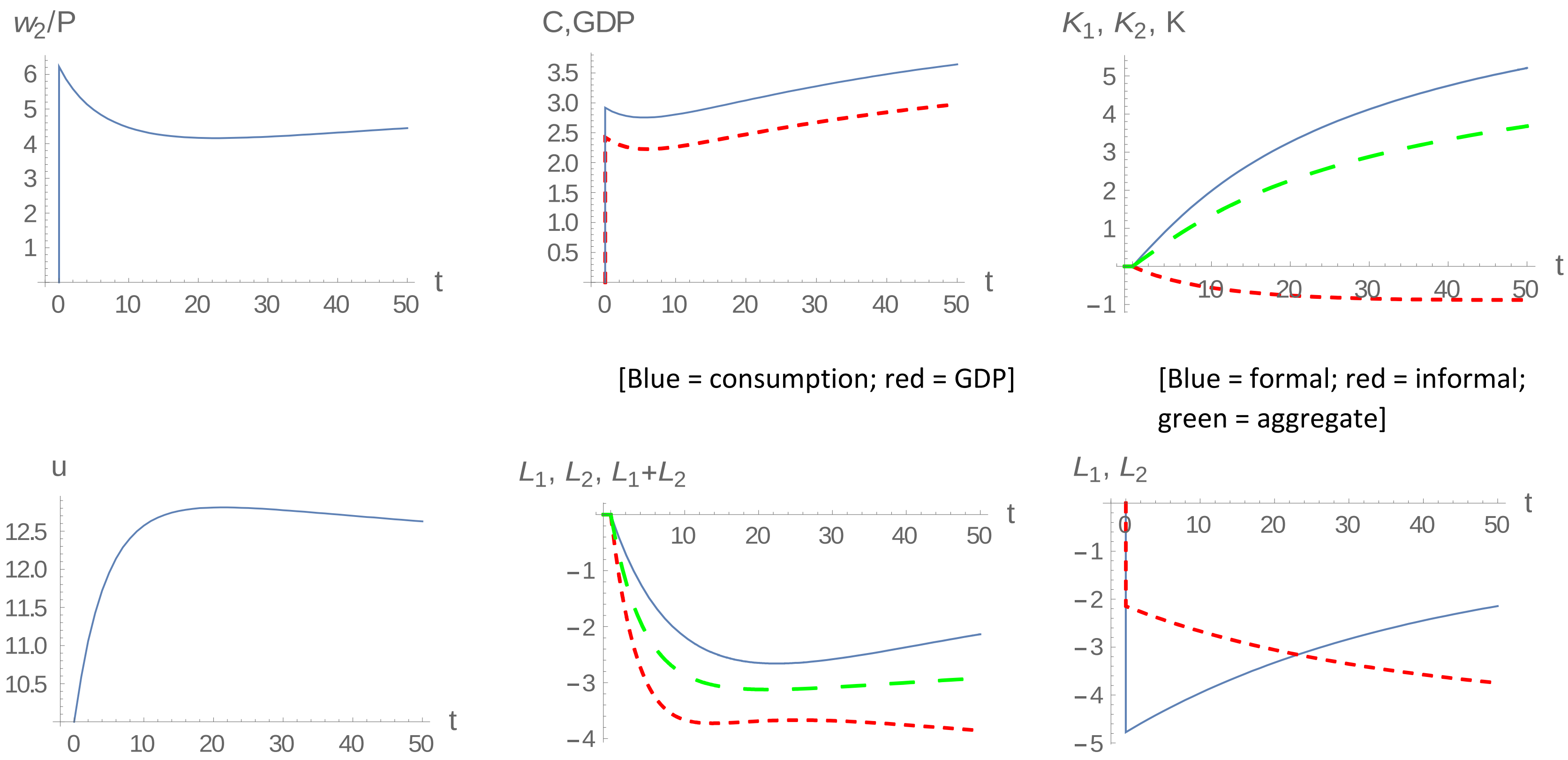


Figure 8

Transition Path: Table 3, panel [d]

[g3/g1 = 1, b3/b1 = 2, ϵ2 = 3 and ϵ3 = 10. v3 = .10 v1 and v4 = .5 v1 k1]



[Blue = consumption; red = GDP]

[Blue = formal; red = informal; green = aggregate]

