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# Informality and structural transformation

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In this paper, we investigate the evolution of the informal sector through structural transformation. We develop both a three-sector and a five-sector dynamic general equilibrium (DGE) model, which can simultaneously account for structural transformation between agriculture, industry and services, and between the informal and formal sectors. First, we incorporate the informal sector into an otherwise two-sector (agriculture and non agriculture) DGE model. Then, we augment this model and build a five-sector DGE model extending the non-agricultural sector into industry and services, to separately account for the evolution of informality in these two sectors. The calibrated model performs remarkably well in accounting for the evolution of the sectoral employment shares and the size of the informal sector. Finally, we use panel data econometric tools to investigate the empirical relationship between structural transformation and the informal sector and find a strong negative relationship between the size of non-agricultural sector and informality.



## 1. Introduction

Economic growth is usually accompanied by substantial changes in the composition of production and employment. These changes generally manifest themselves as a shift of resources from the traditional to modern sectors. Over the past decades, the analysis of how structural transformation occurs and its impacts has been an important focus of research. Different papers have tried to explain the source of reallocation of resources among sectors using multi-sectoral models. However, most papers have focused on sectorizing the economy in terms of agriculture, industry, and services; ignoring a specific issue, informality, which affects the use of resources both among and within sectors. Informality poses serious economic challenges across the world, also affecting allocation of inputs across sectors (See Schneider and Enste (2000) as well as Elgin and Oztunali (2012)).

There is a well-known literature that studies structural transformation in the context of home production (see, for example, Gollin et al. (2004), Ngai and Pissarides (2008) and Rogerson (2008)). These papers develop models of time allocation across sectors, accounting for both market and home production. Although home production is sometimes interpreted to be a part of the informal sector, home production and informal sector are not equivalent. The informal sector is defined by Buehn and Schneider (2012) as market-based production activities that are deliberately concealed from state authority to avoid taxation and regulation. Our framework differs from the home production literature in this regard, as we investigate the evolution of the market-based but hidden sector through structural transformation.

The main contribution of this paper is to build up a framework which can simultaneously account for structural transformation between agriculture, industry and services, and between the informal and formal sectors. In this paper, we first incorporate the informal sector to an otherwise two sector structural transformation model. We show that the size of the informal sector decreases through the transformation of the economy from the agricultural to non-agricultural sector. Then, we build a five-sector model extending the non-agricultural sector into industry and services, in order to account for informality in these two sectors separately. We show that informality declines in both sectors while it remains higher in services. Finally, we use panel data analysis to investigate the effect of structural change on informality. Our findings show that a higher non-agricultural sector size is associated with lower levels of informality.

The multi-sector models trying to the explain sources of

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reallocation across sectors rely mainly on two types of approaches. The first-type of models view structural transformation as a supply side phenomenon. In these types of models, changes in the structure of production and employment are driven by sectoral differences in productivity growth rates or capital intensities. The pioneering work emphasizing the importance of differential rates of productivity growth on structural transformation was done by Baumol (1967) and Baumol et al. (1985). Ngai and Pissarides (2007) provide a modern version of Baumol's hypothesis using exogenous differential rates of productivity growth to explain allocation of capital and labor across sectors. Acemoglu and Guerrieri (2008) provide a framework which shows that different capital intensities and capital deepening can together generate structural transformation. Caselli and Coleman (2002) shows that the productivity of skilled and unskilled labor changes over the course of structural transformation.

The second-type of models, which view structural transformation as a demand side phenomenon, are based on Engel's law. These types of models make use of sectoral differences in income elasticities of demand by utilizing non-homothetic preferences. One of the first papers in this vein is Gollin et al. (2002) which explains industrialization by using the relationship between the dynamics of sectoral employment shares and consumer demand. Another paper which makes a strong case for the impact of Engel's law on structural transformation is Kongsamut et al. (2001). In this paper, they build a three-sector model where consumers have Stone-Geary preferences over agricultural good, manufactured good and services. The other papers combine two different approaches to build a hybrid model (see, for example, Duarte and Restuccia (2010) and Rogerson (2008)). Our framework is also based on a hybrid model, in which structural transformation is driven by both non-homothetic preferences and differential rates of productivity growth.

The informal sector is considered to be an important characteristic of both less-developed and advanced economies, and one which has serious economic and social consequences. Schneider and Williams (2013) provides a comprehensive overview of the shadow economy from a global perspective and Buehn and Schneider (2016) focuses on the definition and causal factors of the informal economy, providing a comparison of the size of shadow economies using different estimation methods. Schramm (2014) estimates the equilibrium effects of taxation on sectoral choice and informal sector. Elgin and Uras (2013) investigates the relationship between financial development and the size of the informal economy. Many studies so far have utilized theoretical models to illuminate the determinants and complexities of informality. For example Fortin et al. (1997), in order to study the effects of taxation and wage controls on the extent of informal economy, builds a model with firm heterogeneity, where a formal and an informal sector endogenously emerge in some productive branches of the economy. Ihrig and Moe (2004) use a two sector dynamic general equilibrium model to investigate the effects of tax rates and enforcement policies on the size of the informal sector. Antunes and Cavalcanti (2007) construct a model with credit constrained heterogenous agents, financial frictions and occupational choices over formal and informal businesses. In this paper we build upon the framework of Ihrig and Moe (2004) to model the interaction between the formal and informal sectors. Moreover, the modelling of informality is also similar to the one in Elgin (2015). However, the current paper significantly differs from these papers by modelling informality in a multi-sector environment and investigating the relationship between informality and structural transformation of an economy that manifest itself as a shift through different sectors.

The paper is organized as follows. Section 2 summarizes the theoretical framework. Section 3 and Section 4 includes detailed descriptions of the three-sector and five-sector versions of the model. Section 5 presents the quantitative implications of the model. Next, Section 6 conducts an empirical analysis in line with the model's predictions. Finally, Section 7 provides some concluding remarks and a discussion.

## 2. Theoretical framework

This section includes three - and five - sector models of structural transformation. In the three sector model, we lay out a framework which accounts for the transition from the agricultural to non-agricultural sector. The structure of the agricultural sector is built on the work of Gollin et al. (2002), where a one-sector neoclassical growth model is extended to include a explicit agricultural sector. In our model, the non-agricultural sector involves both the formal and informal sectors. To account for resource allocation between the formal and informal sectors, we use the framework of Ihrig and Moe (2004).

Then, we extend our framework to a five-sector model, in order to also investigate resource allocation between industry (manufacturing henceforth, to avoid confusion) and services. Here, informality is incorporated into both of the non-agricultural sectors. Allocation of resources between these two sectors is driven by differential rates of productivity growth as emphasized by Ngai and Pissarides (2007). Therefore, structural transformation in the economy is explained by both the non-homothetic preferences and sectoral differences in productivity growth (for a similar environment, see also Bah (2009)).

