Trade openness effects through price channels on firms' informal employment: The case of Peru

Jorge Dávalos*

Department of Business Administration,
Universidad del Pacífico

This version, august 2015

Abstract

This paper seeks to estimate the impact of sector specific international price shocks on informal employment demand. Such impact is specified by a theoretical model where law enforcement (regulation) is an important determinant of the formal-informal employment demand allocation decision. It is shown that trade-openness effects on informality are channeled through prices, thus the proposed *price-informality* multiplier is interpreted as a formal labour vulnerability to trade openness proxy indicator. By combining national accounts and labour force survey data the multiplier is estimated for a set of tradable sectors of the Peruvian economy for 2004-2013. The theoretical and empirical evidence suggests the presence of structural sector specific 'informality traps'. It also raises awareness regarding the need of sector specific regulatory frameworks that could ease the regulatory burden at firms exhibiting structural proneness to formality.

*This research is supported by the R4D initiative on Employment and labour market outcomes, funded by the Swiss National Science Foundation and the Swiss Development Cooperation. The usual disclaimer applies.
Electronic address: `je.davalosc@up.edu.pe`

1 Introduction

Informal employment is considered a core employment quality indicator due to its negative implications e.g. lack of social protection and poor labour regulatory coverage. Even thought informality can be considered as a mean to get out of poverty, it's also the manifestation of structural concerns such as low productivity and inequality which may undermine economic development and inclusive growth. Thus, understanding how informality responds to key economic drivers such as trade-openness and international price shocks, is considered an important topic for policy makers in latin-america, where informality attains almost a half of the employed labour force.

In the latest decades, trade-openness, a key economic development driver, raised in many latin-american countries leading to ambiguous effects on jobs' quality. The empirical literature (Fugazza and Fiess (2010), Aleman-Castilla (2006) and Bachetta, Ekkehard and Bustamente (2009)) finds both positive and negative relationships with unclear theoretical foundations. The more structural approach proposed by Goldberg and Pavcnik (2003) argues that trade-openness (lower tariffs) leads to higher competition in local markets, which in turn leads to lower profits and higher informal employment; such relationships were tested on data from Brazil and Colombia finding a non-significant effect in the former and a significant effect in the latter but only at industries exhibiting the highest tariff cuts. Thus, Goldberg and Pavcnik (2003) explain their empirical findings as the result of the dominant effects of labour market frictions with respect to trade-openness.

This paper acknowledges that low statistical variability in trade-openness makes econometric identification a difficult task.Thus, this paper contributes to the literature by proposing simple structural measurement framework where potential trade-openness effects are only assessed through an observable variable (prices faced by the firm) which exhibits *high variability*. Since prices faced by the firm converge to international ones as trade-openness increases, it follows that a trade-openness effect can also be mimicked by a price variation i.e. price shocks are a trade-openness monotonic function. The measurement framework introduces regulation costs and contributes to the literature by suggesting a proxy for its measurement in the spirit of Wooldridge (2009).

The structural model allows for the estimation of a multiplier of sector specific price shocks on informal employment demand. Such assessment contributes to the identification of 'vulnerable to trade' labour markets and will help policy makers in the implementation of trade and labour market interventions. It is shown that regulatory costs play an important role in such effect.

The paper is structured in five brief sections. The second (next one) presents the set of basic assumptions and the theoretical model behind the definitions of this paper's multipliers. The third section describes the data

and gives a statistical outlook of the Peruvian formal and informal labour market structure. The fourth section presents the econometric methodology and multipliers estimation. The final section presents the concluding remarks.

2 Main assumptions and theoretical model

The model presented in Davalos (2012) links trade openness to informality through the convergence of local prices to international ones. It identifies a dual theoretical macroeconomic relationship that relies upon price competitiveness. The empirical validity of such model has aggregation issues as it assumes that all the firms in the economy had their autarky prices either above or below international ones. To deal with this issue, this paper focus on the microeconomic relationship, at the firm level. The model's main assumptions are summarized below :

a. Under autarky (in a single sector), local prices may be above or below international ones.

b. As trade openness increases, local prices converge to international ones. This implies that local prices (and firms' profits) may increase or diminish.

c. Smaller firms, measured by the number of employees, are less likely to be controlled by fiscal and regulatory institutions, therefore, they are more likely to allocate informal jobs (Almeida and Carneiro, 2009). Informal jobs do not comply with social or health regulatory frameworks and are therefore less costly for the firm.

d. From (b) and (c) it can be shown that an increase in trade-openness will encourage informal jobs if international prices are below autarky ones. Increasing trade openness lowers local prices and firms' profits, which in turn, reduces firms' size and increases their propensity to default taxes/avoid labour regulation. Therefore, under the model assumptions, higher international prices (with respect to autarky ones) imply a negative relationship between trade openness and the propensity to create informal jobs.

e. From (d), lower international prices, with respect to autarky ones, imply a positive relationship.

Theoretical model

The following presents a static theoretical model at the firm level. A firm production function depends on capital and two types of labour $q = q(k, l, \tilde{l})$. Where l and $\tilde{l}$ represent formal and informal employment respectively.

$$q = al^{\alpha}\tilde{l}^{\beta}k^{\gamma} \quad ; \quad q = a_k l^{\alpha}\tilde{l}^{\beta}$$

For the sake of simplicity, capital is assumed fixed such that $a_k = aK^{\gamma}$ whereas the production function has constant returns to scale ($\alpha + \beta + \gamma = 1$).

