Public Debt and Relative Prices in a Cross-Section of Countries

Vahagn Galstyan & Adnan Velic

TEP Working Paper No. 0816

July 2016

Trinity Economics Papers

Department of Economics

Trinity College Dublin

Public Debt and Relative Prices in a Cross-Section of Countries*

Vahagn Galstyan
Trinity College Dublin

Adnan Velic
Dublin Institute of Technology

July 1, 2016

Abstract

This paper examines the effects of debt and distortionary labor taxation on the long-run behavior of the relative price of nontraded goods. At the theoretical level, in a two-sector open economy model we demonstrate that higher public debt, associated with higher taxation, contracts labor supply in both traded and nontraded goods sectors. Relative prices move inversely with relative supply shifts which, in turn, depend on relative factor intensities. At the empirical level, for a panel of advanced economies, we find statistically significant effects of public debt and taxes on the relative price of nontraded goods, with higher debt and taxes associated with higher relative prices.

JEL classification: F00, F41

Keywords: labor taxation, public debt, government spending, relative prices

*We thank Charles Engel, Fabio Ghironi and Philip Lane for invaluable comments. Ivan Baburin and Amil Sabanadzovic provided excellent research assistance.
Email: v.galstyan@tcd.ie, adnan.velic@dit.ie.

1. Introduction

The international macroeconomics literature has emphasized the role of various supply-side and demand-side mechanisms in the determination of long-run relative price movements.[1] These fluctuations are considered to be important in the assessment of real exchange rate misalignments, especially in the context of external adjustment. Furthermore, the macroeconomic aspects of fiscal conduct take on an even greater precedence for members of a currency union that have no monetary or exchange rate policy autonomy. Despite its heightened importance in recent times, the role of sovereign debt as a determinant of relative prices has widely been overlooked.[2] The objective of this paper is to investigate the theoretical and empirical relevance of public debt and labor taxation for relative prices in the long run.

Determining the long-run path of relative prices is especially important for understanding inflation differentials in a monetary union. That is, without a long-run model, it becomes difficult to ascertain whether, below average inflation is reflective of undershooting such that relative prices are below their long-run equilibrium value and reversion is expected, or convergence to a lower fundamentals-based equilibrium associated with greater international price competitiveness. Correspondingly, pinning down the dynamics of relative prices is relevant for projections of external imbalances, and thus for understanding the mechanics of external adjustment.

Emanating from the classical contributions of Balassa (1964) and Samuelson (1964), that emphasize the sectoral productivity differential, the literature on relative prices has predominantly focused on differences in productivity. Bhagwati (1984), for instance, contends that even without differences in sectoral productivity, the real exchange rate may be higher in countries exhibiting higher average productivity relative to trading partners,

[1] See Balassa (1964), Samuelson (1964), Lane and Milesi-Ferretti (2002a, 2002b, 2004), Bergin et al (2006), Galstyan and Lane (2009a,b), Ricci et al. (2013), Berka and Devereux (2013), Berka et al. (2014) and Galstyan (2015).

[2] For studies on public debt and potential ramifications for the economy see Barro (1974), Elmendorf and Mankiw (1999) and Reinhart and Rogoff (2009) among others.

as long as the nontraded goods sector is relatively labor intensive. Bergin et al. (2006) find that while the Balassa-Samuelson effect has grown steadily over time, there is little support for the effect as of the mid 20th century.[3] They reconcile these findings by building a model with endogenous tradability.

In relation to demand-side determinants, a large number of studies have examined the effects of government spending on relative price changes in the long run. Amongst others, Froot and Rogoff (1991), De Gregorio et al. (1994), Chinn (1999), Lee et al. (2008), Galstyan and Lane (2009a,b) and Ricci et al. (2013) find that increases in government consumption are associated with medium- to long-run increases in the relative price of nontraded goods or real exchange rate appreciation. Furthermore, Galstyan and Lane (2009a,b) demonstrate that the long-run effects of government investment are more ambiguous. A notable limitation of these studies, however, is the assumption of balanced public sector budgets and lump-sum taxation.

In this paper, we depart from this restrictive case, and build on the two-sector small open-economy framework of Galstyan and Lane (2009a) by allowing for debt-financed government budget imbalances and distortionary labor taxation.[4] Our study aims to explore the connection between public debt, distortionary labor taxation and the relative price of nontraded goods. At the theoretical level, we show that higher taxes, associated with higher levels of public debt, contract labor supply in both traded and nontraded goods sectors. For a given relative demand, relative prices move inversely with relative supply. Crucially, the sign and magnitude of the supply-side adjustment is determined by relative factor intensities across the two sectors. At the empirical level, for a panel of advanced economies, we find statistically significantly effects of public debt and taxes on the relative price of nontraded goods, with higher debt and taxes associated with higher relative prices.

[3] In a relatively recent survey of the field, Chinn (2012) reports that evidence on the Balassa-Samuelson mechanism is rather mixed.

[4] The assumption of non-distortionary taxation is an implication of full Ricardian equivalence, which is rather stringent.

The remainder of the paper is structured as follows. Section 2 lays out the theoretical model and derives long-run relations. Section 3 describes the corresponding empirical approach adopted for the long-run analysis, while section 4 provides an overview of the data employed. Section 5 discusses the empirical findings for our sample of advanced economies. Lastly, section 6 concludes.

2. Theoretical Framework

In this section, we describe an extension of the standard small open economy model à la Obstfeld and Rogoff (1996) that produces both traded and nontraded goods. For simplicity, the price of the traded good is equal to the normalized world price of one.

