Productivity and Wedges: Economic Convergence and the Real Exchange Rate*

Michael B. Devereux† Ippei Fujiwara‡ Camilo Granados§

March 18, 2025

Abstract

This paper explores the convergence in prices in Eastern European countries. While they have had significant convergence in GDP per capita (relative to the EU average) since the 1990s, convergence in real exchange rates for these countries stalled after the EU crisis, and has been flat since then. We estimate the main drivers of real exchange rates and show that a combination of productivity growth (Balassa Samuelson effects) and labor market distortions help explain real exchange rate trends. We develop a structural two-country model that provides a rich decomposition of the long run determinants of the real exchange rate. Simulations based on observed sectoral productivities and labor market wedges show that the model can very accurately account for the historical path of real exchange rates, both before and after the EU crisis.

Keywords: Real Exchange Rates, Convergence, Balassa Samuelson
JEL codes: F40 F41

*Fujiwara acknowledges financial support from JSPS KAKENHI Grant-in-Aid for Scientific Research (A) No. 22H00058. Devereux thanks the Social Science and Humanities Research Council of Canada for financial support.
†University of British Columbia, NBER and CEPR. E-mail: Michael.Devereux@ubc.ca
‡Keio University, ANU, ABFER and CEPR. E-mail: ippei.fujiwara@keio.jp
§University of Texas at Dallas. E-mail: camilo.granados@utdallas.edu

1 Introduction

Wealthier countries have higher price levels. This is one of the most robust facts, denoted the 'Penn Effect', that comes out of international comparisons of the prices of goods and services. But despite this broad fact, there are significant departures from price equality, or PPP across countries with similar levels of GDP per capita. Rogoff (1996) noted that the most robust evidence for the Penn effect was in the comparison of developing countries with more developed countries. As countries move from one category to another, they tend to exhibit significant real appreciation, but within categories there exists significant heterogeneity.

Our paper focuses on the question of convergence in prices in the European Union. This is a critical issue for policy makers in the EU. The expectation that a more integrated single market would lead to a greater convergence in income levels across the union should have as its by-product a fall in price differentials between countries. When we focus on the high income countries of western Europe, the evidence for price convergence is quite weak. But perhaps this is not surprising, because GDP per capita differentials among these high income countries have not significantly diminished over the life of the single market. However, one clear fact comes out of a focus on Eastern European countries, particularly those countries that were members of the former Soviet Block. In Figure 1 Panel A we see significant and continuing convergence in GDP per capita since these countries became members of the EU. Although there is a slight downturn at the time of the EU crisis, convergence continues strongly until the end of the sample. Then we would expect there to be an equivalent convergence in national price levels, or in other words, significant real exchange rate appreciation relative to the EU averages. Do we see this? Panel B in Figure 1 shows the real exchange rate for the same set of countries, relative to the EU 27 over the same time sample as Panel A in Figure 1. There we encounter a puzzle. Up until 2009, we see a strong real appreciation, or equivalently, a convergence in prices to the EU average. But after 2008, the real exchange rate is flat, or even slightly falling, despite the continuing convergence in GDP per capita.

This paper is an exploration of the relationship between convergence in real GDP and real exchange rate determination, with a specific focus on Eastern European countries. These countries represent a textbook example of GDP convergence over the last two decades. But as the above Figure shows, the pattern of the real exchange rate does not obviously fit the textbook account of relative price convergence. We explore empirically the determinants of real exchange rates for the countries in Eastern Europe. We then build a simple multi-country two-sector model that can separately disentangle the drivers of GDP and real exchange rates. We use the model as a quantitative tool in order to evaluate the simultaneous convergence of GDP and non-convergence of the real exchange rate. Our results show that a combination of sectoral productivity, labor market wedges, and capital inflows all play an important role in explaining the path of GDP and real exchange rates in Eastern European countries.

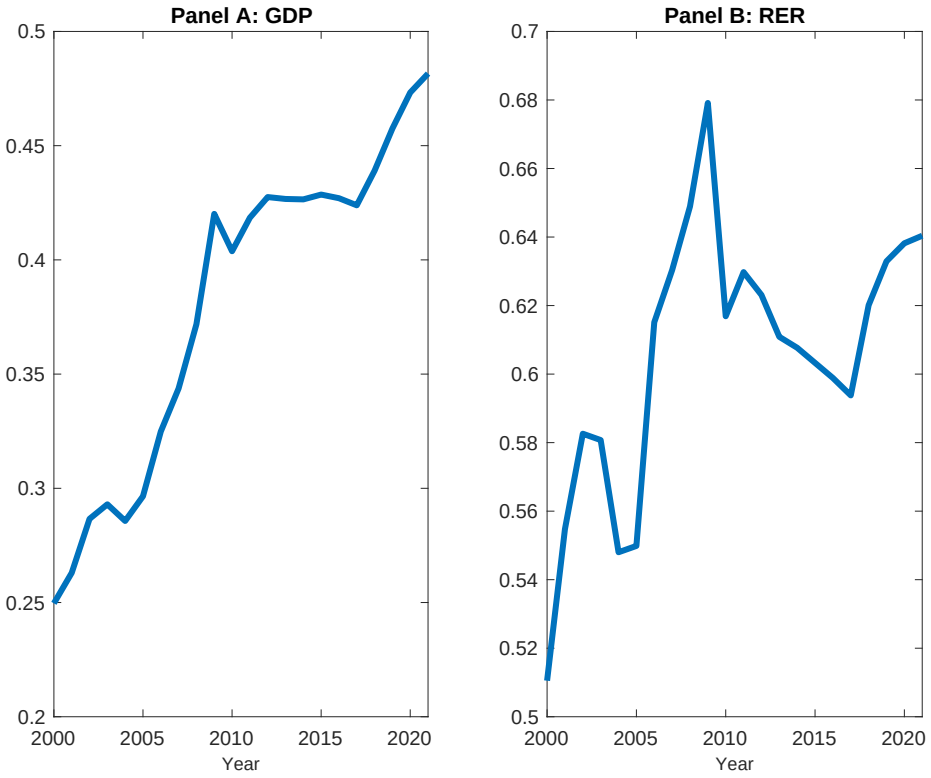


Figure 1: Relative GDP and Real Exchange Rates for Eastern European countries

2 Two country RER model

Here we outline a basic two country model that we will use to interpret the trends in European real exchange rates. Let the countries be Home and Foreign. In each country there are two sectors, Traded (T) and Non-Traded (NT). Production uses labor with a fixed capital stock in each sector. Since we are focusing on relatively low frequency trends we assume that prices and wages are fully flexible in both countries.

2.1 Preferences

Utility of Home consumers can be described by the standard CES lifetime utility function:

$$\mathcal{U} = \sum_{i=1}^{\infty} \beta^t \left(\frac{C^{1-\sigma} - 1}{1-\sigma} - \Psi_{T,t} \frac{L_T^{1+\phi}}{1+\phi} - \Psi_{N,t} \frac{L_N^{1+\phi}}{1+\phi} \right). \tag{1}$$

T, N indicates the sectors Traded and Non-Traded, respectively. σ and ϕ denote the relative risk aversion (inverse of the intertemporal elasticity of substitution) and the inverse of Frisch elasticity, respectively. Ψ represents the labor wedge.

The preferences are represented by the consumption aggregator:

$$C = \left[\Omega^{\frac{1}{\mu}} C_T^{1-\frac{1}{\mu}} + (1-\Omega)^{\frac{1}{\mu}} C_N^{1-\frac{1}{\mu}} \right]^{\frac{\mu}{\mu-1}}. \tag{2}$$

Ω represents the share of the Traded sector. Within Traded goods, there is a Home and Foreign good so that

$$C_T = \left[(1-\gamma)^{\frac{1}{\lambda}} C_{T,H}^{1-\frac{1}{\lambda}} + (1-\gamma)^{\frac{1}{\lambda}} C_{T,F}^{1-\frac{1}{\lambda}} \right]^{\frac{\lambda}{\lambda-1}}.$$

Here, $\gamma = (1 - x(1-n))$, where n is the population share of the Home country, and $0 < x < 1$ allows for some home bias in traded goods preferences. With $x = 1$, there is no home bias. Note that μ represents the elasticity of substitution across sectors, while λ represents the elasticity of substitution across Home and Foreign goods.

Finally, for both home and foreign traded goods, there is a requirement to use inputs of non-traded goods in order to produce final consumption goods. Hence we have

$$C_{T,H} = \left[v^{\frac{1}{\psi}} I_{T,H}^{1-\frac{1}{\psi}} + (1-v)^{\frac{1}{\psi}} I_{N,H}^{1-\frac{1}{\psi}} \right]^{\frac{\psi}{\psi-1}},$$

$$C_{T,F} = \left[v^{\frac{1}{\psi}} I_{T,F}^{1-\frac{1}{\psi}} + (1-v)^{\frac{1}{\psi}} I_{N,F}^{1-\frac{1}{\psi}} \right]^{\frac{\psi}{\psi-1}}.$$

where $I_{T,H}$ and $I_{N,H}$ refer to the use of traded goods and non-traded goods of the home country in the final consumption of the home traded good $C_{T,H}$. Analogous descriptions apply to the consumption of the foreign traded good $C_{T,F}$. The elasticity of substitution between the 'raw' traded good and non-traded inputs is ψ.

Households in the Home country face the following budget constraint:

$$PC + \frac{B_{t+1}}{1+r_{t+1}} = P_T C_T + P_N C_N + \frac{B_{t+1}}{1+r_{t+1}} = W_T L_T + W_N L_N + \Pi_T + \Pi_N + B_t, \tag{3}$$

where price indexes are given by

$$P = \left(\Omega P_T^{1-\mu} + (1-\Omega) P_N^{1-\mu} \right)^{\frac{1}{1-\mu}}, \tag{4}$$

$$P_T = \left[\gamma \tilde{P}_{T,H}^{1-\lambda} + (1-\gamma)\, \tilde{P}_{T,F}^{1-\lambda} \right]^{\frac{1}{1-\lambda}}, \tag{5}$$

and

$$\tilde{P}_{T,H} = \left[v P_{T,H}^{1-\psi} + (1-v)\, P_N^{1-\psi} \right]^{\frac{1}{1-\psi}}, \tag{6}$$

$$\tilde{P}_{T,F} = \left[v P_{T,F}^{1-\psi} + (1-v)\, P_N^{1-\psi} \right]^{\frac{1}{1-\psi}}. \tag{7}$$

Households receive income from wages W and profits Π from all sector firms, and consume at the given prices. They can purchase one period 'nominal' international bonds B at price $\frac{1}{1+r_{t+1}}$.[1] γ and v denote share parameters.

[1] Although the model is purely real, we define a nominal numeraire below.

Household optimal choices are quite standard, and deliver the solution for the consumption of traded and non-traded goods as

$$C_T = \Omega \left(\frac{P_T}{P} \right)^{-\mu} C, \tag{8}$$

$$C_N = (1 - \Omega) \left(\frac{P_N}{P} \right)^{-\mu} C. \tag{9}$$

Given the definition of traded goods, the demand for consumption of home and foreign traded goods is

$$C_{T,H} = \gamma \left(\frac{\tilde{P}_{T,H}}{P_T} \right)^{-\lambda} C_T, \tag{10}$$

$$C_{T,F} = (1 - \gamma) \left(\frac{\tilde{P}_{T,F}}{P_T} \right)^{-\lambda} C_T. \tag{11}$$

Likewise, we have

$$I_{T,H} = vH \left(\frac{P_{T,H}}{\tilde{P}_{T,H}} \right)^{-\psi} C_{T,H}, \tag{12}$$

$$I_{N,H} = (1 - v) \left(\frac{P_N}{\tilde{P}_{T,H}} \right)^{-\psi} C_{T,H}, \tag{13}$$

$$I_{T,F} = v \left(\frac{P_{T,F}}{\tilde{P}_{T,F}} \right)^{-\psi} C_{T,F}, \tag{14}$$

$$I_{N,F} = (1 - v) \left(\frac{P_N}{\tilde{P}_{T,F}} \right)^{-\psi} C_{T,F}. \tag{15}$$

Equilibrium labor supply conditions are given by

$$\frac{W_T}{P} = \Psi_{T,t} C^{\sigma} L_T^{\phi}, \tag{16}$$

$$\frac{W_N}{P} = \Psi_{N,t} C^{\sigma} L_N^{\phi}. \tag{17}$$

Since our approach to capital flows in the model is described further below in Section 2.6, we abstract from the Euler equation implied by an optimal choice of international bonds.