Informal jobs are less costly to the firm since employers evade labour regulations such as social security contributions. Thus, informal wages $\tilde{w}$ lie in between a reservation wage w_r and a formal wage w :

$$\tilde{w}\,\epsilon\,[w_r, w)$$

Firms' probability to be controlled (ψ) increases with its size, which is determined by total employment. Firms consider the evasion penalty as an unknown random event. When caught, firms must pay a fine proportional to their informality degree, where the maximum penalty fee and informality degrees are denoted as τ and δ respectively. Thus, the expected penalty fee may be denoted as $\psi\delta\tau$ while the expected cost function writes:

$$c = wl + \tilde{w}\tilde{l} + rk + \psi\delta\tau$$

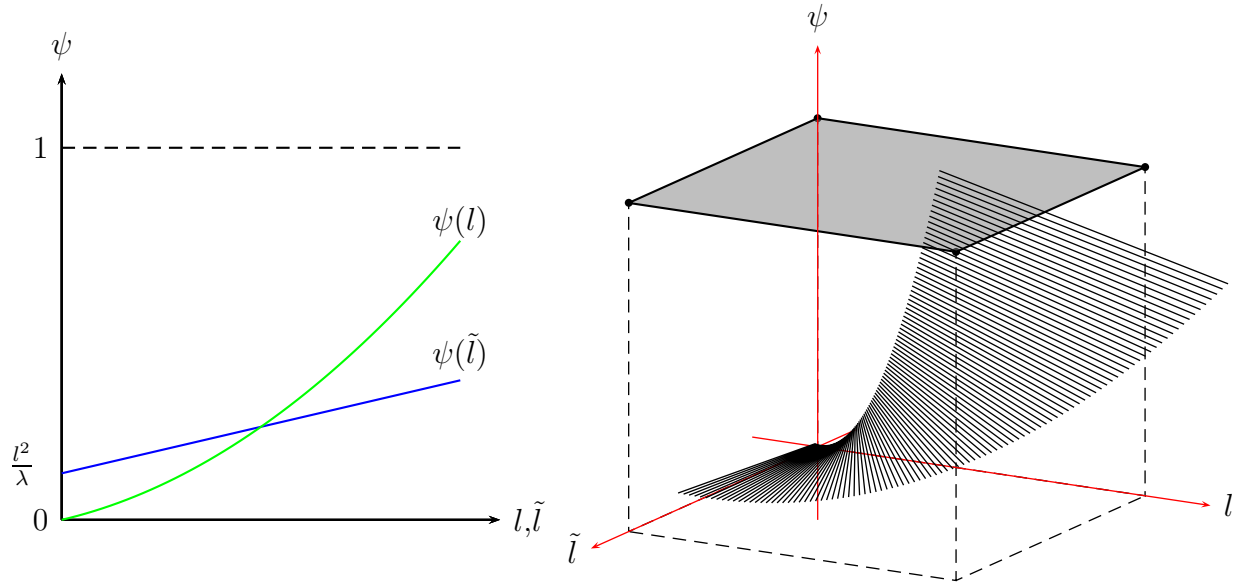
where r is capital unitary cost.

The probability to be controlled (ψ) by a labour market regulatory institution increases with firm's size. More specifically, firms hiring formal employees (declared workers) are more likely to be detected than firms hiring informal ones since the regulatory institution can only measure firm's size by their registered employment. Thus, firm's probability to be controlled is asymmetric with respect to formal and informal employment :

$$\psi = l\,\frac{l+\tilde{l}}{\lambda} \quad ; \quad l(l+\tilde{l}) < \lambda \quad \Rightarrow \quad \psi\,\epsilon\,[0,1)$$

The bounding parameter λ can be interpreted as an asymptotic maximum for $l(l+\tilde{l})$ that ensures the probability to be comprised between 0 and 1. Under this specification an additional informal employee increases the control probability by l/λ whereas an extra formal employee increases such probability by $(2\,l+\tilde{l})/\lambda$.

Figure 1: Control probability and employment levels



The previous figure (1) shows how the probability of being controlled is affected by formal and informal employment. At a given formal employment level, increasing informal employment causes the probability ψ to increase linearly as shown by the $\psi(\tilde{l})$ function (blue). Raising formal employment while keeping informal employment constant has a more important effect on the probability as shown by the $\psi(\tilde{l})$ function (green).

The choice of ψ functional form not only reflects firms higher visibility of formal employment in terms of the probability to be controlled but also allows for tractable analytical expressions, among them: firm's expected penalty fee ($\psi\delta\tau \equiv \frac{l\tilde{l}\tau}{\lambda}$) and the implied differential equations for formal and informal employment demands (see equation 4)

Firm's informality degree is defined as the informal employment share:

$$\delta = \frac{\tilde{l}}{\tilde{l} + l} \quad \Rightarrow \quad \delta \, \epsilon \, [0, 1]$$

Firm's maximize their expected profit (1) by demanding optimal formal and informal employment levels.

$$\tilde{p}q - (wl + \tilde{w}\tilde{l} + \psi\delta\tau) \tag{1}$$

Local prices faced by the firm ($\tilde{p}$) depend on international p and autarky prices p^0. Complete trade openness ($\eta \to \infty$) implies that no trade barriers may exist, thus firms face the international price ($\tilde{p} = p$) whereas under trade absence ($\eta = 0$) firms face a latent autarky one ($\tilde{p} = p_0$). This is reflected by a simple model where prices faced by the firm lie in between international and autarky ones :

$$\tilde{p} = p^{1-\omega_0} \, p_0^{\omega_0} \quad ; \quad \omega_0 = \frac{1}{1+\eta} \, , \quad \eta \, \epsilon \, [0, \infty) \tag{2}$$