## 3. The three-sector model

### 3.1. Environment

There is a representative household, which has $K_0$ units of initial endowment, owns the total land for the economy and has a time endowment $T>0$. It allocates its time endowment across three sectors every period inelastically and consumes two types of goods: agricultural and non-agricultural. The lifetime utility of the household is given by a Stone-Geary variety:

$$\sum_{t=0}^{T} \beta^t \left[log\ \left(C_{M_t}\right) + V\left(C_{A_t}\right)\right] \tag{1}$$

where $C_{A_t}$ and $C_{M_t}$ stands for consumption of agricultural good and non-agricultural good, respectively. Utility from agricultural consumption $V(C_{A_t})$ takes the form

$$V\left(C_{A_t}\right) = \begin{cases} -\infty & \text{if } C_{A_t} < \overline{C}_A \\ min\left(C_{A_t}, \overline{C}_A\right) & \text{if } C_{A_t} \geq \overline{C}_A \end{cases}$$

which implies that the household has to consume at least $\overline{C}_A$ units of agricultural good. After reaching agricultural consumption level $\overline{C}_A$, it will only desire non-agricultural good. Introducing this non-homotheticity will allow labor to flow out of the agricultural sector after reaching the subsistence level agricultural good, regardless of the state of non-agricultural sector (Gollin et al. (2002)).

The economy consists of three sectors: agriculture, formal non-agriculture and informal non-agriculture. Agricultural production has a Cobb-Douglas form of technology which employs land ($L_t$)

and labor ($N_{A_t}$) as factor inputs. The effect of capital can be viewed as captured in the agricultural TFP ($\theta_{A_t}$). A proportional tax $\tau$ is levied on agricultural income. The output of the agricultural sector is used only for consumption. Therefore, the resource constraint becomes:

$$C_{A_t} = (1-\tau)\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi}$$

where TFP evolves as $\theta_{A_t} = \theta_A (1+\xi_{A_t})^t$.

Non-agricultural good is produced in both the formal and informal sectors. Production technology in the formal non-agricultural sector has a Cobb-Douglas form using capital ($K_{M_t}$) and labor ($N_{MF_t}$) inputs. The informal non-agricultural sector has a production technology which utilizes labor ($N_{MI_t}$) and exhibits diminishing returns to scale. A proportional tax $\tau$ is levied on both the formal and informal sector income. However, when operating in the informal sector, the household tends to hide income generated from this sector. So, it only pays taxes at the rate $\rho\tau$, where $\rho$ can be interpreted as the level of enforcement government imposes on the tax collection from the informal sector (see Ihrig and Moe (2004)). The non-agricultural sector's output is used for both consumption and investment, therefore the resource constraint becomes:

$$C_{M_t} + I_t = (1-\tau)\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + (1-\rho\tau)\theta_{MI_t} N_{MI_t}^{\phi}$$

where TFPs evolve as $\theta_{MF_t} = \theta_{MF}(1+\xi_{MF_t})^t$ and $\theta_{MI_t} = \theta_{MI}(1+\xi_{MI_t})^t$. The law of motion for aggregate capital stock is given by $K_{t+1} = (1-\delta)K_t + I_t$.

We assume that government policy variables $\rho$ and $\tau$ are exogenous and tax revenues are used for non-productive activities.

**Definition:** Given $K_{M_0}$, $\theta_{MF_t}$, $\theta_{MI_t}$, $\theta_{A_t}$, $\overline{C}_A$, $\rho$, $\tau$; a competitive equilibrium of three sector model is the set of allocations $C_{A_t}^*$, $C_{M_t}^*$, $K_{t+1}^*$, $L_t^*$, $N_{MF_t}^*$, $N_{MI_t}^*$, $N_{A_t}^*$, $G_t^*$ such that:

1. The household chooses $C_{A_t}$, $C_{M_t}$, $K_{t+1}$, $L_t$, $N_{MF_t}$, $N_{MI_t}$, $N_{A_t}$ to solve the following maximization problem:

$$\max \sum_{t=0}^{T} \beta^t \left[ log\ (C_{M_t}) + V(C_{A_t}) \right]$$

$$\text{where } V(C_{A_t}) = \begin{cases} -\infty & if C_{A_t} < \overline{C}_A \\ min\left(C_{A_t}, \overline{C}_A\right) & if C_{A_t} \geq \overline{C}_A \end{cases}$$

$$\begin{aligned} \text{subject to } & C_{M_t} + I_t = (1-\tau)\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + (1-\rho\tau)\theta_{MI_t} N_{MI_t}^{\eta} \\ & K_{t+1} = (1-\delta)K_t + I_t \\ & C_{A_t} = (1-\tau)\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi} \\ & N_{MF_t} + N_{MI_t} + N_{A_t} = T \end{aligned}$$

2. Government revenue $G_t$ equals $\tau\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + \rho\tau\theta_{MI_t} N_{MI_t}^{\phi} + \tau\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi}$ and is thrown away.

### 3.2. Characterization

First, for simplicity, we normalize the size of total land in the economy to 1. Then equalizing the agricultural consumption to subsistence level, we can easily find the employment in agricultural sector as:

$$(1-\tau)\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi} = \overline{C}_A \tag{2}$$

$$N_{A_t} = \left[ \frac{\overline{C}_A}{(1-\tau)\theta_{A_t}} \right]^{1/\psi} \tag{3}$$

After finding the agricultural employment, our problem is reduced to a two-sector dynamic general equilibrium model similar to the one in Ihrig and Moe (2004). Denoting the time endowment left as $T - N_{A_t} = N_t$, the maximization problem becomes:

$$\max_{\{C_{M_t}, N_t, L_t, K_{t+1}\}_{t=0}^{T}} \sum_{t=0}^{T} \beta^t\ log\ (C_{M_t})$$

$$\begin{aligned} \text{subject to } & C_{M_t} + I_t = (1-\tau)\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + (1-\rho\tau)\theta_{MI_t} N_{MI_t}^{\phi} \\ & K_{t+1} = (1-\delta)K_t + I_t \\ & N_{MF_t} + N_{MI_t} = N_t \end{aligned}$$

Combining the first order conditions of this problem yields the Euler equation and the marginal product equality of the formal and informal sectors, given respectively as:

$$\frac{C_{M_{t+1}}}{C_{M_t}} = \frac{1}{\beta} \left[ 1 - \delta + (1-\tau)\gamma\theta_{MF_{t+1}} \left( \frac{K_{M_{t+1}}}{N_{MF_{t+1}}} \right)^{\gamma-1} \right]^{-1} \tag{4}$$

$$(1-\gamma)(1-\tau)\theta_{MF_t} \left( \frac{K_{M_t}}{N_{MF_t}} \right)^{\gamma} = (1-\rho\tau)\phi\theta_{MI_t} N_{MI_t}^{\phi-1} \tag{5}$$

Rearranging the Euler Equation one can obtain the relative utilization of capital and labor in the informal non-agricultural sector as:

$$\frac{K_t}{N_{F_t}} = \left[ \frac{(1+g_{C_M})/\beta + \delta - 1}{\gamma(1-\tau)\theta_{MF_t}} \right]^{\frac{1}{\gamma-1}} \tag{6}$$

where $g_{C_M} = \frac{C_{M_{t+1}} - C_{M_t}}{C_{M_t}}$ is the growth rate of non-agricultural consumption. Combining equations (4) and (5) we obtain:

$$N_{MI_t} = \left[ \frac{(1-\gamma)(1-\tau)\theta_{MF_t}}{(1-\rho\tau)\phi\theta_{MI_t}} \left[ \frac{(1+g_{C_M})\beta + \delta - 1}{\gamma(1-\tau)\theta_{MF_t}} \right]^{\frac{\gamma}{\gamma-1}} \right]^{\frac{1}{\phi-1}} \tag{7}$$

which gives the evolution of the informal sector in non-agriculture.