2.1. Consumers

The representative household maximizes the present discounted value of lifetime utility

$$U_t = \sum_{j=0}^{\infty} \beta^j \left(\ln C_{t+j} - \frac{L_{t+j}^{1+\psi}}{1+\psi} \right) \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, C is aggregate consumption, L is labor, and ψ is the inverse of the Frisch elasticity of labor supply. The maximization is subject to the following period flow budget constraint

$$\Delta B = rB + r\left(K_T + K_N\right) + w\left(1-\tau\right)\left(L_T + L_N\right) - \left(I_T^K + I_N^K\right) - PC + \Pi_N + \Pi_T \tag{2}$$

where subscripts T and N stand for traded and nontraded sectors, B is an internationally traded bond, r is the world interest rate, τ is the rate of distortionary labor taxation, K is the stock of private capital, I^K is private capital investment which is assumed to require only the tradable good as an input, w is the wage rate, P is the price index, and Π captures non-zero profits generated by the given sector. The rate of capital depreciation

is set equal to zero.[5]

Total consumption is defined as $C = C_T^{1-\gamma} C_N^{\gamma} (1-\gamma)^{\gamma-1} \gamma^{-\gamma}$, such that the elasticity of substitution between traded and nontraded goods is equal to unity and optimal expenditure shares are

$$\frac{C_T}{PC} = (1-\gamma) \text{ and } \frac{P_N C_N}{PC} = \gamma \tag{3}$$

where $P = P_N^{\gamma}$ is the welfare-based price index. Finally, the intratemporal labor-leisure optimality condition sets the ratio between marginal utilities of labor and consumption equal to the net real wage

$$L^{\psi} = \frac{1}{C} \frac{w}{P} (1-\tau) \tag{4}$$

where, conditional on other variables, a higher rate of taxation reduces the supply of labor.

2.2. Firms

The production functions of traded and nontraded goods are given by

$$Y_T = A_T^* F(L_T, K_T) = (A_T Z^{\alpha_Z}) L_T^{\alpha_L} K_T^{\alpha_K} \tag{5}$$

$$Y_N = A_N^* G(L_N, K_N) = \left(A_N Z^{\beta_Z}\right) L_N^{\beta_L} K_N^{\beta_K} \tag{6}$$

where A is a productivity shifter. Inspired by Barro (1990), and following Galstyan and Lane (2009a), we augment the production function in each sector with the exogenous public capital stock, Z.[6] Accordingly, the multifactor productivity term A^* can be viewed as a product of an exogenous sectoral productivity shifter and the public capital stock.

[5] Since our interest is in steady-state relations, a zero depreciation rate of the capital stock allows us to disregard the investment process altogether.

[6] Kamps (2006) finds economically and statistically significant elasticities of aggregate output with respect to public capital. In a panel of 22 OECD countries, the author reports that public and private capital are approximately equally productive. Furthermore, based on the estimation results, formal tests could not determine whether the production function exhibits constant returns to scale in private inputs or in all inputs.

We assume that private capital is mobile across sectors and borders, while labor is mobile across sectors only. Given the exogenous public capital stock, the production functions in both sectors exhibit decreasing returns to scale in private inputs, namely, $\alpha_L + \alpha_K < 1$ and $\beta_L + \beta_K < 1$.[7]

2.3. Government

The government consumes both traded and nontraded goods. To finance spending, it can borrow or tax labor income. Accordingly, the flow budget constraint facing the government is

$$\Delta D + \tau w L = rD + G_T + P_N \left(G_N + I^Z\right) \tag{7}$$

where D is the level of public debt, G_T and G_N are the levels of public consumption of traded and nontraded goods respectively, and I^Z is the level of public investment which is assumed to require only the nontraded good.

2.4. Equilibrium

Equations characterizing equilibrium in the labor market and nontraded goods market are given by

$$L = L_N + L_T \tag{8}$$

$$Y_N = C_N + G_N + I^Z \tag{9}$$

Combining equations (2) and (7) along with the first order conditions of firms we derive the following equation describing equilibrium in the traded goods market

$$\Delta N = rN + Y_T - C_T - G_T - \left(I_T^K + I_N^K\right) \tag{10}$$

[7] When both sectors exhibit constant returns to scale in private inputs, demand-side variables are irrelevant for the determination of the relative price of nontraded goods (Obstfeld and Rogoff 1996). This result is at odds with the empirical literature that underlines the importance of demand-side determinants as well. One way to introduce demand-side determinants is to restrict the cross-border mobility of capital (Rogoff 1992). Another approach is to introduce decreasing returns to scale in endogenously determined production inputs (Galstyan and Lane 2009a). We follow the latter approach.

where $N = B - D$ is the net foreign asset position.

2.5. Solution

Of primary interest is the steady-state (long-run) relation between the relative price of nontraded goods and fundamentals.[8] Accordingly, we first solve the system for the benchmark steady state in which the net foreign asset position, government debt, fiscal spending and taxes are set equal to zero, while sector-specific productivity levels and the exogenous public capital stock are normalized to one. In this benchmark steady state, the equilibrium level of labor is given by

$$\bar{L} = \left(\left(1-\gamma\right)\alpha_L + \gamma\beta_L\right)^{\frac{1}{1+\psi}} \tag{11}$$

with sectoral allocations of $\bar{L}_N = \theta\bar{L}$ and $\bar{L}_T = \left(1-\theta\right)\bar{L}$, where $\theta = \gamma\beta_L / \left(\left(1-\gamma\right)\alpha_L + \gamma\beta_L\right)$.