2.2 Firms

Assume decreasing returns production functions in each sector with fixed capital. So, $1 - \alpha$ is a measure of the labor share. For the Home country we have production in traded and non-traded respectively as

$$Y_{T,H} = A_{T,H} L_{T,H}^{1-\alpha},$$

$$Y_{N,H} = A_{N,H} L_{N,H}^{1-\alpha}.$$

Firms in each sector maximize profits given sector-specific wage W_T and W_N. This is because of the sector-specific labor disutility in equation (1). This implies equalized marginal revenue products so that

$$P_{T,H} A_{T,H} (1-\alpha) L_{T,H}^{-\alpha} = W_T, \tag{18}$$

$$P_N (1-\alpha) A_{T,N} L_{N,H}^{-\alpha} = W_N. \tag{19}$$

In addition, assembly firms in the home country purchase home and foreign traded goods, along with home non-traded goods, to produce the traded good for consumption of domestic households.

2.3 Nominal policy

Although prices are flexible and money neutral, it is convenient to assume a monetary rule so that the price index for each country is normalized to unity. Hence

$$\left[\Omega P_T^{1-\mu} + (1-\Omega) P_N^{1-\mu}\right]^{\frac{1}{1-\mu}} = 1, \tag{20}$$

2.4 Goods market clearing

Goods market clearing in the home and foreign traded good market is described as

$$Y_{T,H} = I_{T,H} + I_{T,H}^*, \tag{21}$$

$$Y_{T,F} = I_{T,F} + I_{T,F}^*, \tag{22}$$

Note we label foreign variables with an asterisk where appropriate.

Likewise, market clearing in the non-traded good sector is described as

$$Y_{N,H} = C_N + I_{N,H} + I_{N,F}, \tag{23}$$

$$Y_{N,F} = C_N + I_{N,H} + I_{N,F}. \tag{24}$$

2.5 International price setting

The law of one price holds and therefore

$$P_{T,H}^* = \frac{P_{T,H}}{S}, \tag{25}$$

$$P_{T,F} = S P_{T,F}^*. \tag{26}$$

S refers to the nominal exchange rate.

The real exchange rate, defined as the relative CPI price of the home to foreign country, is

then just equal to the inverse of the nominal exchange rate:

$$Q = \frac{P}{SP^*} = \frac{1}{S}. \tag{27}$$

This is because $P = P^* = 1$ as in equation (20).

2.6 Balance of payments

We can rewrite the Home budget constraint in equation (3) as

$$\begin{aligned} PC &= P_{T,H}Y_{T,H} + P_N Y_{N,H} + B_t - \frac{B_{t+1}}{1+r_{t+1}} \\ &= P_{T,H}Y_{T,H} + P_N Y_{N,H} + \theta P_{T,H}Y_{T,H} \\ &= (1+\theta)\, P_{T,H}Y_{T,H} + P_N Y_{N,H}. \end{aligned}$$

We abstract from the Euler equation derived from the optimal choice of bonds. Rather than solving the intertemporal optimization problem, we assume that there is a capital inflow of amount $\theta P_{T,H}Y_{T,H}$:

$$B_t - \frac{B_{t+1}}{1+r_{t+1}} = \theta P_{T,H}Y_{T,H}. \tag{28}$$

This capital inflow is measured in terms of the domestic traded goods. We remain agnostic about the underlying causes of this capital flow, which could be driven by factors such as transfers, news shocks, *etc*.

2.7 System of equations

Then, the system of equations consists of equations (5) to (24), and the analogous equations for the Foreign country together with equations (25) to (29).

2.7.1 System of linearized equations

We approximate the system of equations around the symmetric steady state where all relative prices are equal to one, assuming equal country sizes: $n = 1 - n$. This is to obtain tractable solutions. The variable with the circumflex $\hat{X}$ denotes the log deviation from the steady state:

$$\hat{X} := \ln(X) - \ln(\bar{X}) \approx \frac{X - \bar{X}}{\bar{X}},$$

where $\bar{X}$ denotes the steady state value. By substituting out several equations, the system of linearized equations consists of 11 equations for 11 endogenous variables $\hat{P}_{T,H}$, $\hat{P}^*_{T,F}$,$\hat{P}_N$, $\hat{P}^*_N$, $\hat{L}_T$, $\hat{L}^*_T$,$\hat{L}_N$, $\hat{L}^*_N$, $\hat{C}$, $\hat{C}^*$, and $\hat{S}$.

labor market clearing: 4 equations

$$\hat{P}_{T,H} + \hat{A}_{T,H} - \alpha\hat{L}_T = \hat{\Psi}_T + \phi\hat{L}_T + \sigma\hat{C},$$

$$\hat{P}^*_{T,F} + \hat{A}_{T,F} - \alpha \hat{L}^*_T = \hat{\Psi}^*_T + \phi \hat{L}^*_T + \sigma \hat{C}^*,$$

$$\hat{P}_N + \hat{A}_{N,H} - \alpha \hat{L}_N = \hat{\Psi}_N + \phi \hat{L}_N + \sigma \hat{C},$$

$$\hat{P}^*_N + \hat{A}_{N,F} - \alpha \hat{L}^*_N = \hat{\Psi}^*_N + \phi \hat{L}^*_N + \sigma \hat{C}^*,$$

Goods market clearing: 4 equations

$$\hat{A}_{T,H} + (1-\alpha)\,\hat{L}_T = \frac{1}{2}\frac{v\Omega}{1-v\Omega}\left(-\Gamma \hat{P}_{T,H} + \Delta \hat{P}_N + \hat{C}\right) + \frac{1}{2}\frac{v\Omega}{1-v\Omega}\left[-\Gamma\left(\hat{P}_{T,H} - \hat{S}\right) + \Delta \hat{P}^*_N + \hat{C}^*\right],$$

$$\hat{A}_{T,F} + (1-\alpha)\,\hat{L}^*_T = \frac{1}{2}\frac{v\Omega}{1-v\Omega}\left(-\Gamma \hat{P}^*_{T,F} + \Delta \hat{P}^*_N + \hat{C}^*\right) + \frac{1}{2}\frac{v\Omega}{1-v\Omega}\left[-\Gamma\left(\hat{P}^*_{T,F} + \hat{S}\right) + \Delta \hat{P}_N + \hat{C}\right],$$

$$\hat{A}_{N,H} + (1-\alpha)\,\hat{L}_N = \hat{C} - \Xi \hat{P}_N,$$

$$\hat{A}_{N,F} + (1-\alpha)\,\hat{L}^*_N = \hat{C}^* - \Xi \hat{P}^*_N,$$

Prices: 2 equations

$$-\frac{1-\Omega}{\Omega}\hat{P}_N = v\left[\frac{1}{2}\hat{P}_{T,H} + \frac{1}{2}\left(\hat{S} + \hat{P}^*_{T,F}\right)\right] + (1-v)\,\hat{P}_N$$

$$-\frac{1-\Omega}{\Omega}\hat{P}^*_N = v\left[\frac{1}{2}\hat{P}^*_{T,F} + \frac{1}{2}\left(\hat{P}_{T,H} - \hat{S}\right)\right] + (1-v)\,\hat{P}^*_N$$

Balance of payment identity: 1 equation

$$-\Gamma \hat{S} + (1-\Gamma)\,\hat{P}_{T,H} + \frac{1-v\Omega}{v\Omega}\Xi \hat{P}^*_N + \hat{C}^* = (1-\Gamma)\left(\hat{S} + \hat{P}^*_{T,F}\right) + \frac{1-v\Omega}{v\Omega}\Xi \hat{P}_N + \hat{C} - \hat{\theta}. \quad (29)$$

Note that we define the weighted average of elasticities of substitution as follows:

$$\Gamma := (1-v)\,\psi + v\lambda,$$

$$\Xi := \frac{(1-\Omega)\,v\mu + (1-v)\,\psi}{1-v\Omega},$$

$$\Delta := \frac{(1-v)\,\Omega\psi - (1-v\Omega)\,\lambda + (1-\Omega)\,\mu}{\Omega} = \frac{1-v\Omega}{v\Omega}\left(\Xi - \Gamma\right).$$

The four equations in "labor market clearing" show that labor demand (LHS), represented by the marginal product of labor, equals labor supply (RHS), which is the marginal disutility of labor multiplied by the marginal utility of consumption. In this model, wages can differ between traded and non-traded production within the same country due to heterogeneous labor wedges. However, these differences do not lead to significant deviations from the scenario

where the labor market is unified. This is because relative wages are always negatively correlated with the relative labor supply.

The first two equations in "Goods market clearing" describe the conditions for traded goods market equilibrium, where the supply (LHS) equals the demand (RHS). The first term on the RHS represents the demand in the producing country, while the second term represents the demand in the counterpart country. Note that $1/2$ indicates the country size, and Γ and $-\Delta$ denote the price elasticities of $\hat{P}_{T,H}$ ($\hat{P}^*_{T,F}$) and $\hat{P}_N$ ($\hat{P}^*_N$), respectively. The last two equations describe the equilibrium conditions for non-traded goods, where supply (LHS) again equals demand (RHS). Here, Ξ denotes the price elasticity of $\hat{P}_N$ ($\hat{P}^*_N$). As mentioned earlier, several equations are substituted out for simplification. When simplifying the expressions as shown here, we use the two equations in "Prices" below along with the log-linearized equations for price indices.

The two equations in "Prices" define the theoretical price index for final traded goods, as shown in equation (5). The LHS represents the price of the final traded goods, derived from the CPI definition in equation (4). The CPI index is normalized to unity by the central bank. The first term on the RHS represents the input prices of raw traded goods, while the second term represents the input prices of non-traded services. In our economy, producing final traded goods requires v units of raw traded goods and $(1-v)$ units of non-traded services. Additionally, from these two equations, we can derive the equation for the nominal exchange rate, which is the inverse of the real exchange rate, as shown in equation (27). This equation expresses the nominal exchange rate as a function of the prices of non-traded goods:

$$\hat{S} = \frac{1-v\Omega}{v\Omega}\left(\hat{P}^*_N - \hat{P}_N\right) = -\hat{Q}.$$

The RHS of the "Balance of payments identity" represents the gross exports of the domestic country, while the LHS represents the gross imports.

3 Analytical characterization

Section 3 presents the solution to the log-linearized system of equations as described in Section 2.7.1.

3.1 Solution of target variables

3.1.1 Real exchange rate

The solution for the real exchange rate is given by

$$
\begin{aligned}
\hat{Q} \;=\; & -\frac{1-v\Omega}{v\Omega}\left(\hat{P}_N^* - \hat{P}_N\right) \\
& + \frac{1-v\Omega}{v\Omega}\frac{\left[(1-\alpha)\,\sigma + (\alpha+\phi)\right](\Gamma-1)}{\Lambda}\left[(1+\phi)\left(\hat{A}_{T,H} - \hat{A}_{T,F}\right) - (1-\alpha)\left(\hat{\Psi}_T - \hat{\Psi}_T^*\right)\right] \\
& - \frac{1-v\Omega}{v\Omega}\frac{(1-\alpha)\left[1+\sigma\left(\Gamma-1\right)\right] + (\alpha+\phi)\,\frac{v\Omega}{1-v\Omega}\Gamma}{\Lambda}\left[(1+\phi)\left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) - (1-\alpha)\left(\hat{\Psi}_N - \hat{\Psi}_N^*\right)\right] \\
& + \frac{\left[(1-\alpha)\,\sigma + (\alpha+\phi)\right]\left[\frac{1-v\Omega}{v\Omega}(1-\alpha) + (\alpha+\phi)\,\Gamma\right]}{\Lambda}\hat{\theta},
\end{aligned}
\tag{30}
$$

where the denominator is defined as

$$
\begin{aligned}
\Lambda \;:=\; & \left[(1-\alpha)\,\sigma + (\alpha+\phi)\right]\left[\frac{1-v\Omega}{v\Omega}(1-\alpha)\left[\Xi + (\Gamma-1)\right] + (\alpha+\phi)\,\Gamma\Xi\right] \\
& + \left[(1-\alpha)\left[1+\sigma\left(\Gamma-1\right)\right] + (\alpha+\phi)\,\frac{v\Omega}{1-v\Omega}\Gamma\right]\left[(1-\alpha) + (\alpha+\phi)\,\Xi\right].
\end{aligned}
$$

Whether $\Gamma = (1-v)\psi + v\lambda$ is larger or smaller than unity is crucial. Other parameters, such as σ, do not influence the signs of the directions of responses.