Local prices ($\tilde{p}$) are modeled as a geometric weighted mean of autarky and international prices where higher trade openness implies $\omega_0 \to 0$, whereas autarky implies $\omega_0 = 1$. Therefore, trade-openess impact on observed prices is given by the following multiplier with respect to η where p_0 and p are held constant by definition:

$$d \, \log(\tilde{p}) = \underbrace{\frac{1}{(1+\eta)^2}}_{\pi} \log(\frac{p}{p_0}) d\eta \tag{3}$$

Since trade-openness at the sectoral level is not observed, we assume π (which is bounded between 0 and 1) highly stable (constant) i.e. that the relationship between $\log(\tilde{p})$ and η can be accurately proxied by a Taylor first order approximation. Mathematically, such assumption holds for small trade openness variations. Empirically, evidence at the country level suggest that

trade-openness indicators tend to exhibit low variability (Dreher, 2006).

Therefore, in order to measure the impact of trade-openness on informal employment, one first needs to identify the impact of price-shocks on informal employment (chain rule). From the expression above, any trade-openness multiplier would be related to a price ($\tilde{p}$) up to an unknown constant of proportionality given by $\pi \log(p_0/p)$. Thus, instead of focusing on the estimation of trade-openness multipliers, this paper focuses on price multipliers.

2.1 Informal employment demand per formal worker

Real informal employement effects are evaluated through the relative informal to formal employment demand ratio as it determines firm's informality degree :

$$\delta \equiv \frac{1}{1 + (\frac{\tilde{l}}{l})^{-1}}$$

Closed expressions for labour demands are not available due the non-linearities involved at the first order conditions, nevertheless their implied differential equations can be easily retrieved (see eq. 9). Thus, the analytical impact of price changes on the informal to formal employment ratio ($\tilde{l}/l$) is evaluated by calculating the formal and informal employment elasticity differential with respect to local price changes :

$$\frac{d\,\tilde{l}}{\tilde{l}} - \frac{d\,l}{l} = \frac{2-\alpha-\beta}{(1-\alpha)(1-\beta)} \left[\beta - \alpha + \frac{(1-\alpha)wl - (1-\beta)\tilde{w}\tilde{l}}{\psi\delta\tau} \right] \frac{d\,p}{p} \tag{4}$$

This multiplier can be splitted in two components as follow. The first one ($m_1(\alpha, \beta)$) measures the price shock effect on the (relative) informal employment demand due to formal-informal employment intensities. Its sign is leaded by the $\beta - \alpha$ differential i.e. rising prices pushes firm's relative demand of the factor on which they are the most intensive.

$$\frac{d\,\tilde{l}}{\tilde{l}} - \frac{d\,l}{l} = \left[\underbrace{\frac{(2-\alpha-\beta)(\beta-\alpha)}{(1-\alpha)(1-\beta)}}_{m_1} + \underbrace{\frac{(2-\alpha-\beta)wl}{(1-\beta)\psi\delta\tau} - \frac{(2-\alpha-\beta)\tilde{w}\tilde{l}}{(1-\alpha)\psi\delta\tau}}_{m_2)} \right] \frac{d\,p}{p} \tag{5}$$

The second multiplier (m_2) accounts for expected costs attributed to the regulatory risk of employing informal workers. Extreme law enforcement can be accounted by an extreme penalty fee $\tau \to \infty$ which annihilates price shocks effects that results of regulatory risk. Conversely, poor law enforcement ($\tau \to$

0) leads to a higher potential impact (either positive or negative) on informal labour demand[1]

2.2 Trade openness and prices effects on informal employment

Trade openness effects are channeled through prices as can be seen by relating the previous expression to equation 3 :

$$\underbrace{\frac{d\,\tilde{l}}{\tilde{l}} - \frac{d\,l}{l}}_{\mathbf{y}_\eta} = [m_1 + m_2]\,\pi \log(p/p_0) d\eta \tag{6}$$

Since π is bounded between 0 and 1, $m_1 + m_2$ can be interpreted as an upper bound for the overall multiplier. The $\log(p/p_0)$ factor acts as an upper bound as well since the price multiplier will be zero if autarky prices matches international ones. Thus this section focuses on the impact of price variations on firm's informality degree $(m_1 + m_2)$ under the assumption that international and autarky prices are not equal. From eq. (5), a positive impact of price variations on informality implies the following inequality .

$$\frac{1-\beta}{1-\alpha} < \frac{\psi\delta\tau + wl}{\psi\delta\tau + \tilde{w}\tilde{l}} \tag{7}$$

Let's first assume that formal and informal workers have equal intensity $(\alpha = \beta)$ and $w > \tilde{w}$. The following stylized facts follow :

- The formal - informal payroll differential in eq. (4) implies that any price increase would trigger a higher production by unambiguously increasing the share of the cheapest labour force. For instance, a firm facing a positive price shock and with no informal workers $(wl - \tilde{w}\tilde{l} > 0)$ would increase its informality degree. Conversely a firm with no formal workers $(wl - \tilde{w}\tilde{l} < 0)$ would hire more formal workers than informal ones.
- This expression (4) also illustrates that firm's informality degree (δ) will attain an equilibrium once both payrolls equalize. Since formal wages are expected to be higher than informal ones, the equilibrium informality degree is expected to be higher than 0.5. This is a straighforward outcome that results from equalizing equation (4) to zero. Thus, $\frac{w}{\tilde{w}} = \frac{\tilde{l}}{l} > 1$ and the equilibrium informality degree is given by $\frac{w}{w+\tilde{w}}$.