Following Obstfeld and Rogoff (1996), we next log-linearize the system around the benchmark steady state. To do so, for a generic variable X with a value of $\bar{X}$ in the benchmark steady state we define $\hat{X} \approx \left(X - \bar{X}\right)/\bar{X}$, while for the net foreign asset position, government debt and fiscal spending in sector i we define $\tilde{N} = \left(B - D\right)/\bar{Y}_T$, $\tilde{D} = D/\bar{Y}_T$, $\tilde{G}_i = G_i/\bar{Y}_i$. Solving the log-linear system, we derive the primary equation of interest that relates the relative price of nontraded goods to supply and demand side fundamentals

$$\hat{P}_N = -\hat{A}_N + \frac{1-\beta_K}{1-\alpha_K}\hat{A}_T + \frac{\mu_1}{1+\psi}\left(r\hat{N} + \left[\frac{\mu_2}{\mu_1}\tilde{G}_N - \tilde{G}_T\right]\right) + \mu_0\hat{Z} + \frac{\mu_0}{1+\psi}\tau \tag{12}$$

[8] Pesaran (1997) suggests that the empirical counterpart of steady state is cointegration, an approach we adopt in the next section of the paper.

where

$$\begin{aligned}
\mu_0 &= \frac{1-\beta_K}{1-\alpha_K}\alpha_Z - \beta_Z <=> 0 \\
\mu_1 &= \frac{1-\beta_K}{1-\alpha_K}\left(1+\psi\theta\right)\alpha_Z + \psi\left(1-\theta\right)\beta_Z > 0 \\
\mu_2 &= \frac{1-\beta_K}{1-\alpha_K}\psi\theta\alpha_Z + \left(1+\psi\left(1-\theta\right)\right)\beta_Z > 0.
\end{aligned}$$

Regarding unambiguous correlations ($\mu_1 > 0$ and $\mu_2 > 0$), equation (12) shows that higher relative productivity in the traded sector raises the relative price of nontraded goods via the Balassa-Samuelson mechanism (Balassa 1964; Samuelson 1964; Obstfeld and Rogoff 1996). Turning to the transfer effect, a positive net foreign asset position, reflecting a positive wealth transfer from the rest of the world, is associated with a higher relative price of nontraded goods (Lane and Milesi-Ferretti 2002a, 2004; Galstyan and Lane 2009a; Galstyan 2015).[9] Finally, government consumption, biased towards the nontraded sector $\left(\frac{\mu_2}{\mu_1}\tilde{G}_N - \tilde{G}_T > 0\right)$, tends to raise the relative demand for nontraded goods, generating a real appreciation (Galstyan and Lane 2009a; Galstyan 2015).

The effect of the public capital stock and labor taxation on the relative price is ambiguous ($\mu_0 <=> 0$) and depends on relative factor intensities. To further understand the mechanics of long-run relative price changes vis-à-vis fundamentals, observe that the relative price of nontraded goods is determined by the intersection of the relative demand curve

$$RD = -\hat{P}_N + \tilde{G}_N - \tilde{G}_T + r\tilde{N} \tag{13}$$

and the relative supply curve

$$RS = \frac{1}{1-\beta_K}\left(\beta_K\hat{P}_N - \left[\frac{1-\beta_K}{1-\alpha_K}\alpha_L\hat{L}_T - \beta_L\hat{L}_N\right] + \left[\hat{A}_N - \frac{1-\beta_K}{1-\alpha_K}\hat{A}_T\right] - \mu_0\hat{Z}\right). \tag{14}$$

[9]Most of the variation in the net foreign asset position emanates from the cross-sectional dimension, therefore making it difficult to detect a clear-cut association with the real exchange rate in fixed effects estimation (Chinn and Prasad 2003). Accordingly, in the empirical section we rely on the steady-state negative link between the trade balance and net foreign asset position, and instead use the former variable as a regressor with an expected negative sign.

A higher public capital stock directly raises the supply of both traded and nontraded goods. The relative change, however, depends on relative factor intensities captured by the coefficient μ_0. When $\mu_0 < 0$, a higher public capital stock shifts the relative supply curve outwards, putting downward pressure on the relative price. When $\mu_0 > 0$, the opposite happens. Distortionary taxation works indirectly through the labor market, with the equilibrium labor allocation governed by the following equations

$$\hat{L} = \frac{\theta}{1+\psi}\tilde{G}_N + \frac{1-\theta}{1+\psi}\tilde{G}_T - \frac{1-\theta}{1+\psi}r\tilde{N} - \frac{1}{1+\psi}\tau \tag{15}$$

$$\hat{L}_T = -\frac{\psi\theta}{1+\psi}\tilde{G}_N + \frac{1+\psi\theta}{1+\psi}\tilde{G}_T - \frac{1+\psi\theta}{1+\psi}r\tilde{N} - \frac{1}{1+\psi}\tau \tag{16}$$

$$\hat{L}_N = \frac{1+\psi(1-\theta)}{1+\psi}\tilde{G}_N - \frac{\psi(1-\theta)}{1+\psi}\tilde{G}_T + \frac{\psi(1-\theta)}{1+\psi}r\tilde{N} - \frac{1}{1+\psi}\tau. \tag{17}$$

A higher tax rate reduces equilibrium labor proportionally in both sectors. The response of relative supply, as in the case of public capital, depends on relative factor intensities

$$\frac{\partial RS}{\partial \tau} = \left(\frac{\alpha_L}{1-\alpha_K} - \frac{\beta_L}{1-\beta_K}\right)\frac{1}{1+\psi} \quad \begin{cases} > 0 \text{ if } \frac{\alpha_L}{1-\alpha_K} > \frac{\beta_L}{1-\beta_K} \\ = 0 \text{ if } \frac{\alpha_L}{1-\alpha_K} = \frac{\beta_L}{1-\beta_K} \\ < 0 \text{ if } \frac{\alpha_L}{1-\alpha_K} < \frac{\beta_L}{1-\beta_K}. \end{cases} \tag{18}$$