## 4. The five-sector model

### 4.1. Environment

There is a representative household which has $K_0$ units of initial endowment, owns the total land for the economy and has a time endowment $T > 0$. It allocates its time endowment across five sectors every period inelastically and consumes three types of goods: agricultural good, manufactured good and services. The lifetime utility of the household is given by:

$$\sum_{t=0}^{T} \beta^t \left( log\left[ \alpha C_{M_t}^{\varepsilon} + (1-\alpha) C_{S_t}^{\varepsilon} \right]^{1/\varepsilon} + V(C_{A_t}) \right)$$

where $C_{A_t}$, $C_{M_t}$ and $C_{S_t}$ stands for the consumption of agricultural good, manufactured good and services respectively. The parameter $\varepsilon$ governs the elasticity of substitution between non-agricultural goods and $\alpha$ gives the weights of two goods in allocation of non-agricultural consumption. Utility from agricultural consumption $V(C_{A_t})$ again takes the form of Stone-Geary variety.

The specification of the agricultural sector is the same as in the three-sector model. Non-agricultural goods, this time extended into manufactured good and services, are again produced in both the formal and informal sectors. Production technology in formal manufacturing and formal services have Cobb-Douglas forms using capital ($K_{M_t}, K_{S_t}$) and labor ($N_{MF_t}, N_{SF_t}$) with identical intensities, following Herrendorf and Valentinyi (2008). Informal manufacturing and informal service sectors have diminishing returns to scale technologies with labor ($N_{MI_t}, N_{SI_t}$). The degree of diminishing returns to scale in two sectors are different. As in the three sector model, a proportional tax $\tau$ is levied on both the formal and informal sector income, with an enforcement level $\rho$ on tax collection from the informal sector. The manufacturing sector's output is used for both consumption and investment, while the service sector's output is only used for consumption. Therefore the resource constraints become:

$$C_{M_t} + I_t = (1-\tau)\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + (1-\rho\tau)\theta_{MI_t} N_{MI_t}^{\phi}$$

$$C_{S_t} = (1-\tau)\theta_{SF_t} K_{S_t}^{\gamma} N_{SF_t}^{1-\gamma} + (1-\rho\tau)\theta_{SI_t} N_{SI_t}^{\eta}$$

where TFPs evolves as $\theta_{MF_t} = \theta_{MF}(1+\xi_{MF_t})^t$, $\theta_{MI_t} = \theta_{MI}(1+\xi_{MI_t})^t$, $\theta_{SF_t} = \theta_{SF}(1+\xi_{SF_t})^t$ and $\theta_{SI_t} = \theta_{SI}(1+\xi_{SI_t})^t$. The law of motion for aggregate capital stock is given by $K_{t+1} = (1-\delta)K_t + I_t$.

We again assume that government policy variables $\rho$ and $\tau$ are exogenous and tax revenues are used for non-productive activities.

**Definition:** Given $K_{M_0}, \theta_{MF_t}, \theta_{SF_t}, \theta_{MI_t}, \theta_{SI_t}, \theta_{A_t}, \overline{C}_A, \rho, \tau$, a competitive equilibrium of this five-sector model is the set of allocations $C^*_{A_t}, C^*_{M_t}, C^*_{S_t}, K^*_{t+1}, K^*_{M_t}, K^*_{S_t}, L^*_t, N^*_{MF_t}, N^*_{MI_t}, N^*_{SF_t}, N^*_{SI_t}, N^*_{A_t}, G^*_t$ such that:

1. The household chooses $C_{A_t}, C_{M_t}, C_{S_t}, K_{t+1}, K_{M_t}, K_{S_t}, L_t, N_{MF_t}, N_{MI_t}, N_{SF_t}, N_{SI_t}, N_{A_t}$ to solve the following maximization problem:

$$\max \sum_{t=0}^{T} \beta^t \left( \log \left[\alpha C_{M_t}^{\varepsilon} + (1-\alpha) C_{S_t}^{\varepsilon}\right]^{1/\varepsilon} + V(C_{A_t}) \right)$$

$$\text{where} \quad V(C_{A_t}) = \begin{cases} -\infty & \text{if } C_{A_t} < \overline{C}_A \\ \min\left(C_{A_t}, \overline{C}_A\right) & \text{if } C_{A_t} \geq \overline{C}_A \end{cases}$$

$$\begin{aligned} &\text{subject to} \quad C_{M_t} + I_t = (1-\tau)\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + (1-\rho\tau)\theta_{MI_t} N_{MI_t}^{\eta} \\ &K_{t+1} = (1-\delta)K_t + I_t \\ &C_{S_t} = (1-\tau)\theta_{SF_t} K_{S_t}^{\gamma} N_{SF_t}^{1-\gamma} + (1-\rho\tau)\theta_{SI_t} N_{SI_t}^{\eta} \\ &C_{A_t} = (1-\tau)\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi} \\ &K_{M_t} + K_{S_t} = K_t \\ &N_{MF_t} + N_{SF_t} + N_{MI_t} + N_{SI_t} + N_{A_t} = T \end{aligned}$$

2. Government revenue $G_t$ equals $\tau\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + \rho\tau\theta_{MI_t} N_{MI_t}^{\phi} + \tau\theta_{SF_t} K_{S_t}^{\gamma} N_{SF_t}^{1-\gamma} + \rho\tau\theta_{SI_t} N_{SI_t}^{\eta} + \tau\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi}$ and is thrown away.

### 4.2. Characterization

First, for simplicity, we normalize the size of total land in the economy to 1. Then, equalizing the agricultural consumption to subsistence level, we can easily find the employment in the agricultural sector as:

$$(1-\tau)\theta_{A_t} L_t^{1-\psi} N_{A_t}^{\psi} = \overline{C}_A \tag{9}$$

$$N_{A_t} = \left[\frac{\overline{C}_A}{(1-\tau)\theta_{A_t}}\right]^{1/\psi} \tag{10}$$

After finding agricultural employment, our problem is reduced to a four-sector maximization problem. Denoting the time endowment left as $T - N_{A_t} = N_t$, the maximization problem becomes:

$$\max_{\{C_t, N_t, L_t, K_{t+1}\}_{t=0}^{T}} \sum_{t=0}^{T} \beta^t \log \left[\alpha C_{M_t}^{\varepsilon} + (1-\alpha) C_{S_t}^{\varepsilon}\right]^{1/\varepsilon}$$

$$\begin{aligned} &\text{subject to} \quad C_{M_t} + I_t = (1-\tau)\theta_{MF_t} K_{M_t}^{\gamma} N_{MF_t}^{1-\gamma} + (1-\rho\tau)\theta_{MI_t} N_{MI_t}^{\phi} \\ &K_{t+1} = (1-\delta)K_t + I_t \\ &C_{S_t} = (1-\tau)\theta_{SF_t} K_{S_t}^{\gamma} N_{SF_t}^{1-\gamma} + (1-\rho\tau)\theta_{SI_t} N_{SI_t}^{\eta} \\ &K_{M_t} + K_{S_t} = K_t \\ &N_{MF_t} + N_{SF_t} + N_{MI_t} + N_{SI_t} = N_t \end{aligned}$$