[1]The sign of the multiplier (m_2) is determined by the labour shares' relationship :

$$m_2 > 0 \Leftrightarrow \frac{wl}{\tilde{w}\tilde{l}} > \frac{1-\beta}{1-\alpha}$$

- Compliance and law enforcement is an important determinant of price's impact on informal employment demand. Law enforcement translates into a higher probability of being controlled i.e. a lower λ and/or a higher penalty fee (τ), both implying a higher expected cost of hiring informal workers ($\psi\delta\tau$). As a result, law enforcement unambiguously discourages the increase of a firm's informality degree.
- It should be noted that the expected penalty fee imposes a marginal cost to the formal employment since firms' visibility increases with the firms' formal employment.

Inequality (7) refers to an alternative scenario where the firm is formal-employment intensive ($\alpha > \beta$). From it may be concluded that:

i. Firm's informality degree would rise if and only if the formal employment economic payroll ($\psi\delta\tau + wl$) relative to the informal one ($\psi\delta\tau + \tilde{w}\tilde{l}$) is greater than the factor intensity ratio (α/β) i.e. formal employment intensive firms would increase their informality rate if the formal employment economic cost (which includes expected penalty fees) is too important.

Changing the sense of the inequality (7) implies:

ii. Firm's formality degree would rise if and only if the informal employment economic payroll ($\psi\delta\tau + \tilde{w}\tilde{l}$) relative to the formal one ($\psi\delta\tau + wl$) is lower than the factor intensity ratio (α/β) i.e. informal employment intensive firms would increase their formality rate if the informal employment economic cost (which includes expected penalty fees) is too important.

Absolute law enforcement ($\tau \to \infty$), other things been equal, introduces an infinite penalty fee which discourages firms to increase both labour demands (formal or informal) i.e. the previous effects (i and ii) are annihilated.

3 Data & Descriptive statistics

The empirical analysis is implemented at the sectoral level and gathers its employment data from the labour market module of Peru's households living conditions survey (ENAHO[2]) for the period 2004-2013. The ENAHO survey is a 'continuous' one i.e. implemented along the whole year in order to avoid collecting seasonal behaviors. The survey is representative of the many economic activities and regions either 'departamentos' or rural/urban ones. Sampling weights are comparable and adjusted to 2007 national census by INEI. Additional data regarding the national accounts such as sectoral production and prices indexes are collected from the local Statistical Office (INEI[3]).

[2]'Encuesta Nacional de Hogares'
[3]Instituto Nacional de Estadistica e Informatica

Informal employment at the individual level is measured according to ILO's statistical definition. See Hussmanns (2004) for a detailed description on past and current definitions. According to the ILO persons in informal employment (a job-based concept) represents the sum of informal jobs in formal enterprises, informal sector enterprises, and households producing goods for own consumption or hiring paid domestic workers. Persons employed in the informal sector (an enterprise-based concept) include the informal jobs in informal enterprises plus formal jobs in informal sector enterprises. Persons employed in informal employment outside the informal sector include those employed in the formal sector and households producing goods for own use or employing paid domestic workers. Next table (1) shows such distribution for 2013 employed sample. Formal and informal sector, an enterprise based classification, accounts for 35.7% and 57.4% respectively whereas households account for 2.6%. In the case of Peru, the labour force survey questions do not allow for clear classification of agricultural activity households into formal or informal sector, thus it is presented as a category by itself. Finally, informal employment, a job based classification, stays at 73.6%, higher than the latin-american average (around 50%).

Table 1: Formal and informal employment distribution across production units and economic sectors (2013)

	Labour status					
	Formal employment		**Informal employment**		**Total**	
	Col %	Row %	Col %	Row %	Col %	Row %
Production unit						
Formal sector	95.2	65.7	24.4	34.3	47.8	100.0
Informal sector	2.5	1.7	71.5	98.3	48.8	100.0
Households	2.3	22.1	4.0	77.9	3.5	100.0
Total	100.0	33.0	100.0	67.0	100.0	100.0
Economic sector						
Fishing	0.4	16.7	1.1	83.3	0.9	100.0
Minerals, petroleum and gas	3.4	61.3	1.1	38.7	1.9	100.0
Manufacture	15.0	30.3	18.0	69.7	17.0	100.0
Electricity and water services	0.1	89.6	0.0	10.4	0.0	100.0
Construction	6.8	23.7	11.5	76.3	9.9	100.0
Commerce	18.9	19.4	41.2	80.6	33.6	100.0
Transport and communications	4.9	15.4	14.0	84.6	10.9	100.0
Hotels and restaurants	0.9	44.7	0.6	55.3	0.7	100.0
Telecomunications	3.2	83.4	0.3	16.6	1.3	100.0
Financial services	14.6	72.4	2.9	27.6	6.9	100.0
Services to entreprises	19.8	83.0	2.1	17.0	8.2	100.0
Public administration	7.9	69.9	1.8	30.1	3.9	100.0
Other services	4.0	28.8	5.2	71.2	4.8	100.0
Total	100.0	34.3	100.0	65.7	100.0	100.0

Source: Author's calculation from ENAHO 2013 survey

Table 1 also presents the informal employment distribution across the many economic activities. Agriculture, transport and communications, fishing and commerce have the highest informality degrees whereas higher labour productivity sectors such as Electricity and water services, telecommunications, and hotels and services to enterprises exhibit the lowest ones.