Γ represents the price elasticity of the raw traded product in the demand of traded products and is the weighted average of ψ (the elasticity of substitution between raw traded goods and non-traded inputs) and λ (the trade elasticity), with the weight v, which represents the weight for raw traded goods. The trade elasticity, λ, is generally assumed to be much larger than unity. Consequently, it is reasonable to assume that $\Gamma > 1$. When $\Gamma = (1-v)\psi + v\lambda > 1$, all coefficients are positive.

When $0 < \Gamma = (1-v)\psi + v < 1$, the following effects occur: (a) the Balassa-Samuelson effect works in the opposite direction; (b) the response to efficiency changes in the non-traded sector could be reversed; (c), the denominator becomes negative. However, points (b) and (c) are unlikely to occur. Point (a) has not been explored in the previous literature because under the Cobb-Douglas aggregator, it collapses to the trade elasticity.

Whether Γ is greater than unity is irrelevant in the textbook version of the Balassa-Samuelson model. In contrast to our model, the textbook version assumes that: (1) domestic and foreign goods are perfect substitutes; (2) there is no input requirement for non-traded goods; and (3) wages are identical for workers in both the traded and non-traded sectors. However, it is important to note that relaxing assumption (3) does not lead to significant quantitative deviations from the textbook model. This is because the relative wage is always negatively correlated with the relative labor supply.

The reason that $\Gamma > 1$ matters in our model is as follows. In the standard Balassa-Samuelson model, the prices of traded goods are assumed to be the same across countries. As a result, the real exchange rate is determined by the relative prices of traded and non-traded goods in the domestic and foreign economies. The relative price of non-traded goods versus traded goods is determined by the relative technologies in the production of traded and non-traded goods. Since neither the trade elasticity λ nor the elasticity of substitution ψ between traded and non-

traded goods in intermediate goods production are considered, Γ plays no role in this model.

If we relax assumption (1) and assume that domestic and foreign traded goods are imperfect substitutes, the real exchange rate can no longer be expressed solely as a function of the relative technology between traded and non-traded goods. Instead, it becomes a function of both the relative technologies in traded versus non-traded goods and the terms of trade. In this case, whether the trade elasticity is greater than one becomes important. Specifically, in the balance of payments identity, whether net exports increase or decrease in response to improvements in the terms of trade depends on whether the trade elasticity is greater than one. In other words, the direction of the terms of trade's response to macroeconomic conditions depends on whether the trade elasticity exceeds unity.

If we relax assumption (2) further, the real exchange rate is again determined by both the relative technology of traded versus non-traded goods and the terms of trade. However, in this case, the way terms of trade affect net exports is influenced not only by trade elasticity λ, but also by ψ (the elasticity of substitution between traded and non-traded goods in intermediate goods production). This is because the terms of trade affect the relative demand for intermediate traded versus non-traded goods.

This mechanism can be better understood by slightly rewriting the balance of payment identity in equation (29):

$$\left(\hat{C}^* - \hat{C}\right) - \Gamma\hat{S} + (\Gamma - 1)\left(\hat{S} + \hat{P}^*_{T,F} - \hat{P}_{T,H}\right) + \frac{1 - v\Omega}{v\Omega}\Xi\left(\hat{P}^*_N - \hat{P}_N\right) + \hat{\theta} = 0.$$

The way the terms of trade affect net exports is determined by $\Gamma - 1$, which simplifies to $\lambda - 1$ if there is no input requirement for non-traded goods.

Λ is an increasing function of the elasticities μ, λ, and ψ. It is important to note that μ appears only in the denominator of Λ. Thus, an increase in μ (the elasticity in the trade between tradable and non-tradable goods in final production) reduces the impacts of exogenous variables on the real exchange rate. Specifically, when $\mu = \infty$, the real exchange rate becomes constant.

On the other hand, ψ and λ appear in both the numerator and denominator of Λ, and both affect it positively. Therefore, the way these two elasticities influence the impacts on the real exchange rate is not immediately clear.

Appendix B examines how economic conditions, as represented by the deep parameters, α,ψ and ϕ, influence the real exchange rate's response to the fundamental drivers of the trend when we assume Υ:=$\mu = \psi = \lambda > 1$.

Anatomy of real exchange rate dynamics In our calibration, $\Gamma > 1$ and this generally holds under reasonable calibration. So, we here aim to understand the determination of the real exchange rate under this condition. We analyze the dynamics of the real exchange rate through three effects: the Balassa-Samuelson effect (the first term), the effect via the Non-Traded sector (the second term), and the effect through capital flows (the third term).

Balassa-Samuelson effect The first term on the second line of (30) captures the Balassa-Samuelson effect. When the domestic country experiences higher technological progress in the traded goods sector than its foreign counterpart, the real exchange rate appreciates. Conversely, the relative labor wedge in the traded sector, which operates similarly to the relative technology term, has the opposite effect, leading to a depreciation of the real exchange rate. Notice that lower λ and higher ψ dampens the Balassa-Samuelson effect. This is because this lowers Γ, which represents the price elasticity of the the traded product in the demand of the traded goods. In addition, as shown in Appendix B, an increase in α,Y and ϕ reduces the magnitude of the Balassa-Samuelson effect.

The Balassa-Samuelson effect is a special case of the more general 'Penn effect', which posits that countries with a higher level of GDP per capita have higher relative price levels. This is consistent with the Balassa-Samuelson effect as described here to the extent that differences in GDP per capita are mainly driven by different productivity in traded goods sectors.

Non-Traded sector In contrast, the second term in (30) implies that if technological progress in the non-traded goods sector is more pronounced in the domestic country than in the foreign country, the real exchange rate tends to depreciate. This is due to the decline in the domestic price level. Additionally, a relatively lower labor wedge in the non-traded sector in the domestic country will lead to an depreciation of the real exchange rate. Together, these factors, alongside the capital flow channel discussed below, mitigate the Penn effect. As illustrated in Appendix B, an increase in α,Y and ϕ dampens the effect of the non-traded sector channel.

Capital flow The third term presents that capital inflows typically lead to an appreciation of the real exchange rate by increasing the domestic country's relative consumption. Appendix B demonstrates that an increase in Y reduces the impact of capital flows, whereas increases in α and ϕ amplify it.

Caution regarding the use of Cobb-Douglas aggregator When the elasticity of substitution between goods is set to unity ($Y := \psi = \mu = \lambda = 1$), implying that all aggregators are Cobb-Douglas, equation (30) simplifies to

$$\hat{Q} \mid_{\mu=\lambda=\psi=1} = -\frac{1}{2}\left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) + \frac{1-\alpha}{2\left(1+\phi\right)}\left(\hat{\Psi}_N - \hat{\Psi}_N^*\right) + \frac{1}{2}\hat{\theta}.$$

A key insight from this specification is that the Balassa-Samuelson effect disappears when all aggregators are Cobb-Douglas. The intuition comes from the fact that a rise in productivity in traded goods leads to a terms of trade deterioration for the affected country. The wealth effects of the productivity enhancement are then fully shared across countries, so that the relative price of non-traded to traded goods moves equally in each country, leaving the real exchange rate unchanged. This result is particularly striking, as many studies examining the Balassa-Samuelson effect in small open economies have employed Cobb-Douglas aggrega-

tors. This finding highlights a potential pitfall in using the Cobb-Douglas specification in open economies, as it may inadvertently exclude the Balassa-Samuelson effect—one of the most significant channels through which international shocks are transmitted.

3.1.2 Real exchange rate of Non-Traded goods

The real exchange rate of Non-traded goods is defined as

$$Q_N := \frac{P_N}{SP_N^*}.$$

By using the solutions in Section A.4, we have a linear exact form:

$$\hat{Q}_N = -\hat{S} - \left(\hat{P}_N^* - \hat{P}_N\right) = -\frac{1}{1-v\Omega}\hat{S} = 2\hat{Q}. \tag{31}$$

The Non-Traded goods real exchange rate is proportional to the aggregate real exchange and exhibits more volatile dynamics since $1 - v\Omega < 1$.

3.1.3 Real exchange rate of Traded goods

The real exchange rate of Traded goods is defined as

$$Q_T := \frac{P_T}{SP_T^*}.$$

By using the solutions in Section A.4, we have a linear exact form:

$$\hat{Q}_T = -\hat{S} - \left(\hat{P}_T^* - \hat{P}_T\right) = -\hat{S} + \frac{1-\Omega}{\Omega}\left(\hat{P}_N^* - \hat{P}_N\right) = -\frac{1-v}{1-v\Omega}\hat{S} = 2\left(1-v\right)\hat{Q}. \tag{32}$$

The real exchange rate of Traded goods is proportional to the aggregate real exchange and it shows less volatile dynamics than the real exchange rate of Non-Traded goods.

3.1.4 Output of Non-Traded goods

By using the solutions in Section A.4, we have

$$\begin{aligned}
\hat{y}_N &= \left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) + (1-\alpha)\left(\hat{L}_N - \hat{L}_N^*\right) \qquad (33)\\
&= \frac{\frac{1-\alpha}{v\Omega}\left[(1-v\Omega) + v\Omega\sigma\Xi\right](\Gamma-1) + \left(\frac{1-\alpha}{v\Omega} + \frac{\alpha+\phi}{1-v\Omega}\Gamma\right)\Xi}{\Lambda}\left[(1+\phi)\left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) - (1-\alpha)\left(\hat{\Psi}_N - \hat{\Psi}_N^*\right)\right]\\
&\quad + \frac{(1-\alpha)(\Gamma-1)(1-\sigma\Xi)}{\Lambda}\left[(1+\phi)\left(\hat{A}_{T,H} - \hat{A}_{T,F}\right) - (1-\alpha)\left(\hat{\Psi}_T - \hat{\Psi}_T^*\right)\right]\\
&\quad + \frac{(1-\alpha)\left[(1-\alpha) + \frac{v\Omega}{1-v\Omega}(\alpha+\phi)\Gamma\right](1-\sigma\Xi)}{\Lambda}\hat{\theta}.
\end{aligned}$$

Whether $\Gamma = (1-v)\psi + v\lambda$ and/or $\sigma\Xi = \sigma\frac{(1-\Omega)v\mu + (1-v)\psi}{1-v\Omega}$ are larger or smaller than unity is of significant importance. When both Γ and $\sigma\Xi$ are larger than unity, all coefficients are

positive. The trade elasticity, λ, is generally assumed to be much larger than unity, making it reasonable to suppose that $\Gamma > 1$.

Ξ represents the price elasticity of the non-traded product in the demand of the non-traded goods. is the weighted average of ψ (the elasticity of substitution between raw traded goods and non-traded inputs) and μ (the elasticity of substitution between traded and non-traded goods in final production), with weights for both ψ and μ given by v and Ω, respectively.

The value of $\sigma\Xi = \sigma\frac{(1-\Omega)v\mu+(1-v)\psi}{1-v\Omega}$ relative to unity affects the direction of the responses to changes in the efficiency of traded goods production and to capital inflows. Specifically, the reason why $\sigma\Xi > 1$ is important is that when $0 < \sigma\Xi < 1$, traded and non-traded goods are considered to be Edgeworth complements. In this case, both goods move in the same direction. Conversely, when $\sigma\Xi > 1$, the goods are considered to be Edgeworth substitutes, and in this scenario, they move in opposite directions.

This relationship can be mathematically understood by combining labor market clearing conditions and the goods market clearing condition in the non-traded sector in Section (2.7.1).

In our calibration, $\sigma\Xi > 1$. So, we here aim to understand the determination of the output of non-traded goods under this condition. The output of the Non-Traded goods in the domestic country relative to the foreign country increases when

1. In the Non-Traded sector, the domestic (foreign) technology improves (declines) or the domestic (foreign) labor wedge decreases (increases),

2. In the Traded sector, the domestic (foreign) technology declines (improves) or the domestic (foreign) labor wedge increases (decreases),

3. There are capital inflows to the domestic country.

The first channel is straightforward: efficiency improvements in the domestic country's Non-Traded sector increase output relative to the foreign country. The second channel operates through the relative demand for Traded and Non-Traded products in the domestic country. Efficiency gains in the Traded sector lower the relative price of Traded goods, leading to an increase in the production of Traded goods when Traded and Non-Traded goods are substitutes. The third channel works via expenditure switching: capital inflows appreciate the domestic currency.