Equation (18) suggests that a nontraded sector exhibiting a higher labor share than the traded sector ($\beta_L > \alpha_L$) can yield configurations in which relative supply declines raise the relative price of nontraded goods. This, in general, will tend to occur when the nontraded sector relies on a relatively lower share of the public capital stock than the traded sector ($\beta_Z/\alpha_Z < \beta_L/\alpha_L$). To take an example, Figure 1 plots the tax coefficient $\mu_0/(1+\psi)$ for various combinations of factor intenstities in the case of $\alpha_K = 0.40$, $\beta_K = 0.30$ and $\psi \in \{0.5, 1, 2\}$. Across the three cases, the graphs indicate that, for a given value of the labor share in the traded sector, higher values of the labor share in the nontraded sector yield higher values of the tax coefficient. The parametrization suggests that in the case of a labor-intensive nontraded sector the tax elasticity of relative prices is positive,

implying a decline in relative supply and an increase in the relative price.

Finally, the linearized version of the government constraint states that in the long run, for a given level of government spending, a higher level of government debt requires a higher tax rate

$$\tau = \frac{1-\theta}{\alpha_L} r\tilde{D} + \frac{1-\theta}{\alpha_L}\tilde{G}_T + \frac{\theta}{\beta_L}\tilde{G}_N. \tag{19}$$

Accordingly, equation (19) links public debt to taxation in equation (12), demonstrating that sovereign debt can indirectly contribute to the determination of relative prices. The sign, as with taxes, is ambiguous.

3. Data

Our empirical analysis, dictated by data availability, is conducted for a sample of 15 advanced countries at the annual frequency level over the period 1980-2007.[10] Data on the external trade balance on goods and services expressed as a share of GDP are obtained from the World Bank's World Development Indicators repository. The rest of the constructed data set consists of fiscal and sectoral variables.

3.1. Fiscal Variables

Public debt, government consumption, public capital and labor taxes comprise the fiscal variables. General government gross debt as a share of GDP is an end-of-year stock variable that is sourced from the International Monetary Fund's World Economic Outlook database.[11]

Government consumption expenditures, expressed as a fraction of GDP, refer to the purchases of goods and services by the general government sector, including goods and services produced by the public sector. Government spending on transfer programs,

[10] The sample of countries includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

[11] In our analysis we use start-of-period values.

such as social security, welfare, and subsidies, are excluded from the analysis. The data are compiled from the OECD Economic Outlook database.

Public capital stock estimates for the period 1980-2002 are adopted from Kamps (2006). We extend these data to 2007 by using the perpetual inventory method. In particular, government net capital stock volumes at the beginning of period $t+1$, Z_{t+1}, are calculated as $(1-\delta)Z_t + (1-(\delta/2))I_t^Z$ for all $t = 2002, \ldots, 2006$, where $\delta = 0.04$ is the constant depreciation rate of public capital and I_t is the volume of government gross fixed capital formation. The definition implies that new investment is placed in service at midyear, reflecting the notion that investment typically occurs throughout the year.[12] In addition, the current value public capital stock to GDP ratio is examined as an alternative. Series in current prices show public capital assets accumulated over the years that are valued at prices prevailing in the year for which the stock estimate is reported.[13] Data pertaining to the construction of the public capital stock series are obtained from OECD Economic Outlook.

Labor taxation is gauged by the implicit tax rate on labor. Following Eurostat methodology, this is calculated as the sum of all direct and indirect taxes and social contributions, divided by the total economic remuneration of employees working in the economic territory. Direct taxes are defined as the portion of personal income tax revenues that can be allocated to employed labor income. Indirect taxes include payroll and other workforce taxes that are paid by the employer. Finally, the broad measure of gross economic income from employment includes wages and salaries payable in cash or in kind, social insurance contributions payable by employers, and wage bill/payroll taxes. Thus, the implicit tax rate on labor can be interpreted as a summary measure that approximates an

[12] Government investment volumes are obtained by dividing value series by corresponding deflators. The public capital and investment volume measures are expressed in billions of national currency at constant 1995 prices.

[13] The perpetual inventory method entails accumulating assets acquired over a number of years. This can be seen by repeatedly substituting the capital accumulation equation for the capital stock at the beginning of period t. Thus, for the resultant total of a particular year to be meaningful, all of the assets accumulated up to that point have to be valued in the prices of a common year. This procedure is applied to every entry of the current value public capital stock series.

average effective tax burden on labor income in the economy. All tax revenue and employee compensation data are retrieved from the OECD database. The share of personal income tax revenue pertaining to employed labor is acquired from Eurostat.[14,15]

3.2. Sectoral Variables

Relative nontradable prices and relative labor productivity are the sectoral variables. Data required for the construction of these series are gathered from the EU KLEMS (O'Mahony and Timmer 2009) and OECD STAN data repositories. These sources provide detailed information on a range of sectoral variables, including corresponding volume and price indices for gross value added. Manufacturing and services are used to proxy for the traded and nontraded sectors respectively. Manufacturing is measured by "*total manufacturing*" as reported in KLEMS, while services are measured by the sum of "*wholesale and retail trade*", "*hotels and restaurants*", "*transport and storage and communication*", "*finance, insurance, real estate, and business services*" and "*community, social and personal services*".[16] The Fisher index is used to aggregate prices and quantities across the nontraded sub-sectors.[17] The relative price of nontraded goods is subsequently constructed by taking the ratio of the aggregate services price index to the manufacturing price index. Finally, labor productivity in each sector is given by the ratio of value added in constant terms to the total number of employees in the sector.