Combining the first order conditions, and denoting $[\alpha C_{M_t}^{\varepsilon} + (1-\alpha) C_{S_t}^{\varepsilon}] = \chi_t$, we obtain the following equations:

$$\frac{\alpha}{1-\alpha}\left(\frac{C_{M_t}}{C_{S_t}}\right)^{\varepsilon-1} = \frac{\theta_{SF_t}}{\theta_{MF_t}}\left(\frac{K_{S_t}}{K_{M_t}}\right)^{\gamma-1}\left(\frac{N_{SF_t}}{N_{MF_t}}\right)^{1-\gamma} \tag{11}$$

$$\frac{\alpha}{1-\alpha}\left(\frac{C_{M_t}}{C_{S_t}}\right)^{\varepsilon-1} = \frac{\theta_{SF_t}}{\theta_{MF_t}}\left(\frac{K_{S_t}}{K_{M_t}}\right)^{\gamma}\left(\frac{N_{SF_t}}{N_{MF_t}}\right)^{-\gamma} \tag{12}$$

$$(1-\gamma)(1-\tau)\theta_{MF_t}\left(\frac{K_{M_t}}{N_{MF_t}}\right)^{\gamma} = (1-\rho\tau)\phi\theta_{MI_t} N_{MI_t}^{\phi-1} \tag{13}$$

$$\left(\frac{C_{M_t}}{C_{M_{t+1}}}\right)^{\varepsilon-1}\frac{\chi_{t+1}}{\chi_t} = \beta\left[1-\delta+(1-\tau)\gamma\theta_{MF_{t+1}}\left(\frac{K_{M_{t+1}}}{N_{MF_{t+1}}}\right)^{\gamma-1}\right] \tag{14}$$

$$\frac{\alpha}{1-\alpha}\left(\frac{C_{M_t}}{C_{S_t}}\right)^{\varepsilon-1} = \frac{\theta_{SI_t}\eta N_{SI_t}^{\eta-1}}{\theta_{MI_t}\phi N_{MI_t}^{\phi-1}} \tag{15}$$

$$(1-\gamma)(1-\tau)\theta_{SF_t}\left(\frac{K_{S_t}}{N_{SF_t}}\right)^{\gamma} = (1-\rho\tau)\eta\theta_{SI_t} N_{SI_t}^{\eta-1} \tag{16}$$

Equations (9) and (10) equate the marginal products of capital and labor in formal manufacturing and formal services. Equation (11) equates the marginal product of labor between informal manufacturing and informal services. Equations (12) and (13) are the marginal product equality of labor between the informal and formal sectors in manufacturing and services, respectively. Finally, equation (14) is the Euler equation.

Combining equations (9) and (10) with resource constraints, we find that capital and labor ratios are equal between formal sectors:

$$\frac{K_{M_t}}{N_{MF_t}} = \frac{K_{S_t}}{N_{SF_t}} = \frac{K_t}{N_{F_t}} \tag{17}$$

Combining equations (10) and (15) we obtain:

$$\frac{\alpha}{1-\alpha}\left(\frac{C_{M_t}}{C_{S_t}}\right)^{\varepsilon-1} = \frac{\theta_{SF_t}}{\theta_{MF_t}} \tag{18}$$

which implies that the relative consumption of manufactured good and services depends on the productivity ratios of formal manufacturing and service sectors. Then rearranging equation (15), one can obtain the relative utilization of capital and labor in formal sectors as:

$$\frac{K_t}{N_{F_t}} = \left[\frac{\frac{g_{C_M}^{\varepsilon-1} g_\chi}{\beta} + \delta - 1}{\gamma(1-\tau)\theta_{MF_t}}\right]^{\frac{1}{\gamma-1}} \tag{19}$$

where $g_\chi = \frac{\chi_{t+1}-\chi_t}{\chi_t}$ is the growth rate of $\chi_t = [\alpha C_{M_t}^\varepsilon + (1-\alpha)C_{S_t}^\varepsilon]$. Combining this ratio with equation (15) and substituting into Euler equation yields:

$$N_{MI_t} = \left[\frac{(1-\gamma)(1-\tau)\theta_{MF_t}}{(1-\rho\tau)\phi\theta_{MI_t}}\left[\frac{\frac{g_{C_M}^{\varepsilon-1} g_\chi}{\beta} + \delta - 1}{\gamma(1-\tau)\theta_{MF_t}}\right]^{\frac{\gamma}{\gamma-1}}\right]^{\frac{1}{\phi-1}} \tag{20}$$

which gives the evolution of informal labor used in manufacturing sector. Now we can easily find the evolution of informal labor in services by using equation (11):

$$N_{SI_t} = \left[\frac{(1-\gamma)(1-\tau)\theta_{SF_t}}{(1-\rho\tau)\eta\theta_{SI_t}}\left[\frac{\frac{g_{C_M}^{\varepsilon-1} g_\chi}{\beta} + \delta - 1}{\gamma(1-\tau)\theta_{MF_t}}\right]^{\frac{\gamma}{\gamma-1}}\right]^{\frac{1}{\eta-1}} \tag{21}$$

The aggregate expenditure for non-agricultural goods are given by $C_t = p_{M_t}C_{M_t} + p_{S_t}C_{S_t}$, where $p_{M_t}$ and $p_{S_t}$ are the prices of manufacture goods and services, respectively. Also, given the wage rate equality between the sectors, we find the relative equilibrium prices as $\frac{p_{S_t}}{p_{M_t}} = \frac{\theta_{MF_t}}{\theta_{SF_t}}$. Normalizing the price of manufactured good to 1, the aggregate expenditure for manufactured goods and services can be denoted as:

$$C_t = C_{M_t} + \frac{\theta_{MF_t}}{\theta_{SF_t}}C_{S_t} \tag{22}$$

Substituting for $C_{M_t}$ and $C_{S_t}$ from the resource constraints, we obtain the following equation for non-agricultural consumption

$$C_t = \theta_{MF_t}(1-\tau)\left(\frac{K_t}{N_{F_t}}\right)^\gamma N_{F_t} + (1-\rho\tau)\theta_{MI_t}N_{MI_t}^\phi\left[\frac{N_{SI_t}\phi}{N_{MI_t}\eta} + 1\right] + (1-\delta)K_t - K_{t+1} \tag{23}$$

Finally, we need to derive the labor and capital in the formal sectors. Using equation (16), we can denote the manufactured good consumption $C_{M_t}$ as:

$$C_{M_t} = \left(\frac{\theta_{SF_t}}{\theta_{MF_t}}\right)^{\frac{1}{\varepsilon-1}}\left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\varepsilon-1}}C_{S_t} \tag{24}$$