3.1.5 Output of Traded goods

By using the solutions in Section A.4, we have

$$
\begin{aligned}
\hat{y}_T &= \left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) + (1-\alpha)\left(\hat{L}_N - \hat{L}_N^*\right) \qquad (34)\\
&= \frac{\Gamma}{1-v\Omega}\frac{(1-\alpha)\left[v\Omega + (1-v\Omega)\,\sigma\Xi\right] + (\alpha+\phi)\,\Xi}{\Lambda}\left[(1+\phi)\left(\hat{A}_{T,H} - \hat{A}_{T,F}\right) - (1-\alpha)\left(\hat{\Psi}_T - \hat{\Psi}_T^*\right)\right]\\
&\quad + \frac{(1-\alpha)\,\Gamma\,(1-\sigma\Xi)}{\Lambda}\left[(1+\phi)\left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) - (1-\alpha)\left(\hat{\Psi}_N - \hat{\Psi}_N^*\right)\right]\\
&\quad - \frac{(1-\alpha)\,\Gamma}{v\Omega}\frac{\sigma\,(1-\alpha) + (1-v\Omega)\,(\alpha+\phi)\,(1-\sigma\Xi)}{\Lambda}\hat{\theta}
\end{aligned}
$$

Similar mechanisms as explained in the previous section are at play in the case of the relative output in Traded goods.

3.1.6 Relative unit labor cost in Non-Traded sector

The relative unit labor cost in the Non-Traded sector is defined as

$$
u_N = \frac{\frac{W_N}{A_{N,H}L_N^{1-\alpha}/L_N}}{S\frac{W_N^*}{A_{N,F}\left(L_N^*\right)^{1-\alpha}/L_N^*}}.
$$

Using the solutions in Section A.4, we have

$$
\hat{u}_N = -\hat{Q}_N = \frac{1}{1-v\Omega}\hat{Q}. \qquad (35)
$$

The unit labor cost in the Non-Traded sector moves in the same direction to the real exchange rate of Non-Traded goods. Thus, as shown in equation (30), an increase in the labor wedge in the non-traded (traded) goods sector in the home country increases (reduces) the unit labor cost in the non-traded sector.

3.1.7 Relative unit labor cost of Traded goods

The relative unit labor cost in the traded sector is defined as

$$
u_T = \frac{\frac{W_T}{A_{T,H}L_T^{1-\alpha}/L_T}}{S\frac{W_T^*}{A_{T,F}\left(L_T^*\right)^{1-\alpha}/L_T^*}}.
$$

Using the solutions in Section A.4, we have

$$
\hat{u}_T = \left(\hat{P}_{T,H} - \hat{P}_{T,F}^*\right) - \hat{S},
$$

or

$$\begin{aligned}\hat{u}_T &= -\frac{(1-v\Omega)(1-\alpha)(1-\sigma\Xi)}{v\Omega\Lambda}\left[(1+\phi)\left(\hat{A}_{N,H}-\hat{A}_{N,F}\right)-(1-\alpha)\left(\hat{\Psi}_N-\hat{\Psi}_N^*\right)\right] \\ &\quad -\frac{(1-\alpha)\left[v\Omega+(1-v\Omega)\sigma\Xi\right]+(\alpha+\phi)\Xi}{v\Omega\Lambda}\left[(1+\phi)\left(\hat{A}_{T,H}-\hat{A}_{T,F}\right)-(1-\alpha)\left(\hat{\Psi}_T-\hat{\Psi}_T^*\right)\right] \\ &\quad +\frac{(1-\alpha)\left\{\sigma(1-\alpha)+(\alpha+\phi)\left[(1-v\Omega)+v\Omega\sigma\Xi\right]\right\}}{v\Omega\Lambda}\hat{\theta}.\end{aligned} \tag{36}$$

The unit labor cost in the traded sector moves almost in the same direction as the relative output in traded goods. Both labor wedges increase the unit labor cost in the traded sector.

Note that in the regressions below, we only use the aggregate unit labor cost which is the weighted average of equations (35) and (36). Thus, the unit labor cost in the regression represents the aggregate labor wedge.

4 Data

Our data consists of real exchange rates covering all goods, both tradable non-tradable, as well as a number of labor market fundamentals. Our sample of countries are Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovenia, and Slovakia. In most cases we also consider the same variables for the European Union 27 countries group (EU27). Our sample is annual and covers the period 1999-2020.

4.1 Real Exchange Rates

We construct real exchange rates for the sample of Eastern European countries from disaggregated price data. The data are provided by Eurostat as part of the Eurostat-OECD PPP Programme. They are arranged in the form of price level indices (PLIs). A PLI gives the price of a good at a given time for a given country, relative to a reference country price. Hence, it is a good-specific PPP, although if the country chosen is in the Eurozone this measure does not involve different currencies. The reporting frequency is annual for 1999-2020 and the PLIs are available for 223 "basic headings" of consumer goods and services. These include food (including food away from home), clothing, housing costs, durable goods, transportation costs, as well as medical and educational services. They cover 100 percent of the consumption basket. The full list of PLIs for the basic headings of consumer goods and services is contained in the online Appendix Table 14. For each item, the reference price is obtained as a ratio of the domestic price of each good to the EU27 analog and re-expressed in terms of the corresponding EU15 price level for a better comparability for the Eastern European economies case.[2] Hence, the prices are comparable in levels, so that both cross-section and time-series real exchange

[2]The EU15 group includes Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Spain, Sweden, Portugal, Finland, and the United Kingdom, and the EU27 Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

rate variation can be examined. Our sample contains the 12 Eastern European economies mentioned above. We construct aggregate and sectoral real exchange rates from the underlying price series, using expenditure weights. The expenditure weights are constructed using euro expenditures on every basic heading in every country and every year. Thus, the expenditure weights are time-varying, year by year.[3] Let q_{it} be the real exchange rate for country i at time t and let q_{iTt} (q_{iNt}) represent the average real exchange rate for the subset of traded (non-traded) goods. Real exchange rates are measured so that an increase represents an appreciation for the home country.[4]

Relative to other studies that have compared price levels internationally, these data have a number of advantages. They cover the entire consumer basket. For a detailed explanation meant to convey the care taken to make prices comparable see Berka, Devereux and Engel (2018). Here we mention only that exhaustive efforts are made at the item priced level to ensure comparability across countries, including to consider that some products are priced at various types of outlets (for example, department stores, supermarkets, specialty outlets) by increasing the sampling of products when their prices across similar outlets show higher variation.

We separate goods into traded and non-traded categories using a criteria by item reported in Table 14 in the (online) Appendix and along the lines followed by Berka et al. (2018) and Crucini et al. (2005) where all goods with a positive trade share are categorized as "traded", and those with a zero trade as "non-traded."

The composition of the consumption baskets differs across goods, countries, and time. To account for this, we construct expenditure weights for each good, country, and year, using the expenditure data provided in the same Eurostat-OECD Programme. Specifically, for good i, country j, and year t, we construct a weight $\gamma_{i,j,t} = \frac{\exp_{i,j,t}}{\sum_{i=1}^{223} \exp_{i,j,t}}$ where exp is the local expenditure. We then construct expenditure-weighted PLIs for all countries using $\gamma_{i,j,t}$.

Denoting $p_{i,j,t}$ as the log of a PLI, in year t, for a good i in country j relative to EU15, we calculate the log of the real exchange rate of country j, $q_{j,t}$, as the expenditure-weighted arithmetic average:

$$q_{j,t} = \sum_{i=1}^{223} \gamma_{i,j,t} p_{i,j,t}$$

Based on these aggregate measures we report some descriptive statistics for a set of variables in Table 1. The table first reports the average log real exchange rate over the sample for each country, denoted $\bar{q}$, as well as the equivalent measures for the traded goods real exchange rate $\bar{q}_T$, the nontraded goods real exchange rate, $\bar{q}_N$, and also the relative price of nontraded goods $\bar{q}_n = \bar{q}_N - \bar{q}_T$. Note that the level data are expressed as proportions of the EU27 average. Thus if an entry is negative in logs it implies that the country's price is below the average.

The characteristics of the sectoral real exchange rates, and the average relative price of non-

[3] We also experimented with the use of time invariant weights, using average weights over the sample, and the results were essentially identical to those reported below.

[4] Therefore, q_{it} represents the the average price level for country i, relative to the European average.

traded goods closely mirror the aggregate real exchange rates. In general, we see that if for a given country i, we have $\bar{q}_i > 0, (< 0)$, we also have $\bar{q}_{Ti} > 0, (< 0), \bar{q}_{Ni} > 0, (< 0)$, and in more than half of the cases $\bar{q}_{Ni} - \bar{q}_{Ti} > 0, (< 0)$. That is, if a country has a low (high) average price level relative to the European average, its non-traded goods price tends to be proportionately lower (higher) than its traded goods price, relative to the average. This offers some initially encouraging evidence for the Balassa-Samuelson model, in the sense that differences across countries in real exchange rates are mirrored by differences in internal relative sectoral prices in a manner consistent with Balassa-Samuelson.

The right panel of Table 1 reports standard deviations of annual real exchange rates. They are range from three to eleven percent for most countries. As we would anticipate, the standard deviation of non-traded real exchange rates exceeds that of the traded real exchange rates. We can also see some of these features in Table 2 where we report summary statistics by variable. We can see that the volatility and average level of the real exchange rate of non-tradables exceeds that of tradables. Similarly, the real exchange rates tend to display a non-trivial autorregressive component, consistent with the trend towards appreciation across the countries in our sample.[5]

[5]Note that these are standard deviations of logs, rather than log differences.

Table 1: Country Summary Statistics

Country	$\bar{q}$	$\bar{q}_T$	$\bar{q}_N$	$\bar{q}_n$	$s(q)$	$s(q_T)$	$s(q_N)$	$s(q_n)$
BG	3.96	4.16	3.49	-0.67	0.09	0.09	0.15	0.07
CY*	4.49	4.60	4.35	-0.25	0.03	0.03	0.04	0.05
CZ	4.16	4.30	3.91	-0.38	0.11	0.10	0.16	0.08
EE*	4.26	4.38	4.04	-0.34	0.10	0.09	0.12	0.05
HU	4.14	4.29	3.87	-0.42	0.07	0.07	0.09	0.04
LT*	4.18	4.30	3.76	-0.54	0.08	0.09	0.10	0.09
LV*	4.22	4.36	3.95	-0.41	0.09	0.10	0.12	0.08
MT*	4.39	4.53	4.21	-0.32	0.03	0.04	0.06	0.07
PL	4.10	4.23	3.81	-0.42	0.06	0.06	0.09	0.07
RO	3.98	4.16	3.55	-0.61	0.10	0.11	0.11	0.07
SI*	4.36	4.45	4.20	-0.25	0.04	0.04	0.06	0.04
SK*	4.18	4.31	3.91	-0.39	0.18	0.15	0.27	0.14
	$\bar{a}_T$	$\bar{a}_N$	$\bar{a}_{TN}$	$\overline{rulc}$	$s(a_T)$	$s(a_N)$	$s(a_{TN})$	$s(rulc)$
BG	-2.13	-0.51	-1.62	-2.19	0.11	0.21	0.11	0.22
CY*	-0.57	0.19	-0.76	-0.50	0.06	0.04	0.05	0.11
CZ	-0.50	-0.54	0.05	-0.96	0.19	0.04	0.18	0.25
EE*	-0.94	-0.06	-0.88	-1.20	0.18	0.23	0.08	0.32
HU	-0.47	-0.38	-0.08	-1.24	0.11	0.05	0.11	0.15
LT*	-1.21	-0.85	-0.36	-1.44	0.20	0.20	0.07	0.24
LV*	-0.93	-0.30	-0.63	-1.69	0.24	0.21	0.05	0.23
MT*	-0.81	-0.40	-0.41	-0.39	0.05	0.10	0.13	0.21
PL	-0.62	-0.35	-0.27	-1.38	0.13	0.16	0.08	0.11
RO	-1.31	-0.51	-0.81	-2.70	0.25	0.21	0.10	0.19
SI*	-0.45	-0.26	-0.19	-0.45	0.10	0.05	0.08	0.07
SK*	-0.39	-0.17	-0.22	-1.12	0.28	0.12	0.18	0.39

Notes: All real exchange rate variables (q, q_T, q_N, q_n) are home country values relative to EU15 average. q is the expenditure-weighted log real exchange rate (an increase is an appreciation). q_T (q_N) is the real exchange rate for traded (nontraded) goods only, both relative to EU15 average. $q_n \equiv q_N - q_T$. $s(\cdot)$ denotes standard deviation. a_T (a_N) is a logarithm of traded (nontraded) labor productivity of the home country relative to EU27. Traded is an aggregate of one-digit sector's labor productivities aggregated using sectoral gross outputs as weights. $a_{TN} \equiv a_T - a_N$. $rulc$ is a logarithm of relative unit labor costs the home country relative to the EU27 average. The balanced sample period is 1999-2020.