[14]Personal income tax revenues are split across employed labor, self-employed labor, social transfers and pensions, and capital.

[15]Our computed labor tax rates are significantly correlated with the average personal income tax rates from the Andrew Young School World Tax Indicators dataset.

[16]Naturally, the allocation of sectors between traded and nontraded categories cannot be perfectly clean, in that some level of trade occurs in most sectors and tradability is also endogenous to shifts in trading costs and other factors. Accordingly, the sectoral allocation should be interpreted as reflecting degrees of tradability, with more trade occurring in the "traded" sectors and domestic factors being relatively more important in the "nontraded" sectors. In comparison to Galstyan and Lane (2009a) for example, we use much narrower measures of the traded and nontraded sectors.

[17]The Fisher index is a geometric average of the Paasche and Laspeyres indices. An appealing feature of the index is that it is "ideal": for given price or quantity indices ($P_{0,t}$ and $Q_{0,t}$), the value index ($V_{0,t}$) can be backed out from the factor reversal test

$$P_{0,t} \times Q_{0,t} = \sqrt{\frac{\sum p_{j,t} q_{j,0}}{\sum p_{j,0} q_{j,0}} \times \frac{\sum p_{j,t} q_{j,t}}{\sum p_{j,0} q_{j,t}}} \times \sqrt{\frac{\sum q_{j,t} p_{j,0}}{\sum q_{j,0} p_{j,0}} \times \frac{\sum q_{j,t} p_{j,t}}{\sum q_{j,0} p_{j,t}}} = \frac{\sum p_{j,t} q_{j,t}}{\sum p_{j,0} q_{j,0}} = V_{0,t}.$$

4. Results

4.1. Preliminary Analysis

Figure 2 shows the partial relation between changes in gross public debt and relative prices (panel a) and the partial relation between changes in labor taxes and relative prices (panel b) across countries. There is a strong positive link between the fiscal variables and relative prices with correlation coefficients standing at 0.34 and 0.67 correspondingly.[18] Accordingly, the preliminary assessment of the cross-sectional data supports the basic premise of the model.

Next, we turn to the time-series dimension and explore the relation between relative prices and fundamentals in a panel framework. For each of the variables employed in our empirical investigation, Table 1 reports the p-values of various panel unit root tests. In the case of the Breitung (BTNG), Phillips-Perron Fisher (PP-F), and Phillips-Perron Choi (PP-C) panel unit root tests, the null hypothesis is that all series are non-stationary. In contrast, the null hypothesis of the Hadri Lagrange multiplier (HADRI) test is that all series are stationary. Overall, the evidence implies that the variables are characterized by unit root behavior. In particular, at the 5 percent significance level, the BTNG, PP-C, and HADRI tests indicate non-stationarity across all nine variables while the PP-F test suggests non-stationarity in seven instances.

Given these findings, we proceed to examining whether the variables of concern share a common stochastic trend via panel cointegration methods. If appropriate, cointegration provides a platform for the analysis of a long-run equilibrium relation between the relative price of nontraded goods and corresponding fundamentals. Table 2 shows the results of the Kao and Chiang (2000) cointegration test across four different specifications.[19] The combinations of variables vary with the use of labor taxation and public debt, and the use of volume and value measures of the public capital stock. From the

[18] The smaller cross-sectional correlation coefficient for public debt is not surprising given the regime-dependent nature of adjustments (Galstyan and Velic 2016).

[19] For a discussion of Kao and Chiang (2000) and other cointegration tests see Galstyan and Velic (2016).

table, we conclude that the null of no cointegration is rejected in each of the columns at the 1 percent significance level.

4.2. Regression Analysis

Next, we estimate the long-run relation between relative prices and fundamentals by the method of fully modified OLS for heterogeneous cointegrated panels à la Pedroni (2000). The results are presented in Table 3. All specifications control for country-specific effects.

Inspection of the estimates reveals that all covariates are highly statistically significant. Focusing on the fiscal side of the framework, column (1) suggests that a 1 percent of GDP rise in start of period public debt is associated with a long-run increase of 0.03 percent in relative nontraded goods prices. Employing the value instead of the volume measure of the public capital stock, column (2) reports a higher estimate of 0.06 accompanied by an improved statistical significance. In columns (3) and (4) we re-estimate our specification by replacing public debt with the constructed implicit labor tax. Column (3) indicates that a 1 percentage point rise in the effective labor tax rate is associated with a 0.15 percent increase in relative prices. Using the alternative measure of the public capital stock, column (4) yields a marginally larger labor tax coefficient, suggesting that a 5 percentage point increase in the labor tax rate is associated with a 1.10 percent rise in relative prices. Thus, according to our model, this result is consistent with relative factor intensities that satisfy $\alpha_L \beta_Z < \beta_L \alpha_Z$, such that the relative supply of nontraded goods responds negatively with a backward shift in the curve.

Turning attention to the remaining regressors, we find that all coefficients obtain the expected sign. In particular, most of the estimates exhibit quite good congruence with the results of Galstyan and Lane (2009a,b). Across the four columns, the average coefficient on government consumption stands at 0.52, while the average estimates on the volume and value measures of the public capital stock stand at 0.10 and 0.16 respectively.[20] Gov-

[20] Galstyan and Lane (2009a) use public investments instead of public capital stock.

ernment consumption expenditure typically falls more heavily on the nontraded sector, thus engendering a rise in relative prices. Consistent with the model, the public capital stock variables share the same sign as the labor tax variable.[21] Our estimates suggest a long-run scenario in which a higher public capital stock improves the relative productivity of the traded goods sector resulting in an increase in the relative price.