As argued earlier, economic literature acknowledges that smaller firms are more likely to avoid the regulation and therefore, to create informal jobs. The distribution of formal/informal employment across different firm's sizes, measured by the number of employees (Table 2), supports such stylized fact.

The collected data can be best described as a pseudo-panel of economic activities that combine information from household surveys such as sectoral payrolls, formal and informal employment, and national accounts which provide output nominal values. The implied inconsistencies between households surveys and national accounts are acknowledged and assessed. The following

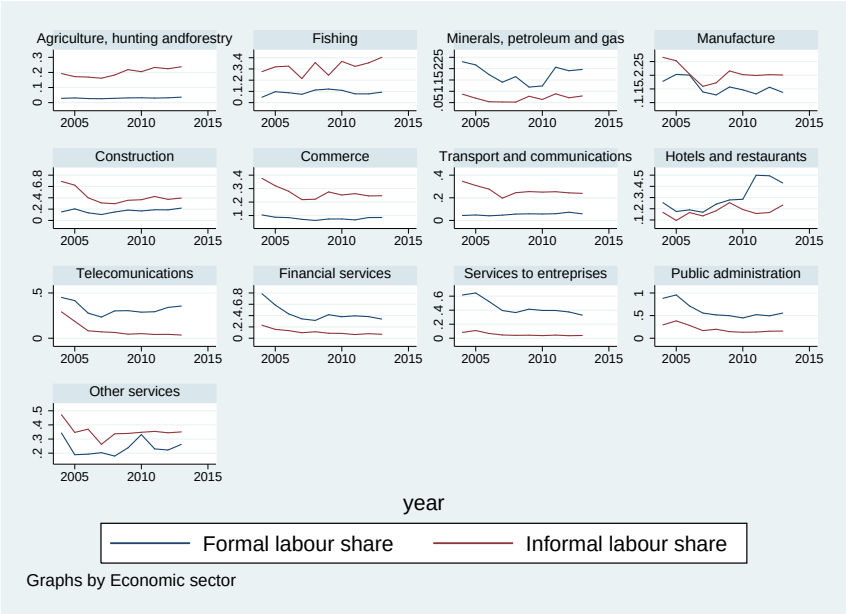
Table 2: Formal and informal employment distribution across firms' size (2013)

Firms' size	Labour status					
	Formal employment		Informal employment		Total	
	Col %	Row %	Col %	Row %	Col %	Row %
<5	15.9	8.7	80.0	91.3	59.2	100.0
6 - 20	12.5	37.8	9.9	62.2	10.7	100.0
21 - 50	8.4	60.1	2.7	39.9	4.5	100.0
51 - 100	6.5	70.7	1.3	29.3	3.0	100.0
101 - 500	11.2	77.7	1.5	22.3	4.7	100.0
>500	45.5	82.4	4.7	17.6	17.9	100.0
Total	100.0	32.4	100.0	67.6	100.0	100.0

Source: Author's calculation from ENAHO 2013 survey

figure (2) presents the formal and informal labour shares for the set of economic activities. As expected, labour shares time series are stable (stationary) and are comprised between zero and one.

Figure 2: **Formal and informal employment labour shares 2004-2013**



Peru's exports are mainly concentrated on two economic sectors: Minerals petroleum & gas and manufactures. As most of these sectors' final demand comes from exports, it's assumed that price variations are mainly leaded by international markets. In terms of our theoretical model (equation 2), this implies that international prices' variations (p) are the most important deter-

minants of observed ones ($\tilde{p}$) i.e. trade openness is at its highest ($\pi \to 0$).

4 Econometric methodology

The econometric methodology seeks to estimate the theoretical relationship (5) linking informality rates and price shocks at the sectoral level. Once measured, such relationship can be interpreted as a theoretical based indicator of sectoral formal employment vulnerability to international price shocks. Many econometric issues make this a challenging task. Among the most important, the lack of sectoral capital stocks data (missing k), short length of the available (formal and informal employment) time series[4] and the endogeneity concerns. As in any production function estimation procedure, the linearized Cobb-Douglass production function does not yield unbiased estimates unless firms' implied simultaneous decision making process is taken into account, which typically involves an instrumental variables, GMM or analog approaches. For a review of alternative methods see Olley and Pakes (1996); Doraszelski and Jaumandreu (2013) and Van Beveren (2012) among others.

Instead, the adopted empirical strategy exploits the following theoretical relationships which result from the first order conditions that relate marginal income and costs under our Cobb-Douglas production function. Also, workers are paid wages that may deviate from its marginal productivity either in the formal or the formal labour markets. This approach allows for the estimation of labour elasticities without controlling for capital. See Felipe and Adams (2005) for further references on the caveats of this approach.

$$w = p\left(\frac{\partial q}{\partial l} + \theta\right) \quad ; \quad \tilde{w} = p\left(\frac{\partial q}{\partial \tilde{l}} + \tilde{\theta}\right) \tag{8}$$