* Countries joining the Eurozone at some point in our sample.

Table 2: Variable Summary Statistics

	q	q_T	q_N	q_n	a_T	a_N	a_{TN}	$rulc$
$mean(std_i(\cdot))$	0.08	0.08	0.11	0.07	0.16	0.14	0.10	0.21
$std(mean_i(\cdot))$	0.16	0.14	0.26	0.13	0.50	0.26	0.46	0.69
$AR(1)$	0.81	0.81	0.81	0.80	0.86	0.82	0.63	0.94

Notes: All real exchange rate variables (q, q_T, q_N, qn) are expressed as home country relative to EU15. q is the expenditure-weighted log real exchange rate (an increase is an appreciation). q_T (q_N) is the real exchange rate for traded (nontraded) goods only, both relative to EU15 average (an increase is an appreciation). $q_n \equiv q_N - q_T$.a_T (a_N) is a logarithm of traded (nontraded) labor productivity in the home country relative to EU27. Traded is an aggregate of one-digit sector's TFP levels aggregated using sectoral gross outputs as weights. $rulc$ is a logarithm of relative unit labor costs of each home country relative to EU27. The balanced sample period is 1999-2020. The top row reports average time series standard deviation $(\text{std}_i(\cdot)$, where i indexes countries) and the second row standard deviation of average real exchange rates $(\text{mean}_i(\cdot)$, where i indexes countries). The bottom row reports the autocorrelation coefficient from a fixed-effects panel AR(1) regression.

Figure 2 displays some properties of the aggregate real exchange rates in our Eastern European sample. We can see that there is a substantial convergence towards the mean in the whole sample for all levels of aggregation (all goods, traded, non-traded); furthermore we see that the relative price of non-tradables, shown in panel D, shows a noticeable stability in most countries, which reflects either a substantial comovement between the traded and non-traded components of the real exchange rate (RER), or even a convergence of these variables.

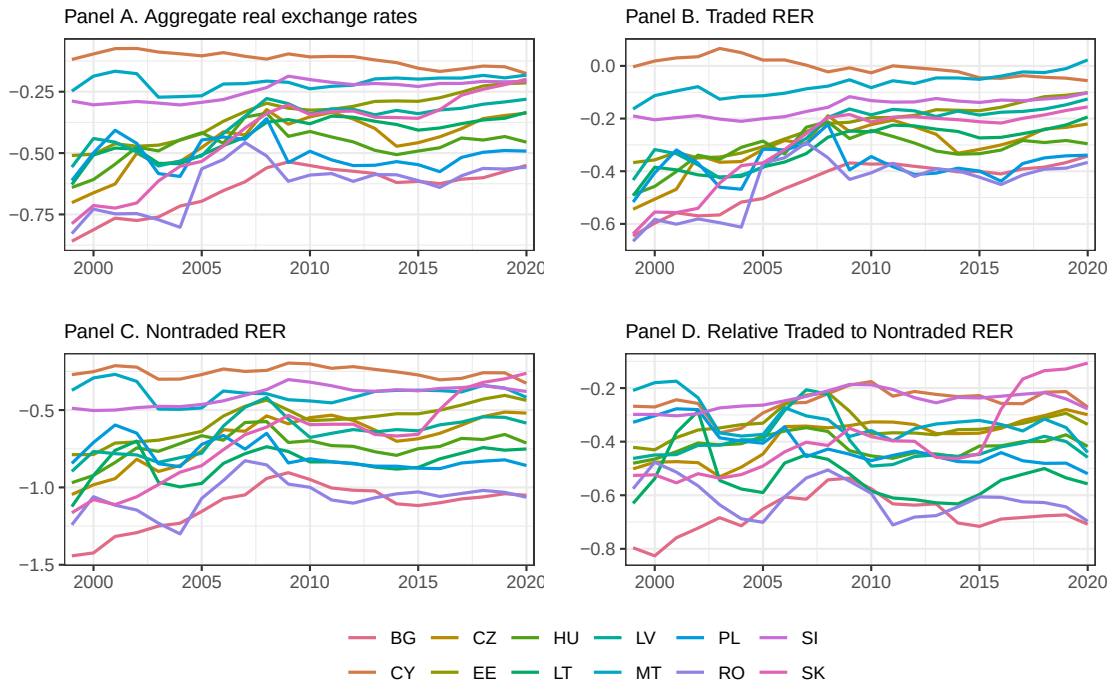


Figure 2: Real Exchange Rates

4.2 Productivity and Unit labor Costs Data

We wish to associate the real exchange rate data with supply-side indicators that are suggested by the theoretical discussion above. For the latter we consider labor productivity data for the whole economy and at the sectoral level.[6] Similarly, we consider labor market conditions to account for the possibility that the real exchange rates are influenced by factors beside productivity. These are accounted for by including the unit labor costs.

We obtain indexes of real labor productivity per hour from Eurostat at the sectoral level for the single-letter NACE Rev. 2 classification. We proceed to adjust these indexes by the sectoral output level relative to the EU25 analog. To do this adjustment, we multiply each labor productivity sectoral index by the corresponding sectoral output per-hour worked from the 1997 Productivity Level Database reported by the Groningen Growth and Development Centre (GGDC) and along the lines of Berka et al. (2018) where, importantly, we adjust the levels to be expressed in terms of the EU25 sectoral output rather than the US levels as in the official data release. Once we have sectoral level adjusted indexes, we aggregate these into tradable and non-tradable broader-sector categories, using a weighted average of the tradable and non-tradable sectors with weights approximated by the sectoral contribution to the total economy value added obtained from the 2023 Productivity Level Database reported by the GGDC (see Inklaar, Marapin and Gräler, 2023, for details). For this calculation, we adapt the sectoral mapping into tradable and non-tradable sectors from Berka et al. (2018) into the single letter NACE Rev. 2 sectoral classification that are considered in the Eurostat, and GGDC datasets. Table 3 shows the sectors considered and their tradability categorization we use.

At the same time, we compute a measure of relative labor productivity in the tradable sector with respect to the non-tradable one, and express this ratio, in relative terms with respect to the analog quantity for the EU27 group. This variable can be obtained based on the relative real labor productivity of each type of aggregate (tradable, non-tradable) with respect to EU27 as follows:

$$RLprod = \frac{\frac{realLabProd_{T,it}}{realLabProd_{T,EUt}}}{\frac{realLabProd_{N,it}}{realLabProd_{N,EUt}}} = \frac{\frac{realLabProd_{T,it}}{realLabProd_{N,it}}}{\frac{realLabProd_{T,EUt}}{realLabProd_{N,EUt}}}$$

In addition we consider a measure of real relative unit labor costs which we compute based on Nominal Unit labor Cost data in euros from Eurostat at the sectoral level, divided by the Producer Price Index data (PPI) of each economy which we obtain from the IMF-IFS database (and complement for the EU27 group using the industry PPI from 2018 to 2020 from Eurostat). After obtaining such real labor unit costs per hour, we divide it in each case by the same measure for the EU27 group which gives us the real relative unit labor costs per sector.

Tables 1 (lower panel) and 2 report descriptive statistics for traded and non-traded labor productivity in the same form as reported for the real exchange rate data. In general we see that the traded labor productivity tends to be more volatile than the non-traded one. We also

[6] One might want to consider TFP data directly instead of factor-specific productivity data as in Berka et al. (2018). However, in contrast to the Western Europe case, this data is not available for our sample of Eastern European countries. Thus, we use the labor productivity indexes sectoral data from Eurostat.

illustrate the properties for these variables across time in Figure 3. We can see in Panel C that there is substantial variation of the unit labor costs over time which justifies the inclusion of these costs as a separate determinant for the real exchange rate.

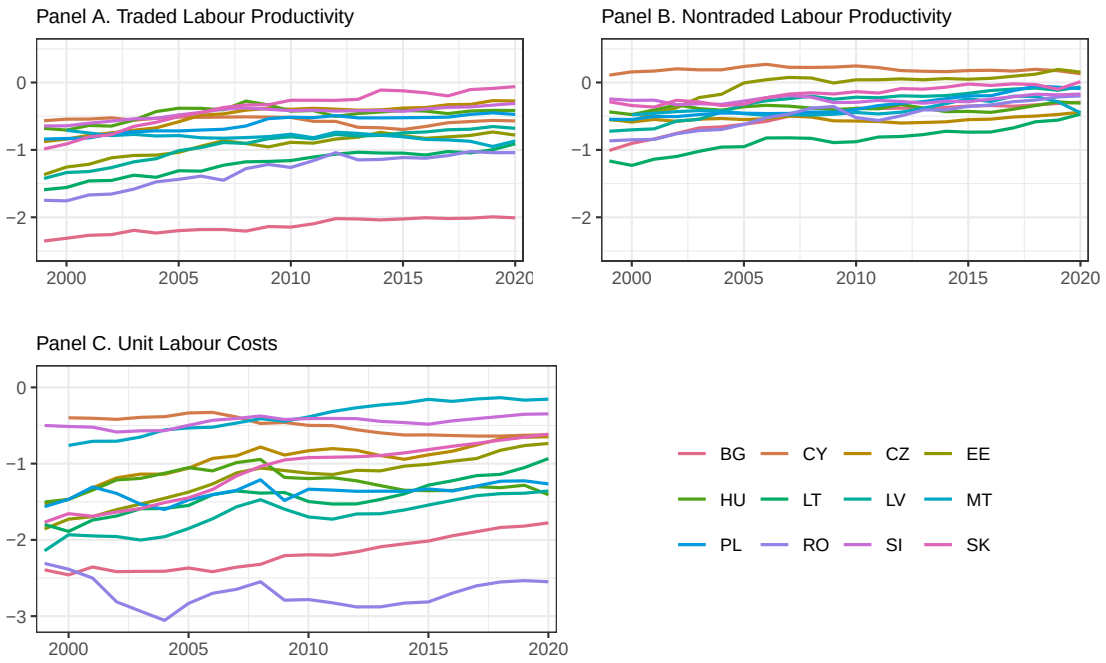


Figure 3: labor productivity by sectors and unit labor costs

Table 3: Sectoral Classification and Tradability

NACE Rev. 2 Sector Letter	Sector Name	Tradability
A	Agriculture, forestry and fishing	T
B	Mining and quarrying	T
C	Manufacturing	T
D	Electricity, gas, steam and air conditioning supply	N
E	Water supply; sewerage, waste management and remediation activities	N
F	Construction	N
G	Wholesale and retail trade	T
H	Transportation and storage	N
I	Accommodation and food service activities	N
J	Information and communication	N
K	Financial and insurance activities	N
M	Professional, scientific and technical activities	N
N	Administrative and support service activities	N
R	Arts, entertainment and recreation	N
S	Other service activities	N
B-E	Industry (except construction)	T
G-I	Wholesale and retail trade, transport, accommodation and food services	N
M-N	Professional, scientific. services	N
R-U	Arts, entertainment, recreation, and other services	N

Notes: T and N refer to the tradable and non-tradable sectoral classification.

We can also summarize the relative productivities and unit labor costs by sectors. To this end, we consider population-weighted averages across the countries in our sample and illustrate the associated Eastern European region indicators over time in Figures 5 and 4. We can see that the comovement between sectoral productivities and the substantial unit labor costs variation over time we highlighted before is also visible at the regional level for both tradable (T) and non-tradable sectors (N).