Substituting for services consumption $C_{S_t}$ in this equation yields the following equation for manufactured goods consumption:

$$C_{M_t} = \theta_{MF_t}\left(\frac{\theta_{SF_t}}{\theta_{MF_t}}\right)^{\frac{\varepsilon}{\varepsilon-1}}\left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\varepsilon-1}}(1-\tau)\left(\frac{K_{S_t}}{N_{SF_t}}\right)^\gamma N_{SF_t} + \left(\frac{\theta_{SF_t}}{\theta_{MF_t}}\right)^{\frac{1}{\varepsilon-1}}\left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\varepsilon-1}}(1-\rho\tau)\theta_{SI_t}N_{SI_t}^\eta \tag{25}$$

Combining equation (20) with equation (22) and substitution services consumption $C_{S_t}$, we can obtain the following:

$$C_t = \left[1 + \left(\frac{\theta_{SF_t}}{\theta_{MF_t}}\right)^{\frac{\varepsilon}{\varepsilon-1}}\left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\varepsilon-1}}\right]\left[(1-\tau)\theta_{MF_t}\left(\frac{K_t}{N_{F_t}}\right)^\gamma N_{SF_t} + \frac{(1-\rho\tau)\phi\theta_{MI_t}N_{MI_t}^{\phi-1}N_{SI_t}}{\eta}\right] \tag{26}$$

Rearranging the last equation, we find the evolution of labor in the formal service sector:

$$N_{SF_t} = \frac{C_t \Big/ \left[1 + \left(\frac{\theta_{SF_t}}{\theta_{MF_t}}\right)^{\frac{\varepsilon}{\varepsilon-1}}\left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\varepsilon-1}}\right] - \frac{(1-\rho\tau)\phi\theta_{MI_t}N_{MI_t}^{\phi-1}N_{SI_t}}{\eta}}{\theta_{MF_t}(1-\tau)\left(\frac{K_t}{N_{F_t}}\right)^\gamma} \tag{27}$$

Given these, one can easily derive the evolution of labor in formal manufacturing, capital in formal manufacturing and formal services, and all sectoral outputs.

## 5. Quantitative analysis

Having characterized the equilibrium, we will now evaluate the performance of the three-sector and five-sector models under the assumption that the economy is at the steady state. We will compare the implications of our framework with the US and world average time series. The data of sectoral hours worked for the US and sectoral employment shares for other countries are obtained from the Groningen 10-Sector Database. For the informal sector size, we use the estimates of Elgin and Oztunali (2012). [1]

### 5.1. The three-sector model

Before running the numerical simulations, we have to determine the parameter values. We normalize the initial TFP levels in agricultural ($\theta_A$) and non-agriculture sectors ($\theta_{MF}$) to 1. Given these, we set the value of the initial TFP parameter in informal non-agriculture ($\theta_{MI}$) to 20 in order to match the initial size of the informal sector in the US.[2] We set the subsistence level consumption ($\overline{C}_A$) to 2 percent in order to match the initial size of the agricultural sector in the US. To match the world average informal sector size and subsistence level consumption, we set $\theta_{MI}$ and $\overline{C}_A$ to 30 and 6.5 percent, respectively. We take the values of TFP growth rates in agriculture ($\xi_A$) and non-agriculture ($\xi_{MF}$) as 0.0326 and 0.013 from Gollin et al. (2002) and Rogerson (2008), where the environments are similar to ours. We set the TFP growth rate in informal non-agriculture ($\xi_{MI}$) to 0.016.

The capital share in non-agriculture ($\gamma$) is chosen as 0.3 which is standard in the literature. The labor share in agriculture ($\psi$) and the degree of diminishing returns to scale in informal non-agriculture ($\eta$) are set to 0.7 and 0.495 following Restuccia et al. (2008) and Ihrig and Moe (2004), respectively. We choose the values of $\beta$ and $\delta$ as 0.96 and 0.08 from the standard values found in literature. We

[1] We use an average of 27 countries for world average: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Venezuela, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, Denmark, Spain, France, Italy, Netherlands, Sweden, UK and US.

[2] Observe that the TFP level for formal non-agricultural sector is normalized to 1. However, as an outcome of the calibration, the TFP of informal non-agricultural sector turn out to be greater than 1 (A similar result will show up in the five-sector model - see next section). At first sight, informal sectors having higher TFPs than formal sectors might seem puzzling and counter intuitive. However, this is quite normal since the production function assumed for informal economy in the literature does not have capital as an input (only labor and TFP) and, thus, the contribution of capital in informal sector is counted/captured by the informal TFP level, which is quite standard in the informal economy literature (see Ihrig and Moe (2004) for more details).

also set the parameter value of tax rate ($\tau$) to 0.093 following Ihrig and Moe (2004). Finally, we choose the value of ($\rho$) as 0.8, however the results are not sensitive to small changes in the enforcement rate. The parameter values are summarized in Table 1.

The results are shown in Figs. 1–4. As seen in Figs. 1 and 2, the model can track the reallocation of hours worked between agriculture and non-agriculture and the share of the informal sector remarkably well for the US. The share of employment decreases from 9 percent to 2 percent in the US between 1950 and 2005. The model predicts this decrease to be from 9 percent to 1 percent. The size of the informal sector decreases from 13 percent to 8 percent between 1960 and 2009, both in the model prediction and its data counterpart. Therefore, the model has a good predictive power for the US economy. Fig. 3 shows that, for the world average, the model predicts a faster decrease in agriculture, and therefore a faster incense in non-agriculture than its data counterpart. For the period 1951–2005, the model predicts a 9 percent larger decrease for the share of agricultural employment. Similarly, for the size of the informal sector, the model is able to pick up the downward trend, but predicts a faster decrease. The informal sector size falls from 39 percent to 25 percent during the period of 1961–2008, while the

**Table 1**
Parameter values for the three-sector model.

| | | | |
|---|---|---|---|
| $\gamma$ | 0.33 | $\beta$ | 0.96 |
| $\eta$ | 0.495 | $\delta$ | 0.08 |
| $\psi$ | 0.7 | $\xi_A$ | 0.0326 |
| $\tau$ | 0.093 | $\xi_{MF}$ | 0.013 |
| $\rho$ | 0.8 | $\xi_{MI}$ | 0.016 |