Here, (θ, $\tilde{\theta}$) are real wage differentials between the received wage and perfect competition ones. Thus, replacing marginal productivities leads to the labour shares expressions:

$$\frac{wl}{pq} = \alpha - \frac{\psi\delta\tau}{pq} + \theta\frac{l}{pq} \equiv \alpha - \frac{\tau}{\lambda}\frac{\tilde{l}\,l}{pq} + \theta\frac{l}{pq}$$
$$\frac{\tilde{w}\tilde{l}}{pq} = \beta - \frac{\psi\delta\tau}{pq} + \tilde{\theta}\frac{\tilde{l}}{pq} \equiv \beta - \frac{\tau}{\lambda}\frac{\tilde{l}\,l}{pq} + \tilde{\theta}\frac{\tilde{l}}{pq}$$

where the left-hand side terms are the formal and informal employment labour shares. Empirically, the previous relationship can be interpreted as a theoretical expectation of formal and informal labour shares hereafter noted y and $\tilde{y}$, conditional on the share of expected informality costs on total output value ($\psi\delta\tau/pq \equiv l\tilde{l}/pq$) and the payroll differential with respect to perfect

[4] Available from 2004 to 2013 , $T = 9$

competition (i.e. $\theta l/pq$ and $\tilde{\theta}\tilde{l}/pq$). Introducing sectoral subscripts leads to a two equations panel specification where time indices are omitted for simplicity of our notation.

$$\mathbb{E}\left(y_i|.\right) = \alpha_i - \frac{\tau}{\lambda}\frac{\tilde{l}_i\, l_i}{p_i q_i} + \theta\frac{l_i}{p_i q_i} \qquad ; \qquad \mathbb{E}\left(\tilde{y}_i|.\right) = \beta_i - \frac{\tau}{\lambda}\frac{\tilde{l}_i\, l_i}{p_i q_i} + \tilde{\theta}\frac{l_i}{p_i q_i}$$

which can be written as:

$$\mathbb{E}\left(y_i|x_i, z_i\right) = \alpha_i - \frac{\tau}{\lambda}x_i + \theta z_i \qquad ; \qquad \mathbb{E}\left(\tilde{y}_i|x_i, \tilde{z}_i\right) = \beta_i - \frac{\tau}{\lambda}x_i + \tilde{\theta}\tilde{z}_i$$

The system of two equations for the *i-th* sector in matrix notation, as a function of y_i x_i, z_i, $\tilde{z}_i$, $\mathbf{1}$, $\mathbf{0}$ ϵ_i and $\tilde{\epsilon}_i$, all vectors of the size of the time series length.

$$\begin{bmatrix} y_i \\ \tilde{y}_i \end{bmatrix} = \begin{bmatrix} \mathbf{1} & 0 & x_i & z_i & \mathbf{0} \\ 0 & \mathbf{1} & x_i & \mathbf{0} & \tilde{z}_i \end{bmatrix} \begin{bmatrix} \alpha_i \\ \beta_i \\ \tau/\lambda \\ \theta \\ \tilde{\theta} \end{bmatrix} + \begin{bmatrix} \epsilon_i \\ \tilde{\epsilon}_i \end{bmatrix} \quad i = 1, ..., n$$

The model is estimated from its structural form by 3SLS and IV-3SLS (see Table 3). While the former assumes the exogeneity of the explanatory variables the latter controls for the endogeneity that arises from the simultaneous determination of labour shares and labour demands. The chosen instruments include current and lagged prices, lagged wages (formal and informal) and lagged interactions noted as x in the system above. A Hausman endogeneity tests does not reject the exogeneity assumption, thus, the multipliers identified in equation 5 are estimated from the 3SLS estimator.

The underlying expected informality cost function ($\psi\delta\tau$) that enters the previous system is unknown to the econometrician. Therefore the term $\tilde{l}l\tau/\lambda$ can be interpreted as a proxy of an unobserved variable in the espirit of Wooldridge (2009). The econometric results exhibit the expected signs despite the lack of statistical significance for the τ/λ parameter[5]. Nevertheless, it should be noted that expected regulatory costs $\psi\delta\tau \equiv \tilde{l}l\tau/\lambda$ are highly significant at 1% level.

.

[5]Such result requires careful interpretation since its estimated bilateral p-value is 0.145 and a unilateral test (whose alternative hypothesis can not be other than this parameter been positive) would be accepted at at 8% significance level

Table 3: Econometric estimation: 3SLS with endogenous regressors

	(F)	(I)	IV (F)	IV (I)
Fishing	0.057	0.270	0.016	0.261
	(0.024)*	(0.017)**	(0.044)	(0.021)**
Minerals, petroleum and gas	0.163	0.067	0.142	0.065
	(0.023)**	(0.017)**	(0.023)**	(0.015)**
Manufacture	0.119	0.183	0.083	0.187
	(0.024)**	(0.017)**	(0.038)*	(0.016)**
Construction	0.134	0.380	0.098	0.348
	(0.024)**	(0.017)**	(0.040)*	(0.016)**
Commerce	0.038	0.197	0.012	0.205
	(0.026)	(0.018)**	(0.032)	(0.019)**
Transport and communications	0.025	0.208	-0.005	0.192
	(0.024)	(0.017)**	(0.034)	(0.018)**
Hotels and restaurants	0.048	0.112	-0.180	0.145
	(0.058)	(0.021)**	(0.236)	(0.030)**
Telecomunications	0.224	0.083	0.097	0.062
	(0.033)**	(0.017)**	(0.110)	(0.015)**
Financial services	0.412	0.109	0.348	0.095
	(0.024)**	(0.017)**	(0.032)**	(0.015)**
Services to entreprises	0.289	0.046	0.092	0.047
	(0.042)**	(0.017)**	(0.170)	(0.015)**
Public administration	0.500	0.190	0.342	0.184
	(0.034)**	(0.017)**	(0.123)**	(0.015)**
Other services	0.196	0.318	0.152	0.320
	(0.025)**	(0.018)**	(0.038)**	(0.019)**
τ/λ	-0.000	-0.000	-0.002	-0.002
	(0.000)	(0.000)	(0.001)	(0.001)
θ	0.005		0.010	
	(0.001)**		(0.005)*	
$\tilde{\theta}$		0.001		0.002
		(0.000)**		(0.000)**
R^2	0.96	0.96	0.94	0.95
N	130	130	117	117