In relation to the sectoral variables, we obtain average elasticities of -0.83 and 0.78 for nontraded and traded productivities. The point estimates suggest that, in the long run, a 5 percent increase in nontraded sector productivity is associated with approximately a 4 percent decline in the relative price of nontraded goods, while a similar increase in the traded sector produces the opposite result. Lastly, the typical trade balance coefficient stands around -1.32. Given the steady-state negative link between the trade balance and net foreign asset position, the estimated coefficient shows that a positive wealth transfer from the rest of the world is associated with an increase in relative prices.

4.3. Consolidated Summary

In our model, we demonstrate that higher levels of sovereign debt can indirectly contribute to the determination of relative prices through higher distortionary labor taxation. In particular, although higher taxes proportionately attenuate the supply of labor across sectors, the adjustment in the relative supply of nontraded goods is ambiguous and determined by factor intensities. Our findings of statistically significant positive effects of public debt and taxes on relative prices in the data are consistent with a nontraded sector that exhibits a higher labor share than the traded sector ($\beta_L > \alpha_L$), such that the relative supply of nontraded goods falls. More generally, such configurations will tend to arise when the nontraded sector relies relatively less on the public capital stock than the traded sector ($\beta_Z/\alpha_Z < \beta_L/\alpha_L$). Regarding the remaining empirical results, the estimates are qualitatively consistent with both our model and the preceding literature. Thus, our em-

[21] μ_0 determines the sign of both the public capital stock and taxes in the long-run relative price equation of the model.

pirical analysis of the proposed theoretical framework shows that public debt plays a significant role in the determation of the long-run path of relative sectoral prices.

5. Conclusions

Our study contributes to the literature on the structural determinants of long-run relative prices of nontraded goods. Despite the substantial research that exists on the effects of sovereign debt, the implications for relative prices have remained rather unexplored. The novel element of our paper is the analysis it provides on the relation between government debt, distortionary labor taxation and relative sectoral prices in the long run.

Adopting a two-sector small open economy framework, we theoretically demonstrate that the effect of higher public debt on the relative price of nontraded goods depends on relative factor intensities. In particular, a higher stock of public debt, associated with higher taxation, contracts labor supply in both traded and nontraded sectors. In turn, the relative supply of nontraded goooods responds in accordance with the relative sensitivities of sectoral outputs to labor and capital. The second part of our study augments the analysis by applying the theory to the data for a panel of advanced economies. The empirical findings suggest that public debt and effective labor taxation play significant roles in the long run, comoving positively with relative prices.

Overall, our paper indicates that public debt and taxes are important determinants of relative prices, and thus bear implications for international price competitiveness. This is particularly important in the context of a monetary union where the macroeconomic aspects of fiscal conduct take on great precedence for member countries with no monetary or exchange rate policy autonomy.

References

Balassa, Bela (1964), "The Purchasing-Power Parity Doctrine: A Reappraisal," *Journal of Political Economy* 72, 584-596.

Barro, Robert (1974), "Are Government Bonds Net Wealth?" *Journal of Political Economy* 82, 1095-1117.

Barro, Robert (1990), "Government Spending in a Simple Model of Endogenous Growth," *Journal of Political Economy* 98, 103-126.

Bergin, Paul, Reuven Glick and Alan Taylor (2006), "Productivity, Tradability, and the Long-Run Price Puzzle," *Journal of Monetary Economics* 53, 2041-2066.

Berka, Martin and Michael Devereux (2013), "Trends in European Real Exchange Rates," *Economic Policy* 28, 193-242.

Berka, Martin, Michael Devereux and Charles Engel (2014), "Real Exchange Rates and Sectoral Productivity in the Eurozone," NBER Working Paper No. 20510.

Bhagwati, Jagdish N. (1984), "Why Are Services Cheaper in the Poor Countries?," *The Economic Journal* 94, 279-286.

Chinn, Menzie (1999), "Productivity, Government Spending and the Real Exchange Rate: Evidence for OECD Countries," in R. MacDonald and J. Stein (ed.), Equilibrium Exchange Rates, Boston: Kluwer Academic Publishers.

Chinn, Menzie (2012), "Macro Approaches to Foreign Exchange Determination," in J. James et al. (Ed), Handbook of Exchange Rates, Wiley.

Chinn, Menzie and Eswar Prasad (2003), "Medium-Term Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Exploration," *Journal of International Economics* 59, 47-76.

De Gregorio, Jose, Alberto Giovannini and Holger Wolf (1994), "International Evidence on Tradables and Nontradables Inflation," *European Economic Review* 38, 1225-1244.

Elmendorf, Douglas and Gregory Mankiw (1999), "Government Debt," in J.Taylor and M. Woodford (Ed), Handbook of Macroeconomics, North-Holland.

Froot, Kenneth and Kenneth Rogoff (1991), "The EMS, the EMU, and the Transition to a Common Currency," *NBER Macroeconomics Annual* 6, 269-317.

Galstyan, Vahagn (2015), "Country Size and Exchange Rates," *Economica* 82, 222-235.

Galstyan, Vahagn and Philip Lane (2009a), "The Composition of Government Spending and the Real Exchange Rate," *Journal of Money, Credit and Banking* 41, 1233-1249.

Galstyan, Vahagn and Philip Lane (2009b), "Fiscal Policy and International Competitiveness: Evidence from Ireland," *The Economic and Social Review* 40, 299-315.

Galstyan, Vahagn and Adnan Velic (2016), "Debt Thresholds and Real Exchange Rates: An Emerging Markets Perspective," *Journal of International Money and Finance*, forthcoming.