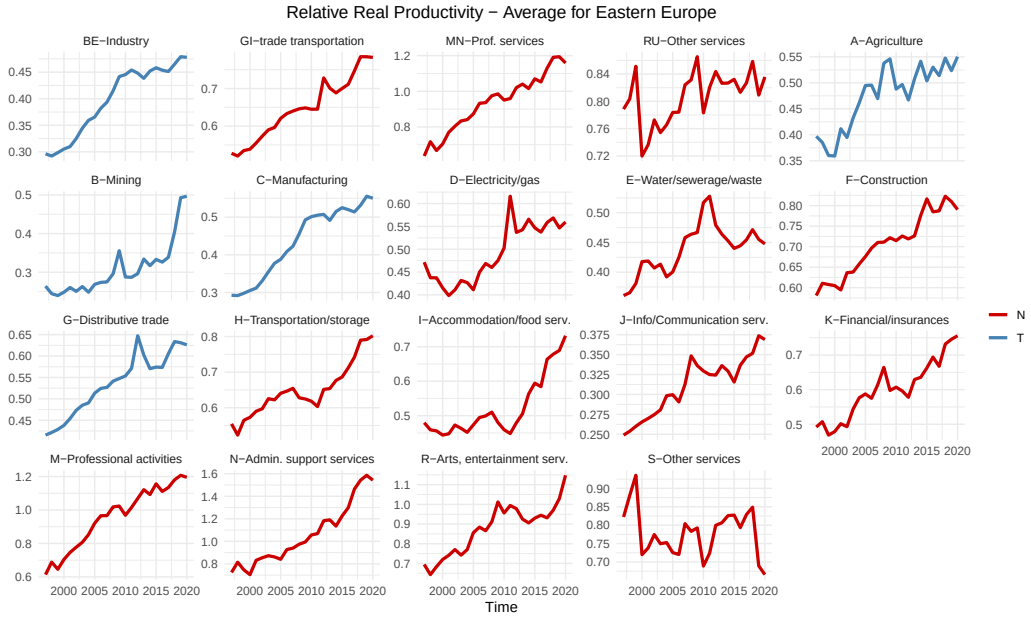


Figure 4: Average Relative Real labor Productivity for Eastern Europe (12 countries).

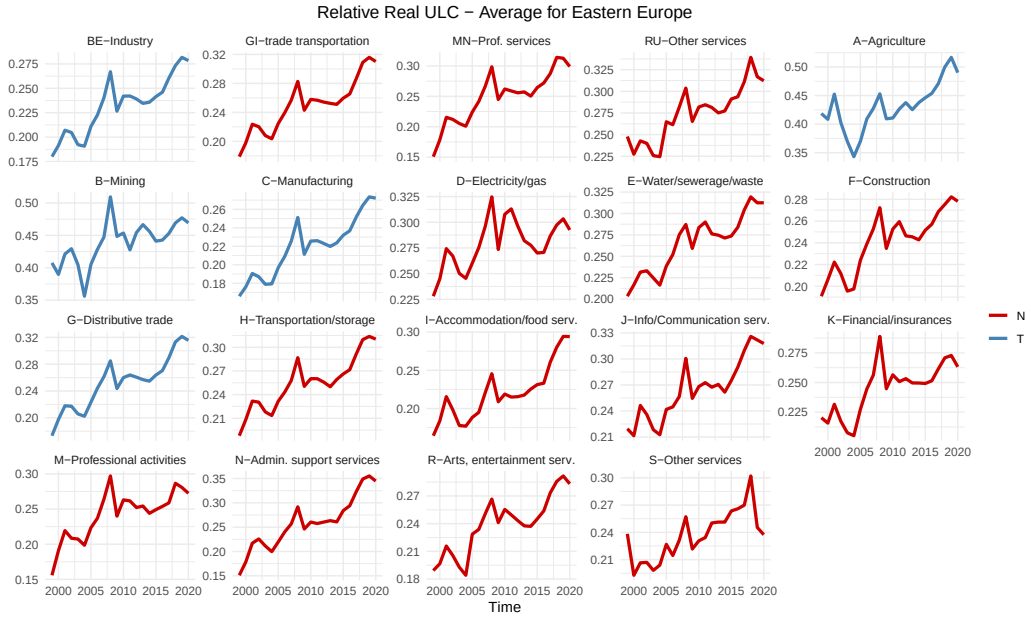


Figure 5: Average Relative Real Unit labor Cost for Eastern Europe (12 countries).

5 Real Exchange Rate regressions

Based on our data described above, here we summarize a set of estimations to explore the relationship between real exchange rates at different levels of aggregation and the relative sectoral productivities and the labor cost dynamics.

Estimations with productivity for tradable and non-tradable sectors

We present an empirical setup in which the real exchange rate (RER) is dependent on the relative labor productivity of the tradable and non-tradable sectors, as well as the real labor unit cost (relative to the EU). We consider versions of the regression where the relative (traded to non-traded) labor productivity enters as a single variable ($RLprod$), then one in which we consider the real labor productivity of tradable and non-tradable sectors as separate variables (relative to EU27), and a final estimation where we consider the separate productivities, and the relative unit labor costs ($RULC$).

Our data consists on a panel with annual frequency and country level observations (computed from sectoral data). We report panel estimations with fixed and random effects. All standard errors are computed using a panel corrected standard errors clustering method following Beck and Katz (1995). We also report the result of the Hausman test (HT) for the random effects regression (rejection of the null implies no difference between the Fixed effects and Random effects estimations, interpreted as a weak preference for the Fixed effects model).

We report estimations for the real exchange rate for all goods, a second group of estimates for the real exchange rate of tradable goods, and a final for non-tradable goods. For interpretations, it is also useful to remember that the RER is defined in a way that an increase indicates a real appreciation.

The regression specifications are described as follows:

$$\log RER^{j}_{it} = \alpha_0 + \beta_1 \log \overbrace{\left(\frac{\frac{realLabProd_{T,it}}{realLabProd_{N,it}}}{\frac{realLabProd_{T,EUt}}{realLabProd_{N,EUt}}} \right)}^{RLprod} + \beta_2 \log \overbrace{\left(\frac{RealULC_{it}}{RealULC_{EUt}} \right)}^{RULC} + \epsilon_{ti},$$

$$\log RER^{j}_{it} = \alpha_0 + \beta_1 \log Lprod_{T,it} + \beta_2 \log Lprod_{N,it} + \beta_3 \log RULC_{it} + \epsilon_{ti}, \quad \text{for } j = \{All, T, N\},$$

where in the first type of regression $RLprod$ denotes the real labor productivity of the tradable sector relative to the non-tradable one expressed itself in relative terms with respect to the same quantity for the EU. Similarly, $RULC$ is the real unit labor cost of each country relative to the same measure in the EU. As for the second type of panel, $Lprod_T$ and $Lprod_N$ denote respectively the real labor productivity of the tradable and non-tradable sectors with respect to the analog quantity for the EU.

As implied by equations (30), (31) and (32) in Section 3 above, we note that the presumptive sign on both β_1 and β_2 in the first regression is positive. A rise in traded relative to non-traded goods productivity as well as a rise in the labor wedge and/or the terms of trade —both of

which enter into the relative unit labor cost, should be associated with a real exchange rate appreciation. Likewise, for the same reasons, in the second regression, we expect that β_1 and β_3 to be positive, while β_2 to be negative.

We note that the estimated coefficients are the largest for RERN and they are similar for RER and RERT. This result is consistent with the theoretical prediction from equations (30), (31) and (32).

In evaluating the empirical results, it is important to consider the following two points. (1) The primitives in the model are the labor wedges for the Traded and Non-Traded sectors. Ideally, estimation should be conducted using exogenous variables, with these labor wedges included as explanatory variables. However, since these variables are unavailable, we use unit labor cost as a proxy that combines the labor wedges. (2) Unit labor cost is not a primitive; rather, it is expressed as a function of technology and the labor wedge. As a result, the use of relative unit labor cost in the estimation may introduce multicollinearity, which could lead to estimated parameters whose signs may not fully align with the theoretically consistent ones as assumed above.

Table 4 shows the results for regressions for the real exchange of all goods (as dependent variable). Similarly, in the tables 5 and 6 we report the results for the real exchange of traded and non-traded goods. The coefficients on traded and non-traded productivity have the right sign, and the former is significant. At the same time, it is important to include the relative unit cost variable which is also significant in all cases. As we will see, this specification is an initial point that can be subject to improvements by considering the inclusion of additional variables as we show below.

Table 4: Model for the RER (all goods)

	Fixed effects				Random effects			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$RLprod$	**0.281****	**0.198****	—	—	**0.207*****	0.093	—	—
	(0.13)	(0.08)			(0.08)	(0.04)		
$Lprod_T$	—	—	**0.397*****	**0.296*****	—	—	**0.325*****	**0.202*****
			(0.07)	(0.06)			(0.06)	(0.05)
$Lprod_N$	—	—	0.005	-0.063	—	—	0.062	0.023
			(0.08)	(0.07)			(0.07)	(0.07)
$RULC$	—	**0.298*****	—	**0.188*****	—	**0.266*****	—	**0.175*****
		(0.04)		(0.04)				(0.04)
$R^2(adj.)$	0.23	0.63	0.61	0.71	0.26	0.62	0.6	0.69
N	263	262	263	262	263	262	263	262
HT					not reject	reject	reject	reject

Notes: Dependant variable: log real exchange rate (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Table 5: Model for the RER of Traded goods

	Fixed effects				Random effects			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$RLprod$	**0.245***	**0.168****	—	—	**0.171****	0.063	—	—
	(0.13)	(0.08)			(0.07)	(0.04)		
$Lprod_T$	—	—	**0.36*****	**0.28*****	—	—	**0.295*****	**0.19*****
			(0.06)	(0.05)			(0.05)	(0.05)
$Lprod_N$	—	—	0.041	-0.012	—	—	0.092	0.064
			(0.06)	(0.06)			(0.06)	(0.06)
$RULC$	—	**0.276*****	—	**0.149*****	—	**0.241*****	—	**0.139*****
		(0.04)		(0.04)				(0.03)
$R^2(adj.)$	0.23	0.61	0.65	0.71	0.26	0.59	0.63	0.69
N	263	262	263	262	263	262	263	262
HT					not reject	reject	reject	reject

Notes: Dependant variable: log real exchange rate for traded goods (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Table 6: Model for the RER of Non-traded goods

	Fixed effects				Random effects			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$RLprod$	**0.359****	**0.248****	—	—	**0.308*****	0.14	—	—
	(0.17)	(0.12)			(0.12)	(0.06)		
$Lprod_T$	—	—	**0.49*****	**0.321*****	—	—	**0.41*****	**0.19****
			(0.13)	(0.12)			(0.1)	(0.09)
$Lprod_N$	—	—	-0.033	-0.147	—	—	0.048	0.001
			(0.15)	(0.13)			(0.12)	(0.11)
$RULC$	—	**0.4*****	—	**0.317*****	—	**0.375*****	—	**0.292*****
		(0.07)		(0.08)				(0.06)
$R^2(adj.)$	0.19	0.54	0.43	0.56	0.23	0.57	0.46	0.61
N	263	262	263	262	263	262	263	262
HT					not reject	reject	reject	reject

Notes: Dependant variable: log real exchange rate for non-traded goods (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Additional Explanatory Variables

We consider specifications with additional controls, namely fiscal indicators (relative government expenditure and deficit), and financial indicators (relative long-run interest rates). The

full set of regressions is shown in the appendix. Here we report a summarized output of the models where the financial conditions are introduced in the model and an interaction with a Global Financial Crisis dummy is included which generates an improvement in the significance of the sectoral productivity indicators. As shown in equations (30), (31), and (32), capital inflows increase the real exchange rate. Here, this interaction term of relative long-run interest rates and the Global Financial Crisis dummy is expected to have a negative coefficient, as it represents capital outflows for Eastern European countries.

The results are shown in Table 7 for the real exchange rate of all goods, and in tables 8 and 9 for the real exchange rate of traded and non-traded goods.

In this case, after including additional economic variables as controls the results indicate not only the right signs for the relative sectoral productivities and labor unit costs, but their significance. In addition, the financial conditions, measured either via the long-run interest rate spread vis-a-vis the Euro area (EU27) or the interaction of the spread with a Global Financial Crisis dummy becomes significant in the panels for the real exchange rate of traded and non-traded goods.