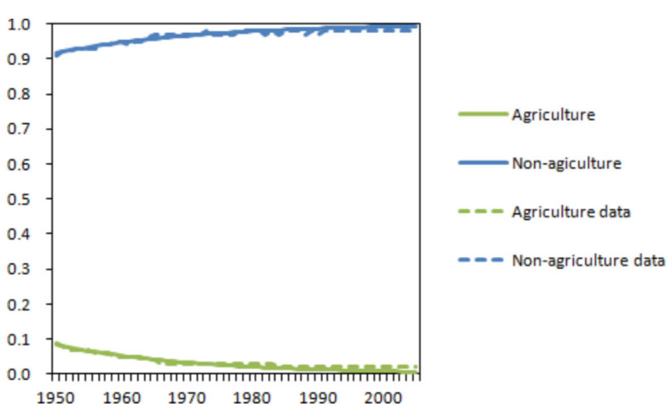


**Fig. 1.** Sectoral shares of hours worked in the U.S.

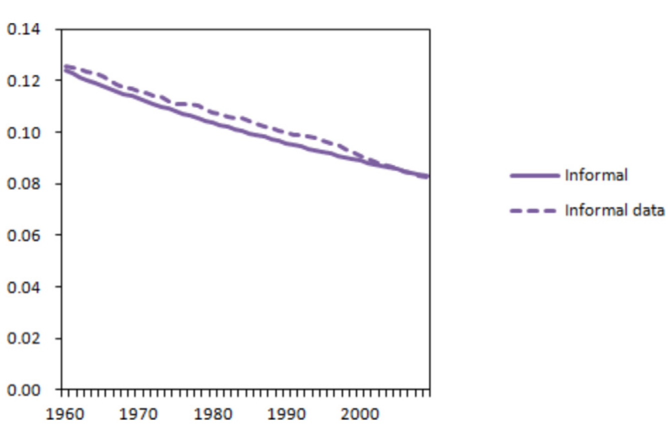


**Fig. 2.** The size of informal sector in the U.S.

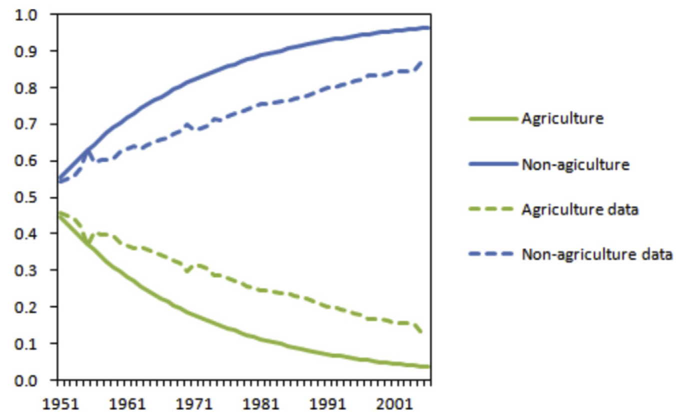


**Fig. 3.** Employment shares in world average.

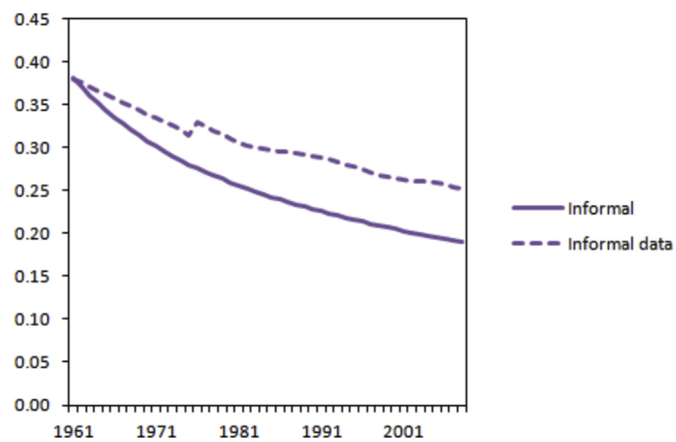


**Fig. 4.** The size of informal sector in world averag.

model predicts this decrease to be from 39 percent to 20 percent (see Fig. 4).

### 5.2. The five-sector model

The choices of parameter values are mostly similar to the three-sector model. We normalize the TFP levels in agriculture ($\theta_A$), formal manufacturing ($\theta_{MF}$) and formal services ($\theta_{SF}$) to 1. Given these, we set the initial value of TFP in informal manufacturing ($\theta_{MI}$) to 11 and informal services ($\theta_{SI}$) to 17 in order to match the initial size of the sectoral shares and informality in the US, and subsistence level consumption ($\overline{C}_A$) to 2 percent in order to match the initial size of agricultural sector in the US. To match the world average informal sector size and sectoral shares, we set the initial value of TFP in informal manufacturing ($\theta_{MI}$) to 13 and informal services ($\theta_{SI}$) to 30. We also set $\overline{C}_A$ to 5 percent to match the initial agricultural employment. We take the values of TFP growth rates in formal agriculture ($\xi_A$), formal manufacturing ($\xi_{MF}$) and formal services ($\xi_{SF}$) as 0.0326, 0.0247 and 0.0126 from Rogerson (2008). We choose the TFP growth rates in informal manufacturing ($\xi_{MI}$) and informal services ($\xi_{SI}$) as 0.03 and 0.024, respectively. Notice that the TFP growth rate in informal manufacturing is higher than that of informal services and similar to that of the formal sector.

The capital shares ($\gamma$) in manufacturing and services are both set to 0.33 (see Herrendorf and Valentinyi, 2008). Similar to the three sector model, we set the labor shares in agriculture to 0.7. The degree of diminishing returns to scale in informal manufacturing and informal services ($\eta$) are set to the same parameter value in order to be consistent with the formal sectors. This value is chosen as 0.495 following the estimates of Ihrig and Moe (2004), as in the three-sector model. The choices of the parameter values for $\beta$, $\delta$, tax rate ($\tau$) and enforcement rate ($\rho$) are similar to the three-sector model. Finally the elasticity of substitution parameter $\varepsilon$ and $\alpha$ are set to −2.65 and 0.01 respectively, following Rogerson (2008) and Ngai and Pissarides (2008). Table 2 summarizes the parameter values for the five-sector model.

Fig. 5 shows the allocation of hours worked in agriculture, manufacturing and services in the US economy between 1950 and 2005. The model makes a good prediction of the decrease in agriculture. As also seen in three-sector model predictions, agriculture decreases from 9 percent to 2 percent in that period. The model predicts this decrease to be from 9 percent to 1 percent. The model also picks up the upward trend in services, which is one of the main contribution of five-sector model compared to the three-sector model, whereas the predicted increase is slower than its data counterpart. Share of service sector increases from 57 to 78 percent in that period and the model predicts a 10 percent smaller increase. Also, the model is successful in tracking the share of employment in manufacturing in the first half of the period. However, it underperforms in capturing the decrease in the second half. After 1980, the share of manufacturing employment falls from 30 percent to 21 percent, while the model predicts only a 2 percent decrease. However, observe that the five-sector model can predict the increase in services employment and decrease in manufacturing employment simultaneously, which is one of the main contribution of five-sector model compared to the three-sector model.

Fig. 6 shows that for the size of the informal sector in the US, the model makes a reasonably well prediction as in three-sector model. It is successful in capturing the 4 percent decrease. Informality in both manufacturing and services is decreasing, while there is a sharper decrease in services. However, informality in services still remains approximately two times higher than in manufacturing.

The results for the world average are shown in Figs. 7 and 8. The model is again successful in capturing the downward and upward trends for agricultural and services employment although it predicts a faster decrease in agriculture. Employment in the service sector increases from 31 to 65 percent in the given period, and the model predicts this increase to be 31 to 62 percent. However, while the data shows a 32 percentage points decrease in agricultural employment from 45 percent, the model predicts a 42 percentage points decrease. As observed in the US predictions, the model captures the rise in the manufacturing employment in the first half of the period, however it falls short of tracking the inverse-U trend. We should also note here that although it successfully captures the employment shares, the 5-sector model generates counterfactual results on output shares.