Kamps, Christophe (2006), "New Estimates of Government Net Capital Stocks for 22 OECD Countries, 1960-2001," *IMF Staff Papers* 53, 120-150.

Kao, Chihwa, and Min-Hsien Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data," in B. H. Baltagi (Ed.), Advances in Econometrics, vol. 15, JAI Press.

Lane, Philip and Gian Maria Milesi-Ferretti (2002a), "External Wealth, the Trade Balance and the Real Exchange Rate," *European Economic Review* 46, 1049-1071.

Lane, Philip and Gian Maria Milesi-Ferretti (2002b), "Long-Run Determinants of the Irish Real Exchange Rate," *Applied Economics* 34, 549-553.

Lane, Philip and Gian Maria Milesi-Ferretti (2004), "The Transfer Problem Revisited: Net Foreign Assets and Real Exchange Rates," *Review of Economics and Statistics* 86, 841-857.

Lee, Jaewoo, Gian Maria Milesi-Ferretti, Jonathan Ostry, Alessandro Prati and Luca Ricci (2008), "Exchange Rate Assessments: CGER Methodologies," IMF Occasional Paper No.261.

Obstfeld, Maurice and Kenneth Rogoff (1996), *Foundations of International Macroeconomics*, Cambridge, MA: MIT Press.

O'Mahony, Mary and Marcel Timmer (2009), "Output, Input and Productivity Measures at the Industry Level: the EU KLEMS Database," *Economic Journal* 119, 374-403.

Pedroni, Peter (2000), "Fully Modified OLS for Heterogenous Cointegrated Panels," in B. H. Baltagi (Ed.), Advances in Econometrics, vol. 15, JAI Press.

Pesaran, Hashem (1997), "The Role of Economic Theory in Modelling the Long Run," *Economic Journal* 107, 178-191.

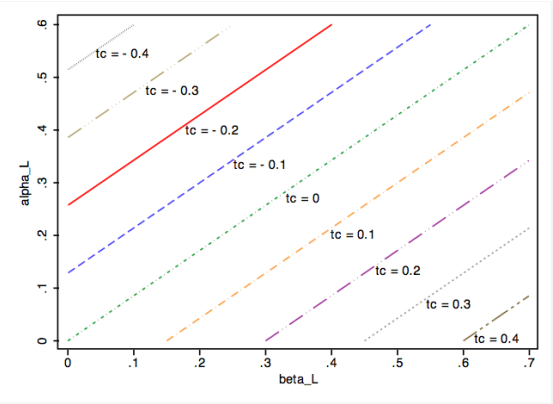
Reinhart, Carmen and Kenneth Rogoff (2009), This Time is Different: Eight Centuries of Financial Folly, Princeton University Press.

Rogoff, Kenneth (1992), "Traded Goods Consumption Smoothing and the Random Walk Behavior of the Real Exchange Rate," *Monetary and Economic Studies* 10, 1-29.

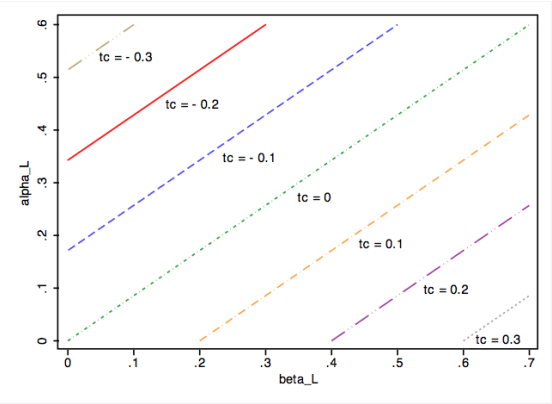
Ricci, Luca, Gian Maria Milesi-Ferretti and Jaewoo Lee (2013), "Real Exchange Rates and Fundamentals: A Cross-Country Perspective," *Journal of Money, Credit and Banking* 45, 845-865.

Samuelson, Paul (1964), "Theoretical Notes on Trade Problems," *Review of Economics and Statistics* 46, 145-154.

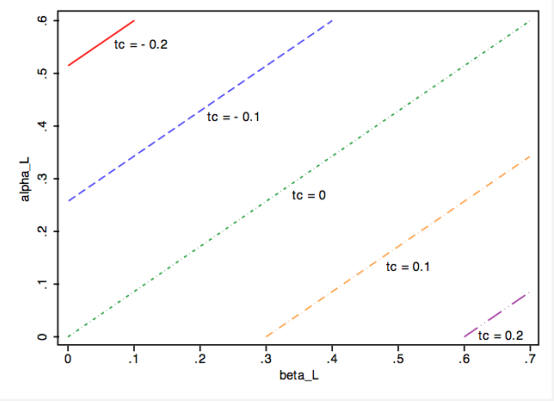
Figure 1: Calibrations of the Tax Coefficient