Table 7: Model for the RER (all goods)

	Fixed effects				Random effects			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$RLprod$	**0.189*****	**0.192*****	—	—	0.068	**0.08***	—	—
	(0.05)	(0.05)			(0.05)	(0.05)		
$Lprod_T$	—	—	**0.186*****	**0.19*****	—	—	**0.095***	**0.107***
			(0.07)	(0.06)			(0.06)	(0.06)
$Lprod_N$	—	—	**-0.193*****	**-0.195*****	—	—	-0.05	-0.067
			(0.07)	(0.07)			(0.07)	(0.07)
$RULC$	**0.283*****	**0.284*****	**0.286*****	**0.286*****	**0.246*****	**0.25*****	**0.232*****	**0.238*****
	(0.04)	(0.03)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
LR	0.0016	0.0039	0.0016	0.0039	0.0019	0.0039	0.0019	0.0040
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
$LR \times GFC$	—	-0.0048	—	-0.0048	—	-0.0042	—	-0.0043
		(0.003)		(0.003)		(0.003)		(0.003)
$R^2(adj.)$	0.63	0.64	0.63	0.64	0.9	0.9	0.9	0.89
N	214	214	214	214	214	214	214	214
HT					reject	reject	reject	reject

Notes: Dependant variable: log real exchange rate (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. LR is a spread between the real long-run (10-year) bonds rate of each country relative to EU (EU19). The rates are made real by subtracting CPI inflation. GFC is a dummy variable taking the value of 1 for the years 2007-2009. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Table 8: Model for the RER of Traded goods

	Fixed effects				Random effects			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$RLprod$	**0.136*****	**0.137*****	—	—	0.042	0.052	—	—
	(0.05)	(0.05)			(0.04)	(0.04)		
$Lprod_T$	—	—	**0.158*****	**0.159*****	—	—	**0.084***	**0.095***
			(0.06)	(0.06)			(0.05)	(0.05)
$Lprod_N$	—	—	-0.1	-0.101	—	—	0.004	-0.009
			(0.07)	(0.07)			(0.06)	(0.06)
$RULC$	**0.267*****	**0.268*****	**0.242*****	**0.242*****	**0.233*****	**0.237*****	**0.202*****	**0.207*****
	(0.03)	(0.03)	(0.05)	(0.05)	(0.03)	(0.03)	(0.04)	(0.04)
LR	**0.0030***	0.0040	**0.0030***	0.0041	**0.0033***	0.0040	**0.0032***	0.0041
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
$LR \times GFC$	—	-0.0020	—	-0.0021	—	-0.0015	—	-0.0017
		(0.003)		(0.003)		(0.003)		(0.003)
$R^2(adj.)$	0.64	0.64	0.64	0.64	0.91	0.9	0.91	0.9
N	214	214	214	214	214	214	214	214
HT					reject	reject	reject	reject

Notes: Dependant variable: log real exchange rate for traded goods (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. LR is a spread between the real long-run (10-year) bonds rate of each country relative to EU (EU19). The rates are made real by subtracting CPI inflation. GFC is a dummy variable taking the value of 1 for the years 2007-2009. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Table 9: Model for the RER of Non-traded goods

	Fixed effects				Random effects			
	(1a)	(1b)	(1c)	(1d)	(2a)	(2b)	(2c)	(2d)
$RLprod$	**0.269****	**0.277*****	—	—	0.124	**0.138***	—	—
	(0.11)	(0.1)			(0.08)	(0.08)		
$Lprod_T$	—	—	0.197	**0.207***	—	—	0.096	0.107
			(0.12)	(0.12)			(0.09)	(0.09)
$Lprod_N$	—	—	**-0.387*****	**-0.393*****	—	—	-0.135	-0.152
			(0.14)	(0.14)			(0.11)	(0.11)
$RULC$	**0.356*****	**0.359*****	**0.441*****	**0.442*****	**0.332*****	**0.335*****	**0.344*****	**0.349*****
	(0.07)	(0.07)	(0.1)	(0.09)	(0.06)	(0.06)	(0.07)	(0.07)
LR	-0.0010	0.0048	-0.0010	0.0046	-0.0004	0.0051	-0.0003	0.0051
	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)
$LR \times GFC$	—	**-0.0117****	—	**-0.0114****	—	**-0.0112****	—	**-0.0111****
		(0.005)		(0.005)		(0.005)		(0.005)
$R^2(adj.)$	0.47	0.48	0.48	0.49	0.78	0.78	0.79	0.79
N	214	214	214	214	214	214	214	214
HT					reject	reject	reject	reject

Notes: Dependent variable: log real exchange rate for non-traded goods (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. LR is a spread between the real long-run (10-year) bonds rate of each country relative to EU (EU19). The rates are made real by subtracting CPI inflation. GFC is a dummy variable taking the value of 1 for the years 2007-2009. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

6 Quantitative evaluation of the model

We now return to the theoretical model to explore the degree to which the model can account for the historical evolution of the real exchange rate, GDP and other macro aggregates in the Eastern European data. The model is extremely sparse - there are just two countries and two sectors in each country. There are no trade or financial frictions, and except for measures of the labor wedge, as described in Section 2 above, there are no other distortions. Preferences are homothetic, so differential income elasticities play no role in the baseline model. Thus, the exercise here should be seen as an exploration of the ability of a minimally parameterized general equilibrium model to account for the joint behaviour of real exchange rates and GDP in the region.

Our simulation strategy is to take the observed labor productivities by sector as in the data, for both regions, and use these as an input in the model. We then compare the model solution with the data for the full sample years. The measure of success of the model is represented by the degree to which the simulated model can fit the data, both in levels and changes over the sample years. We conduct this comparison for aggregate and sectoral real exchange rates, aggregate and sectoral GDP, and for the measure of relative unit labor cost, which represented an important explanatory variable in our above empirical estimates.

Table (10) reports the minimal calibration used for the model. All parameters and elasticities are identical across countries except for the labor wedge in traded goods as described below. The share of produced tradable goods in the retail traded goods consumption aggregate (for both home and foreign goods) is set at $v = 0.3$, following Burstein et al. (2003). Ω is set so that the share of the Traded goods share becomes 0.5 as is consistent with the data. The population share of Western Europe is set at $n = 0.78$, to match the data or relative population size. The elasticity terms λ, ψ,$and\mu$ are taken from Berka et al. (2018).

To come close to matching the data, it is important to take a stand on the size of the sectoral labor wedges. Our regression estimates indicate that sectoral labor productivity alone is insufficient to account for the movement in real exchange rates in the Eastern European data. The importance of the relative unit labor cost in the regressions suggests the need to allow for differential labor wedges across regions with the calibration. In reality, it is likely that there have been substantial labor market distortions in Eastern Europe, unrelated to measures of labor productivity. In order to allow for these distortions, we calibrate the labor wedge in the traded good sector in the home country so as to match the model solution for the relative unit labor cost in the initial period. In the baseline solution, this parameter is then kept constant for all years in the sample. Given this matching of the initial simulated RULC series with the data, we can then see how close the simulated series of real exchange rates and GDPs match those of the data.

Table 10: Model Calibration

	Parameter
$n = 0.78$	Size of Western European countries
$\Omega = 0.75$	Weight on traded goods
$v = 0.5$	Share of wholesale traded good in C_T
$\lambda = 8$	Elasticity of substitution between H and F retail traded goods
$\mu = 0.25$	Elasticity of substitution between traded good and retail service
$\psi = 0.7$	Elasticity of substitution between traded and non-traded good
$\sigma = 2$	Inverse elasticity of inter-temporal substitution
$\phi = 1$	Inverse Frisch elasticity of labor supply
$\alpha = \frac{1}{3}$	labor share (1 minus)

Impulse responses Figure (**??**) reports the theoretical impulse responses to shocks to the four key exogenous variables in the model. A rise in traded goods productivity leads to a rise in GDP and an exchange rate appreciation. A shock to non-traded goods productivity has a positive effect on GDP also but leads to a real exchange rate depreciation. A rise in Ψ_T, the home labor wedge in the traded sector, leads to a fall in GDP and a real exchange rate depreciation. A capital inflow θ leads to a simultaneous rise in GDP and a real exchange rate depreciation also.

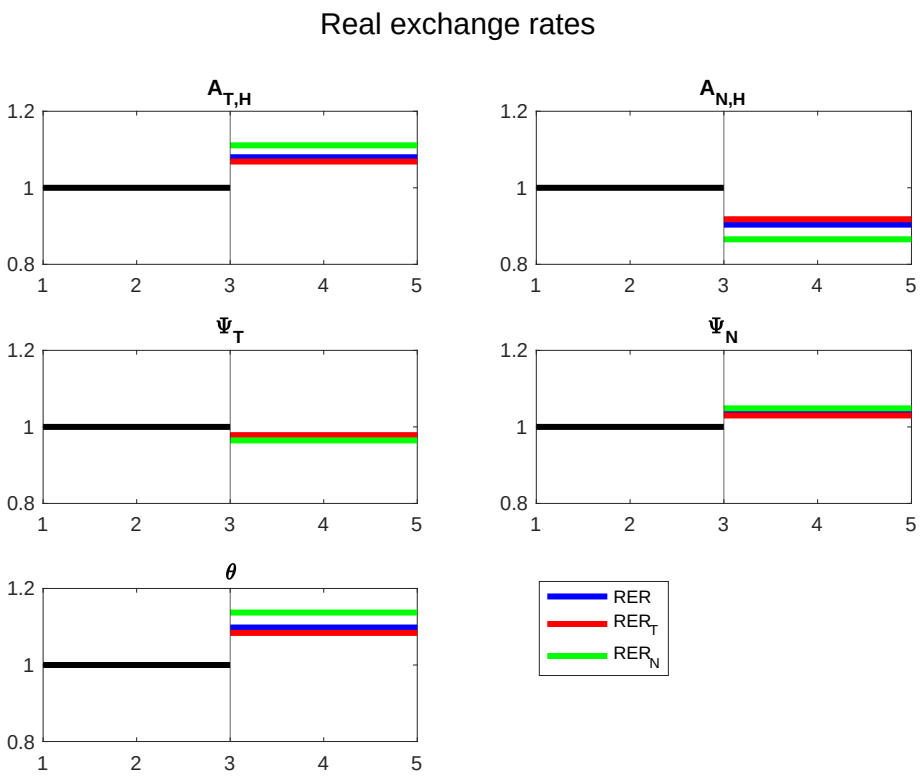


Figure 6: Response of Real Exchange Rate to shocks

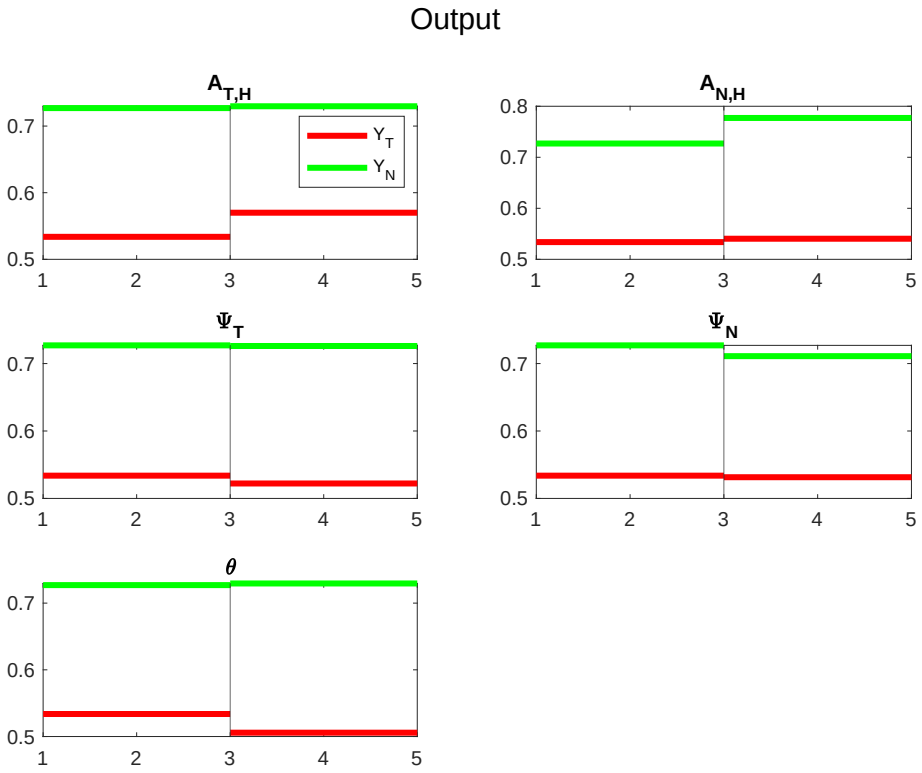


Figure 7: Response of output to shocks

Model Simulation We now simulate the model using the measured sectoral labor productivity series as proxies for $A_{T,H}$ and $A_{N,H}$ in the model. The model is solved period by period. In the baseline version of the model with assume $\theta = 0$, so there are no transfers from the foreign

to the home country.