* $p < 0.05$; ** $p < 0.01$

Hausman exogeneity test: p-value 0.20

The overall multiplier is dominated by m_1 (table 4) which is interpreted as the percentage change in the relative informal employment demand ($\tilde{l}/l$). Tradable sectors that are intensive in formal rather than informal employment (financial services and services to enterprises) are prone to reduce their informality degrees as trade-openness and international prices rise. Conversely, sectors intensive in informal labour such as fishing, commerce and manufacture increase their informal employment demand.

Table 4: Informality sensitivity to price shocks, tradable sectors (m_1-multiplier)

Sector	$\hat{\alpha}$	$\hat{\beta}$	**Multiplier**	Confidence interval (95%)	
	(F)	(I)		Lower bound	Upper bound
Fishing	0.057 *	0.27 **	**0.52**	0.42	0.63
Minerals, petrol. & gas	0.163 **	0.067 **	**-0.22**	-0.33	-0.13
Manufacture	0.12 **	0.18 **	**0.14**	0.029	0.22
Commerce	0.038	0.197 **	**0.36**	0.26	0.47
Transports & comm.	0.025	0.208 **	**0.42**	0.31	0.50
Hotels and restaur.	0.048	0.112 **	**0.14**	0.01	0.32
Telecomunications	0.224 **	0.083 **	**-0.33**	-0.51	-0.17
Financial sevices	0.412 **	0.109 **	**-0.85**	-1.29	-0.93
Services to entreprises	0.289 **	0.046 **	**-0.59**	-0.35	-0.95
Other services	0.196 **	0.318 **	**0.33**	0.21	0.44

* $p < 0.05$; ** $p < 0.01$

In other words, due to the labour market segmentations, economic sectors facing higher trade-openness (international prices) and that are more intensive in low skilled labour will tend to increase their informality degree.

The second multiplier (m_2) captures the effects related to economic costs. The 'cheaper'[6] factor will unambiguously increase its relative demand (see Table 5). Thus, fishing, manufacture, transports & communications and other services exhibit informality reductions ($m_2 < 0$) as a consequence of positive price shocks. The m_2 low magnitude is explained by the high regulation costs in its denominator ($\psi\delta\tau \equiv l\tilde{l}\tau/\lambda$).

[6]In the sense of equation 7

5 Concluding remarks

From a single theoretical microeconomic model, a multiplier relating price shocks to formal and informal employment demand is defined and splitted in two components. The first multiplier (m_1) reproduces stylized facts such as the decrease of informality rates for formal (high skilled) intensive ($\alpha > \beta$) sectors facing a rise in trade-openness and international prices. A similar conclusion applies to low skilled labour intensive firms as they increase their informality degree pushed by higher international prices.

A second multiplier (m_2) accounts for relative cost effects i.e. it measures how the 'cheaper' factor[7] ,either formal or informal labour, raises its relative demand as trade-openness and prices increase. Such additional effect is attenuated by the expected regulatory costs. For one side, increasing formality raises firms' likelihood to be controlled (ψ) by the regulatory institution which in turns increases the overall expected regulatory cost ($\psi\delta\tau$). From the other, a higher informality degree (δ) increases firm's potential penalty fee $\delta\tau$. At then end, higher regulatory costs attenuate the trade-openness effects on firms' labour demand either formal or informal. In a limiting case, absolute law enforcement exposes firms to infinite expected penalty fees and anihiliates firms' labour demand caused by relative costs differentials ($m_2 \to 0$). Conversely, lack of regulation increases firms response in terms of formal or informal jobs creations.

Estimation of the first multiplier (m_1) for a set of peruvian tradable economic sectors (2004-2013) allows the identification of vulnerable labour markets. Fishing and Transports & communications, exhibit the highest multipliers i.e. their higher informal labour intensity implies their informality degrees are prone to rise as a consequence of trade-openess or international prices positive shocks. Conversely formal employment intensive sectors such as financial services and services to entreprises would exhibit the most important informality reductions as consequence of trade openness shocks. From the previous findings (theoretical and empirical) impacts based on m_1 signal the presence of an 'informality trap' i.e. only formal intensive sectors would be prone to reduce their informality degrees whereas informal intensive ones, would tend to increase it.

The previous evidence poses challenging policy concerns. First, the existence of a potential 'informality trap' which would be purely explained by the production technological process themselfs ($m_1(\alpha, \beta)$). As such, they could only be treated by medium to long term policies intended to promote structural productivity shifts at the economic sectors that are intensive in low skilled labour i.e. concerned by higher informality rates. A second issue, is related to the role of regulation and its pervasive effects even for formal jobs creation.

[7] In the sense of equation 7

From the theoretical model, such issue could be addressed by applying a regulatory penalty fees mechanism that considers firms technological structure.