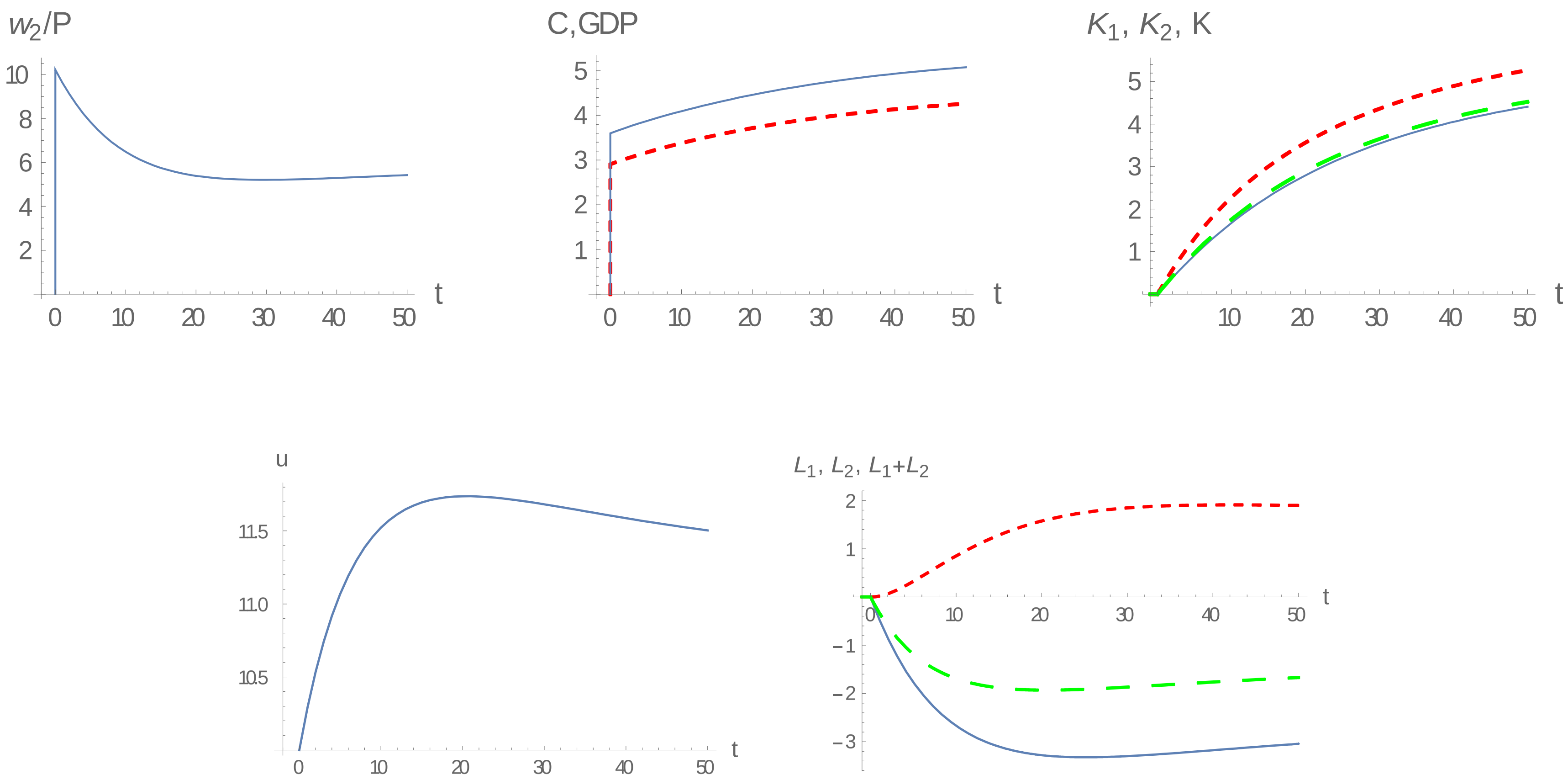
[Blue = formal; red = informal Green = aggregate

[Blue = formal; red = informal]

Figure 9

Transition Path: Table 4, panel [c]

[g3/g1 = 1, b3/b1 = 2, ϵ2 = 3 and ϵ3 = 10. v3 = .10 v1 and v4 = .5 v1 k1]