(a) $\psi = 0.5$



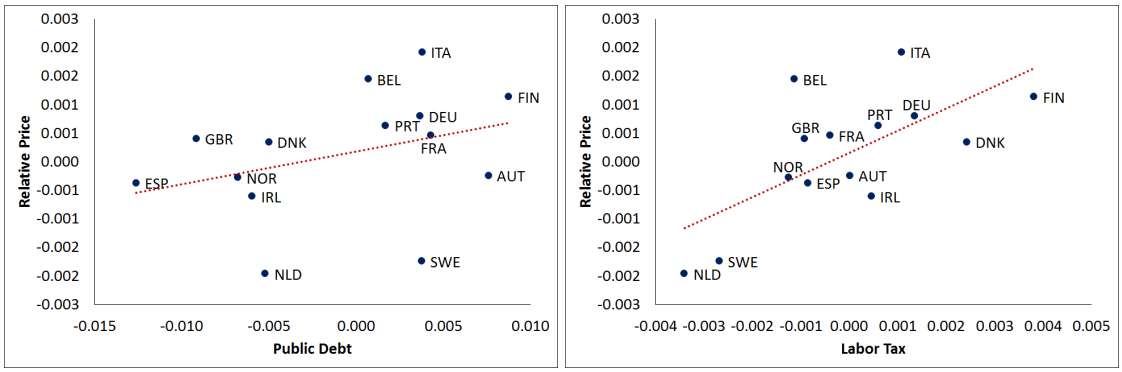
(b) $\psi = 1.0$



(c) $\psi = 2.0$

Note: Authors' calculations of the tax coefficient (tc) $\mu_0/(1+\psi)$ for various combinations of factor intenstities in the case of $\alpha_K = 0.40$, $\beta_K = 0.30$ and $\psi \in \{0.5, 1, 2\}$.

Figure 2: Cross-Country Relation Between Debt, Taxes and Relative Prices



(a) Public Debt (b) Labor Tax

Note: The scatterplot shows the cross-country (Greece excluded) partial correlation between changes in fiscal variables and changes in the relative price over 1980-2007.

Table 1: Panel Unit Root Test

	BTNG	**PP-F**	**PP-C**	**HADRI**
Relative Price	0.986	0.972	1.000	0.000
Productivity, Traded	0.762	0.900	1.000	0.000
Productivity, Nontraded	0.345	1.000	1.000	0.000
Trade Balance	0.726	0.035	0.058	0.000
Labor Tax	0.677	0.128	0.071	0.000
Gov. Debt	1.000	0.312	0.183	0.000
Gov. Consumption	0.212	0.265	0.108	0.000
Gov. Capital Stock	0.441	0.836	0.998	0.000
Gov. Capital Stock, Volume	0.963	0.000	0.924	0.000

Notes: The table reports the p-values for a range of panel unit root tests. In the case of Breitung (BTNG), Phillips-Perron Fisher (PP-F) and Phillips-Perron Choi (PP-C) panel unit root tests, the null hypothesis is that all series are non-stationary. Conversely, the null hypothesis for the Hadri Lagrange multiplier (HADRI) test is that all series are stationary. Relative prices are given by the logarithm of the services price index relative to the manufacturing price index; Productivity is the log of labor productivity in manufacturing for the traded sector and services for the nontraded sector; Trade Balance is the trade balance as a share of GDP; Labor Tax is the implicit tax rate on labor; Gov. Debt is government debt as a share of GDP; Gov. Consumption is government consumption as a share of GDP; Gov. Capital Stock is the public capital stock as a share of GDP; Gov. Capital Stock Volume is the logarithm of the public capital stock measured in constant prices.

Table 2: Panel Cointegration Test

	(1)	(2)	(3)	(4)
Government Debt	✓	✓		
Labor Tax			✓	✓
Productivity, Non-Traded	✓	✓	✓	✓
Productivity, Traded	✓	✓	✓	✓
Trade Balance	✓	✓	✓	✓
Government Consumption	✓	✓	✓	✓
Government Capital Stock, Volume	✓		✓	
Government Capital Stock		✓		✓
Kao Cointegration Test	-5.39***	-5.52***	-5.40***	-5.38***

Notes: The dependent variable is the logarithm of the services price index relative to the manufacturing price index; Productivity is the log of labor productivity in manufacturing for the traded sector and services for the nontraded sector; Trade Balance is the trade balance as a share of GDP; Labor Tax is the implicit tax rate on labor; Gov. Debt is government debt as a share of GDP; Gov. Consumption is government consumption as a share of GDP; Gov. Capital Stock is the public capital stock as a share of GDP; Gov. Capital Stock Volume is the logarithm of the public capital stock measured in constant prices.

Table 3: Relative Prices and Fundamentals, Panel Cointegration

	(1)	**(2)**	**(3)**	**(4)**
Government Debt	0.029	0.058		
	(0.014)**	(0.013)***		
Labor Tax			0.151	0.215
			(0.022)***	(0.021)***
Productivity, Non-Traded	-0.876	-0.748	-0.902	-0.774
	(0.011)***	(0.010)***	(0.012)***	(0.011)***
Productivity, Traded	0.748	0.794	0.759	0.803
	(0.011)***	(0.011)***	(0.011)***	(0.011)***
Trade Balance	-1.261	-1.361	-1.272	-1.400
	(0.021)***	(0.020)***	(0.026)***	(0.024)***
Government Consumption	0.485	0.620	0.416	0.551
	(0.013)***	(0.012)***	(0.016)***	(0.017)***
Government Capital Stock, Volume	0.104		0.102	
	(0.003)***		(0.003)***	
Government Capital Stock		0.166		0.154
		(0.008)***		(0.008)***

Notes: The dependent variable is the logarithm of the services price index relative to the manufacturing price index; Productivity is the log of labor productivity in manufacturing for the traded sector and services for the nontraded sector; Trade Balance is the trade balance as a share of GDP; Labor Tax is the implicit tax rate on labor; Gov. Debt is government debt as a share of GDP; Gov. Consumption is government consumption as a share of GDP; Gov. Capital Stock is the public capital stock as a share of GDP; Gov. Capital Stock Volume is the logarithm of the public capital stock measured in constant prices. Long-run relation estimated by weighted fully modified panel ordinary least squares. Asterisks ***,**,* indicate significance at 1%, 5% and 10% levels respectively.