As argued earlier, firms' regulatory burden imply both formal and informal marginal costs that could be eased for economic sectors that find 'cheaper' to hire formal workers ($m_2 < 0$). From our estimations such sectors would be: manufacture, commerce transport and communications, and other services. Conversely, other sectors structural proneness to informality could be discouraged by higher sector specific (production technology) penalty fees.

A Intermediate calculations

Differential equations for formal and informal employment demands are obtained from the first order conditions that result from (1). The following equation is obtained by first, solving for the first order conditions; second, by equalizing both equations on the informal to formal employment ratio ($\tilde{l}/l$):

$$\left[\frac{\tilde{l}\lambda\tau + w}{\alpha A\tilde{p}}\right]^{\frac{1}{1-\alpha}} = \left[\frac{l\lambda\tau + \tilde{w}}{\beta A\tilde{p}}\right]^{\frac{1}{1-\beta}} \tag{9}$$

Informal and formal employment differential equations are given by:

$$\begin{aligned}
\frac{d\tilde{l}}{\tilde{l}} &= -\frac{1}{\lambda\tau\tilde{l}}\,dw - \frac{(1-\alpha)(1+w/\lambda\tau\tilde{l})}{(1-\beta)(\tilde{w}+l\lambda\tau)}\,d\tilde{w} + \frac{2-\alpha-\beta}{1-\beta}\left(1+\frac{w}{\lambda\tau\tilde{l}}\right)\frac{dp}{p} \\
\frac{dl}{l} &= -\frac{1}{\lambda\tau l}\,d\tilde{w} - \frac{(1-\beta)(1+\tilde{w}/\lambda\tau l)}{(1-\alpha)(w+\tilde{l}\lambda\tau)}\,dw + \frac{2-\alpha-\beta}{1-\alpha}\left(1+\frac{\tilde{w}}{\lambda\tau l}\right)\frac{dp}{p}
\end{aligned}$$

B Informal employment demand multiplier (m_2)

Table 5: Informality sensitivity to price shocks, exporting sectors (m_2-multiplier)

Sector	$\hat{\alpha}$	$\hat{\beta}$	**Multiplier**	Confidence interval (95%)	
	(F)	(I)	m_2	Lower bound	Upper bound
Fishing	0.057 *	0.27 **	**- 0.0017**	-.0018	-0.0016
Minerals, petrol. & gas	0.163 **	0.067 **	**0.002**	0.0018	0.002
Manufacture	0.12 **	0.18 **	**-0.00021**	-0.00024	-0.000017
Commerce	0.038	0.197 **	**-0.000035**	-0.000037	-0.000033
Transports & comm.	0.025	0.208 **	**-0.00019**	-0.00021	-0.00019
Hotels and restaur.	0.048	0.112 **	**0.000013**	0.000011	0.000014
Telecomunications	0.224 **	0.083 **	**0.0011**	0.0010	0.0011
Financial sevices	0.412 **	0.109 **	**0.0091**	0.0087	0.0096
Services to entreprises	0.289 **	0.046 **	**0.00044**	0.00042	0.00045
Other services	0.196 **	0.318 **	**-0.000024**	-0.000028	-0.00002

* $p < 0.05$; ** $p < 0.01$

References

Aleman-Castilla, B. (2006), 'The effect of trade liberalization on informality and wages: Evidence from mexico', CEP Discussion Paper 763.

Almeida, R. and Carneiro, P. (2009), 'Enforcement of labor regulation and firm size', *Journal of Comparative Economics* **37**(1), 28 – 46. Symposium: Labor Regulation In Developing Countries Symposium: Labor Regulation In Developing Countries.

Bachetta, M., Ekkehard, E. and Bustamente, J. (2009), *Globalization and informal jobs in developing countries*, WTO and ILO.

Davalos, J. (2012), Trade openness and Informal employment: a Robust Exponential Tilting approach, PhD thesis, University of Geneva.

Doraszelski, U. and Jaumandreu, J. (2013), 'R&d and productivity: Estimating endogenous productivity', *The Review of Economic Studies* **80**(4), 1338–1383.

Dreher, A. (2006), 'Does globalization affect growth? empirical evidence from a new index', *Applied Economics* **38**(10), 1091–1110.

Felipe, J. and Adams, F. G. (2005), '"a theory of production" the estimation of the cobb-douglas function: A retrospective view', *Eastern Economic Journal* **31**(3), 427–445.

Fugazza, M. and Fiess, N. M. (2010), 'Trade liberalization and informality: New stylized facts', UN Policy Issues in International Trade and Commodities Study.

Giles, D. and Johnson, B. (2000), Taxes, risk-aversion, and the size of the underground economy: A nonparametric analysis with new zealand data, Econometrics Working Papers 0006, Department of Economics, University of Victoria.

Goldberg, P. and Pavcnik, N. (2003), 'The response of the informal sector to trade liberalization', *Journal of Development Economics* **72**(2), 463–496.

Hussmanns, R. (2004), Measuring the informal economy:from employement in the informal sector to informal employement, Working Paper 53, International Labour Office(Geneva), Geneva, Switzerland.

Olley, G. S. and Pakes, A. (1996), 'The dynamics of productivity in the telecommunications equipment industry', *Econometrica* **64**(6), 1263–1297.

Van Beveren, I. (2012), 'Total factor productivity estimation: A practical review', *Journal of Economic Surveys* **26**(1), 98–128.

Wooldridge, J. M. (2009), 'On estimating firm-level production functions using proxy variables to control for unobservables', *Economics Letters* **104**(3), 112 – 114.