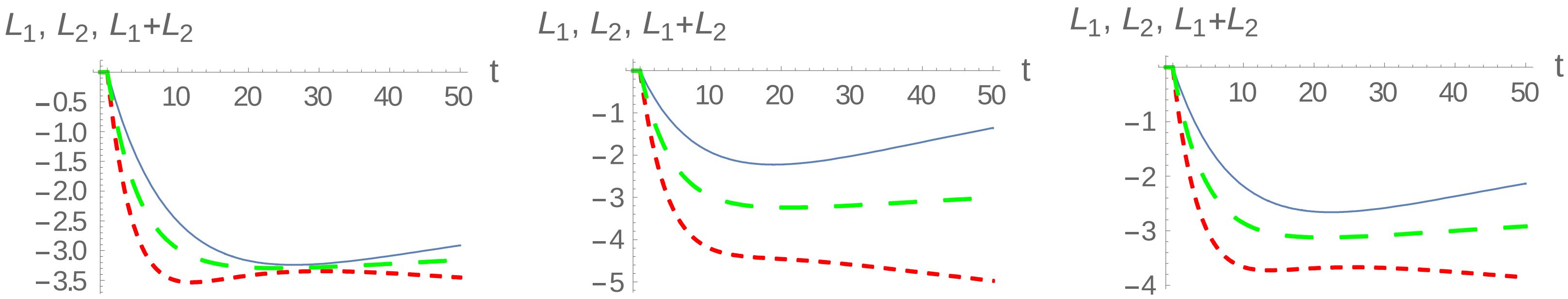


Notes: see Figure 8.

Figure 10

Transition Paths: Table 3, column 2

[g3/g1=1, b3=2; v3 = .10 v1 and v4 = .5 v1 k1]

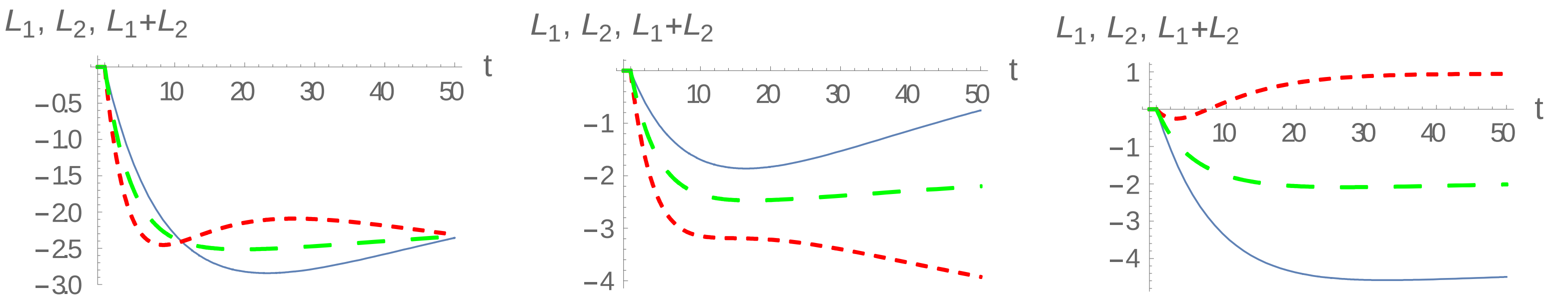


$\epsilon_2 = \epsilon_3 = 3$ $\epsilon_2 = 5, \epsilon_3 = 10$ $\epsilon_2 = 3, \epsilon_3 = 10$

Figure 11

Transition Paths: Table 3, column 3

[g3/g1=1.5, b3=3; v3 = .10 v1 and v4 = .5 v1 k1]

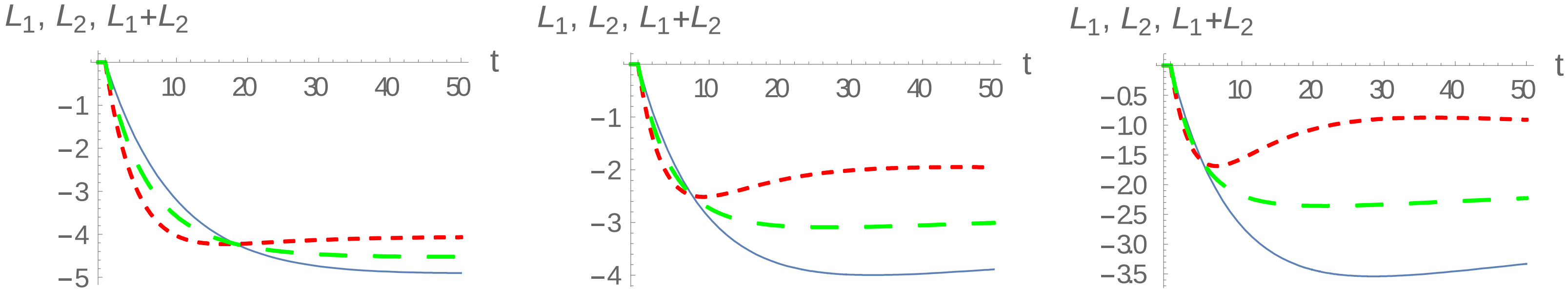


Notes: see Figure 8.