Finally, as seen in Fig. 8, the model succeeds in picking up the decrease in the informal sector. During the period 1960–2008, size of the informal sector decreases from 38 percent to 25 percent. Similarly in the model counterpart, it decreases from 38 percent to 22 percent. Notice that again, informality in services is significantly higher than in manufacturing. This is consistent with the findings of various surveys (see, for example, Lubell (1991)).

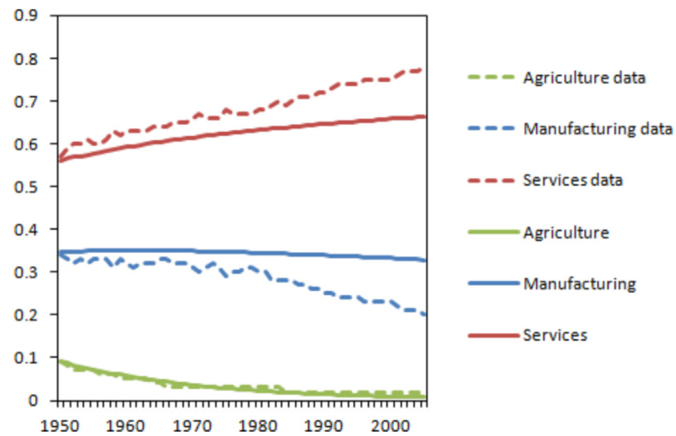


**Fig. 5.** Sectoral shares of hours worked in the U.S.

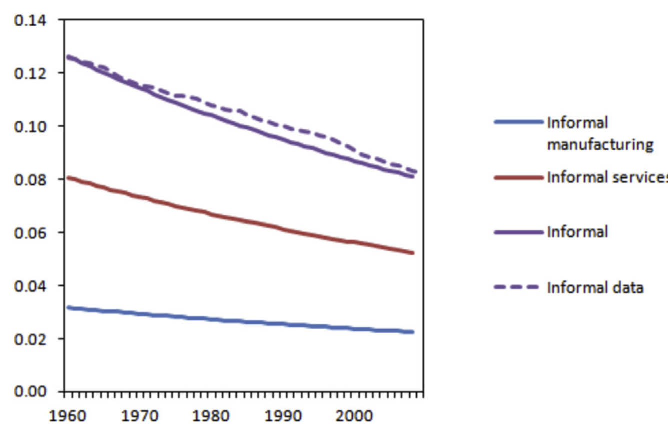


**Fig. 6.** The size of informal sector in the U.S.

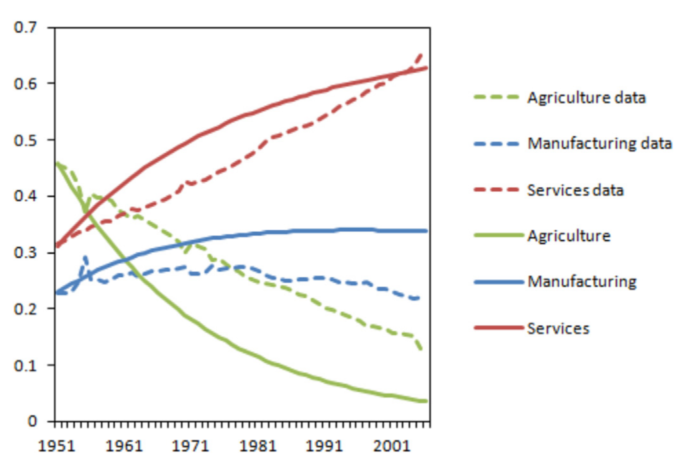


**Fig. 7.** Employment shares in world average.

**Table 2**
Parameter values for the five-sector model.

| | | | | | |
|---|---|---|---|---|---|
| $\varepsilon$ | −2.65 | $\psi$ | 0.7 | $\xi_A$ | 0.0326 |
| $\alpha$ | 0.01 | $\beta$ | 0.96 | $\xi_{MF}$ | 0.0247 |
| $\gamma$ | 0.33 | $\delta$ | 0.08 | $\xi_{SF}$ | 0.0126 |
| $\eta$ | 0.495 | $\tau$ | 0.093 | $\xi_{MI}$ | 0.03 |
| $\varphi$ | 0.495 | $\rho$ | 0.8 | $\xi_{SI}$ | 0.024 |

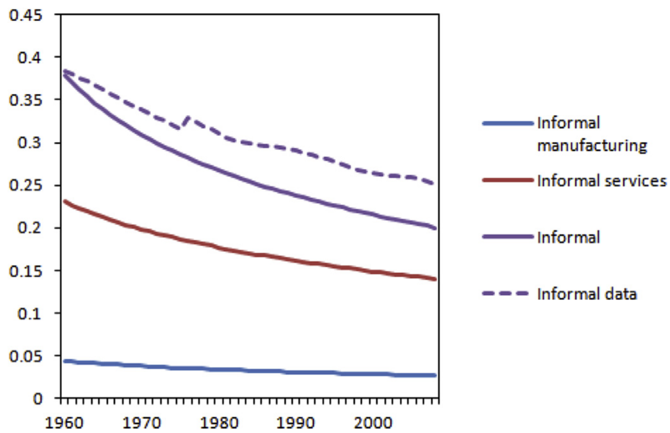


**Fig. 8.** The size of informal sector in world average.

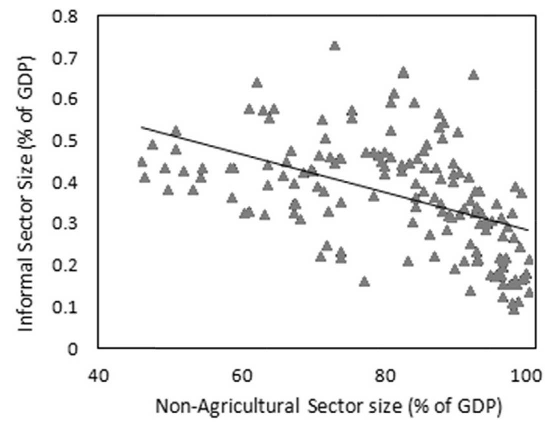


**Fig. 9.** Correlation between informal and non-agricultural sector size.

## 6. Empirical analysis

As documented in the previous section, our model performs remarkably well in accounting for the evolution of informal economy size in different sectors as well as the overall size of informal economy and the sectoral employment shares. The size of informality decreases substantially as the labor force moves out from agriculture to industry and services. The negative cross-country correlation between the informal sector and non-agricultural sector for 161 countries (see Appendix) between 1960 and 2009 is also depicted in Fig. 9. In this section, we will batter this result to a battery of econometric tests and analyze the relationship between informality and the size of non-agricultural sector.

### 6.1. Methodology

In order to establish a correlation between informal economy size and non-agricultural sector size, we will estimate the following regression equation using the fixed-effects (FE) estimator[3]:

$$IS_{i,t} = \alpha_0 + \alpha_1 NONAGR_{i,t} + \sum_{k=2}^{n} \alpha_k X_{ki,t} + \theta_i + \gamma_t + \varepsilon_{i,t} \quad (28)$$

Here, $IS_{i,t}$ is the informal sector size and $NONAGR_{i,t}$ is the non-agricultural sector size as % of GDP in country $i$ in year $t$. $X_{k_{i,t}}$ denotes the other explanatory variables, which are GDP per-capita, trade openness, government spending, capital-output ratio, growth rate, law and order index, corruption control index and bureaucratic quality index. $\theta_i$, $\gamma_t$ are the country and period fixed effects, respectively. Finally, $\varepsilon_{i,t}$ denotes the error term.