Figure 12

Transition Paths: Table 3, panel [b]

[v3 = .10 v1 and v4 = .5 v1 k1]

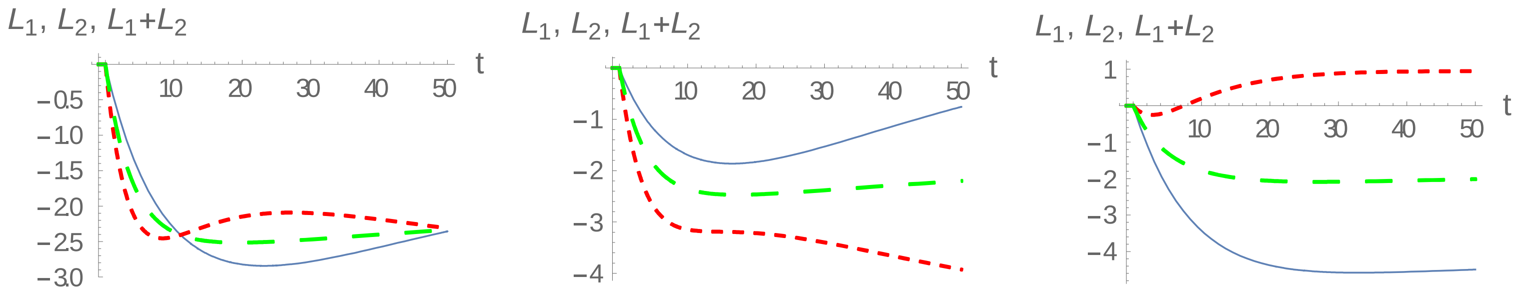


$g_3/g_1 = .5, b_3 = 1$ $g_3/g_1 = 1, b_3 = 2$ $g_3/g_1 = 1.5, b_3 = 3$

Figure 13

Transition Paths: Table 4, column 2

[v3 = .10 v1 and v4 = .5 v1 k1]

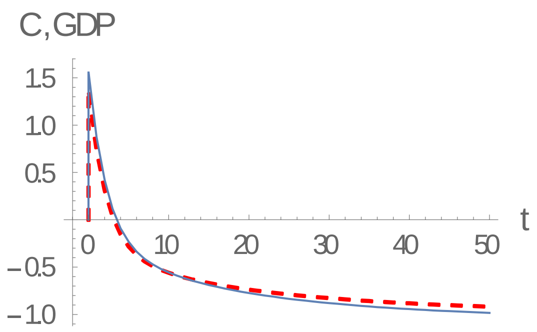


$\epsilon_2 = \epsilon_3 = 3$ $\epsilon_2 = 3$ and $\epsilon_3 = 10$ $\epsilon_2 = 1$ and $\epsilon_3 = 10$

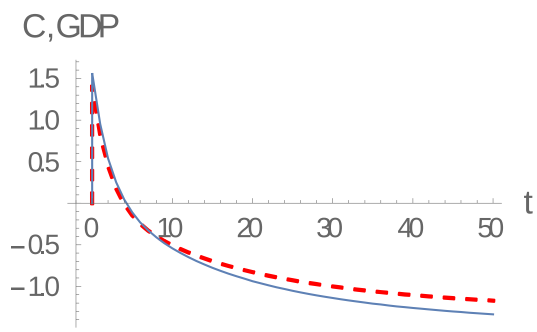
Figure 14

Transition Paths: Table 5, column 1

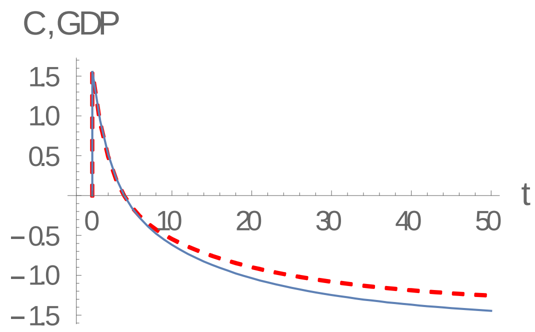
[v3 = .10 v1 and v4 = .5 v1 k1]



$\epsilon_2 = \epsilon_3 = 3$



$\epsilon_2 = 1$ and $\epsilon_3 = 10$



$\epsilon_2 = 1$ and $\epsilon_3 = 1$

Notes: see Figure 8.