### 6.2. Data

Empirical studies on informality are rare because of limited data availability, since informality is hard to measure by definition. The largest data set in the literature was the one constructed by Buehn and Schneider (2012), and this included data from 161 countries but only for 9 years (from 1999 to 2007). However, the size of the non-agricultural sector, which is the central component of our empirical analysis, does not vary much over a short time horizon such as 9 years. Since we aim at examining the evolution of the shadow economy through the course of structural transformation, we borrow from the shadow economy estimates constructed by Elgin and Oztunali (2012) for 161 countries over the period from 1950 to 2009.

We measure the size of the non-agricultural sector as the total of industry (ISIC Rev.3 divisions 10–45) and services value added (ISIC Rev.3 divisions 50–99) as % of GDP. The data is extracted from the World Development Indicators of the World Bank. Other control variables that we use are GDP per-capita, trade openness (defined as the ratio of the sum of exports and imports to GDP), government spending (as % of GDP), capital-output ratio and three institutional quality indices, i.e. corruption control, law and order and bureaucratic quality. The indices are obtained from the International Country Risk Guide of the PRS Group and the rest of the variables from Penn World Tables 7.1. The list of countries used in the empirical analysis is given in the Appendix.

The dataset covers 161 countries for the years between 1960 and 2009. However, in order to avoid identifying business cycle effects, we took five year averages, reducing the time dimension of the panel to 10. Table 3 provides descriptive statistics for all variables used in the empirical analysis.

### 6.3. Estimation results

Estimation results are reported in Table 4. We observe that a larger non-agricultural sector size is associated with a smaller informal sector size in 1 percent significance level, and this result is robust to the inclusion of different control variables. Another variable that seems to have an important effect is capital-output ratio. Capital-output ratio has a negatively significant coefficient in all regression equations. We also observe that government spending is significantly correlated with the informal sector size when all of the explanatory variables are included. A higher government spending indicates lower levels of informality. Finally, we observe that institutional quality matters. Higher values of law and order and bureaucratic quality indices are significantly associated with a lower informal sector size.

## 7. Conclusion

The importance of informality in both less-developed and advanced countries is widely acknowledged. In this paper we aim to shed light on the evolution of the informal sector through the process of structural transformation. We show that a combined framework of non-homothetic preferences and differences in sectoral productivity can drive the labor reallocation between agriculture, industry and services, and between the formal and

[3] For robustness checks, we also have estimated the same equation using different estimators and obtained qualitatively similar results.

**Table 3**
Complete dataset summary statistics: 5-Year averages from 1960 to 2009.

| | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Informal Sector Size (%) | 35.98 | 14.3 | 8.09 | 80.01 |
| Non-agricultural Sector Size (%) | 80.73 | 15.88 | 11.62 | 100 |
| GDP per-capita (thousand USD) | 8.68 | 11.63 | 0.16 | 125.37 |
| Trade Openness | 72.25 | 48.93 | 2.51 | 415.28 |
| Govt. Spending (%) | 11.03 | 7.29 | 0.35 | 56.49 |
| Capital-Output Ratio | 1.92 | 0.89 | 0.22 | 11.67 |
| Growth (%) | 2.24 | 4.26 | −31.59 | 54.45 |
| Law and Order | 3.65 | 1.48 | 0.73 | 6 |
| Corruption Control | 3.1 | 1.35 | 0 | 6 |
| Bureaucratic Quality | 2.16 | 1.19 | 0 | 4 |

**Table 4**
Informality vs. Structural Transformation: FE Estimations (5-year averages).

| Informality | −1 | −2 | −3 | −4 | −5 | −6 | −7 | −8 |
|---|---|---|---|---|---|---|---|---|
| Non-Agr. | −0.28* | −0.28* | −0.28* | −0.25* | −0.25* | −0.15* | −0.15* | −0.14* |
| | (-7.61) | (-7.63) | (-7.62) | (-6.16) | (-6.03) | (-3.66) | (-3.66) | (-3.29) |
| GDP per capita | | −0.03 | −0.03 | −0.05 | −0.05 | −0.02 | −0.02 | −0.02 |
| | | (-0.49) | (-0.44) | (-1.09) | (-1.06) | (-0.61) | (-0.57) | (-0.47) |
| Openness | | | −0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | | | (-0.45) | −0.98 | −0.95 | −0.95 | −1.03 | −1.08 |
| Govt. Sp. | | | −0.04 | −0.01 | −0.01 | −0.12 | −0.12 | −0.13*** |
| | | | (-0.67) | (-0.12) | (-0.08) | (-1.51) | (-1.57) | (-1.73) |
| Capital-output ratio | | | | −3.75* | −3.65* | −2.90* | −2.90* | −3.04* |
| | | | | (-4.96) | (-4.31) | (-3.53) | (-3.43) | (-3.92) |
| Growth | | | | | 0.03 | 0.02 | 0.03 | −0.01 |
| | | | | | −0.46 | −0.43 | −0.44 | −0.28 |
| Law | | | | | | −0.54* | −0.60* | −0.49** |
| | | | | | | (-2.69) | (-2.99) | (-2.38) |
| Corruption | | | | | | | 0.24 | 0.39 |
| | | | | | | | −0.93 | −1.55 |
| Bur. Qual. | | | | | | | | −0.66** |
| | | | | | | | | (-2.23) |
| R-squared | 0.27 | 0.29 | 0.28 | 0.36 | 0.36 | 0.3 | 0.28 | 0.3 |
| Observations | 1063 | 1063 | 1063 | 895 | 895 | 522 | 522 | 522 |
| F-Test | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Time F-Test | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

All panel regressions include a country fixed effect and year dummies. Absolute values of robust t-statistics are reported in parentheses. *, **, *** denote 1, 5 and 10% confidence levels, respectively. F-test refers to the p-value of the joint significance of all the coefficients, whereas Time F-test refers to the joint significance of the year dummies.

informal sectors. We find that labor moves to the sectors with lower rates of productivity growth, as emphasized by Ngai and Pissarides (2007). We also find that the size of the informal sector decreases through structural transformation, with informality decreasing in both industry and services.

The quantitative implications of our models are consistent with the data where employment share in agriculture decreases, industry follows an inverse-U-shaped pattern and services increases through the period 1950–2005. Predictions of the model also match well with the informal sector dynamics observed in the data set. Finally, using panel data estimations, we find strong empirical support for our observation in the model on the relationship between the size of non-agricultural sector and informality. We show that a larger non-agricultural sector is associated with a smaller informal sector size.

## APPENDIX

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Bosnia, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Chile, China, Colombia, Democratic Republic of Congo, Republic of Congo, Costa Rica, Cote Divore, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea Republic, Kuwait, Kyrgyzstan, Latvia, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syria, Taiwan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

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