Figure (8) shows the results for the baseline case. The top left panel displays the data for labor productivity in the traded and non-traded sectors for Eastern Europe. Note that the scale in all panels in the Figure are the same, in each case indicating that the variable is measured relative to the EU27. For instance, the GDP panel shows that GDP per capita for Eastern Europe began at approximately 25 percent of the EU27 average. The simulated model matches closely the levels of aggregate and sectoral GDP as well as the overall real exchange rate and the sectoral real exchange rates. In the second from left top panel, we see that the model is surprisingly successful in matching the rapid rise in the real exchange rate and GDP at the beginning of the sample, and the subsequent leveling off in the real exchange rate (with some fluctuations) despite the continuing convergence in GDP. The key feature involved seems to be the rapid recovery in non-traded goods productivity after the GFC and EU crisis, relative to the relatively smooth growth in traded good productivity.

While Figure (8) assumes a constant labor wedge which is set to match the initial observed labor wedge. We explore an alternative hypothesis, by allowing for a time varying labor wedge. We take our direction from Berka and Devereux (2013), who show that among both Western European and Eastern European countries, the path of GDP alone explains a substantial share of the trends in relative real exchange rates in European countries. Accordingly, we set the path of the traded goods labor wedge so as to match the value of aggregate relative GDP over the sample. Figure (9)) illustrates the sample simulation results for the real exchange rate, the sectoral GDP and real exchange rates, and the relative unit labor costs. We see that adjusted in this way, the simulations obtain a significantly closer match to the sample data. While aggregate GDP is matched by construction, sectoral GDPs follow the data closely. In addition, the real exchange rate inferred from this simulation is almost identical to the historical sample path. Figure (11) (left hand panel) plots the inferred path of the traded good labor wedge underlying this simulation. We see that the wedge starts at a considerably elevated level, before dropping sharply in the early 2000's, and then fluctuating around a relative stable value thereafter. The fact that an addition of the inferred labor wedge improves the simulation fit of the model real exchange rate dovetails well with the regression estimates in Section 5 above, which suggest that the dynamics of the labor wedge (as part of the drivers of RULC) play a significant role in the real exchange rate trends in Eastern Europe.

As a final exercise we ask to what the degree the labor wedge alone can explain the real exchange rate movement over the sample. To this end, Figure (10) sets the relative sectoral productivity constant at their mean levels, and again sets the traded goods labor wedge so as to match the movement in relative GDP (in Figure (11 right hand panel). Here we see that the model still matches the average real exchange rates quite well, but misses out on the dynamics. The implied real exchange rate is too low in the early part of the sample, since the sample mean productivity in the traded goods sector is lower than that in the non-traded goods sector, and then the real exchange rate is too high in the later part of the sample, since the continuing convergence of relative GDP drives a greater than warranted real appreciation, without taking

account of the fact that traded goods and non-traded goods productivity display equal growth rates after the GFC.



Figure 8: Model with observed productivities in traded and non-traded sectors

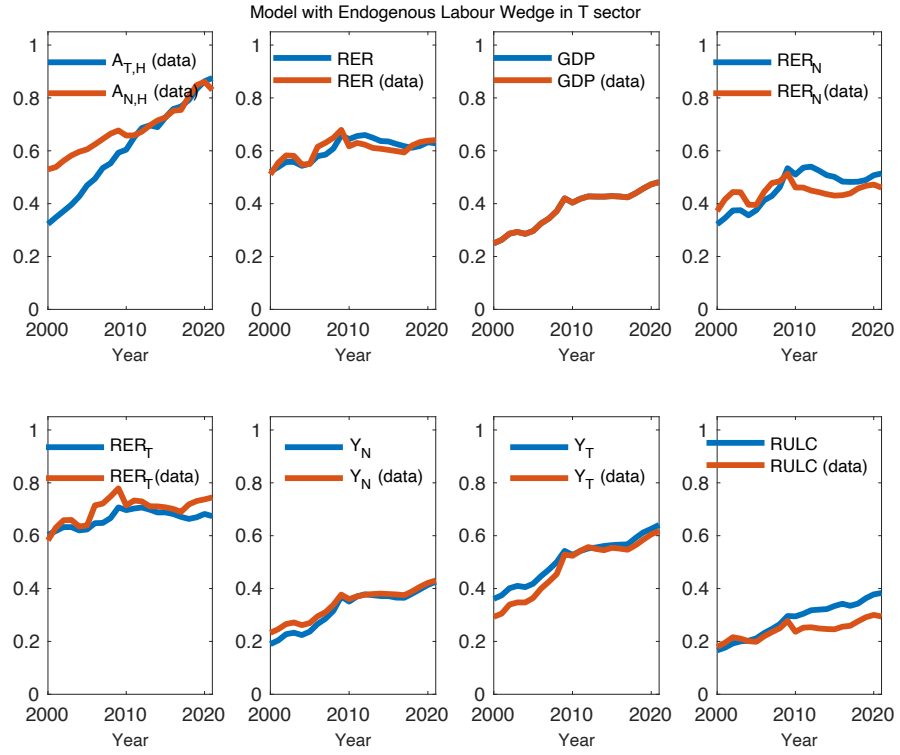


Figure 9: Model with observed productivities in traded and non-traded sectors and an endogenous traded sector wedge

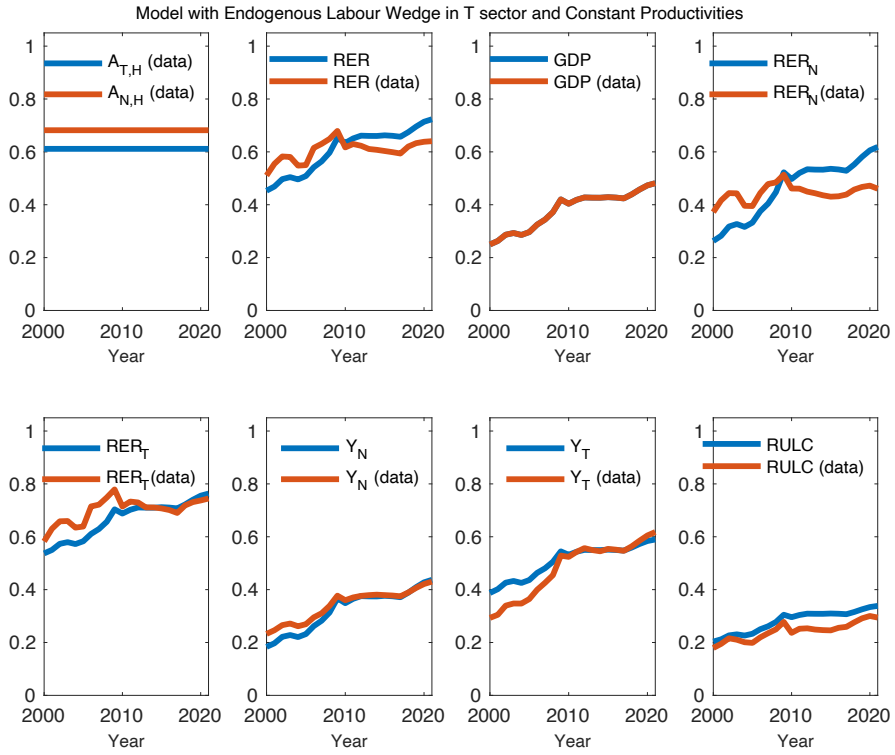


Figure 10: Model with constant productivities in traded and non-traded sectors and an endogenous traded sector wedge

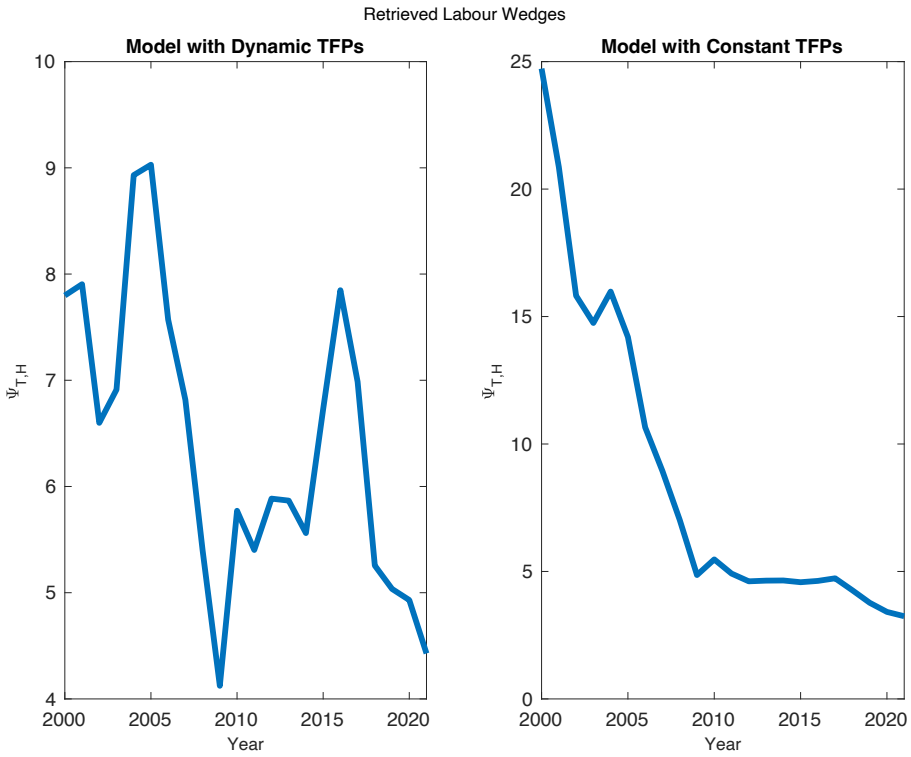


Figure 11: Retrieved labor wedges in traded sectors associated to models that target GDP

7 Conclusions

A large literature in international macroeconoimcs has focused on the understanding of high frequency movements in real and nominal exchange rates. A common conclusion from these studies is that it is hard to establish the relevance of fundamental based models of exchange rates, particularly among floating exchange rate countries. In the longer run, we expect to see real exchange rate appreciation in fast growing countries, consistent with the 'Penn Effect'. But evidence supporting the Penn effect is mixed. This paper focuses on longer run determinants of real exchange rates, and focuses on real exchange rate movements between countries of Eastern Europe relative to the EU as a whole. Some of these countries are pegged to the euro, while most others maintain stable exchange rates vis a vis the euro. We find support for the Penn effect, and the more specific Balassa Samuelson version of this relationship. But as documented in the introduction, there is a puzzle regarding the lack of convergence in the real exchange rate after the GFC. Our premilinary evidence suggests that movements in the labor wedge may explain this. Our model simulations provide encouraging support for this hypothesis.

References

Beck, Nathaniel and Jonathan Katz, "What To Do (and Not to Do) with Time-Series Cross-Section Data," *American Political Science Review*, 1995, *89* (3), 634–647.

Berka, Martin and Michael B. Devereux, "Trends in European real exchange rates [Trade costs]," *Economic Policy*, 2013, *28* (74), 193–242.

__ , __ , and Charles Engel, "Real Exchange Rates and Sectoral Productivity in the Eurozone," *American Economic Review*, June 2018, *108* (6), 1543–1581.

Burstein, Ariel T., Joao C. Neves, and Sergio Rebelo, "Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations," *Journal of Monetary Economics*, September 2003, *50* (6), 1189–1214.

Crucini, Mario J., Chris I. Telmer, and Marios Zachariadis, "Understanding European Real Exchange Rates," *American Economic Review*, June 2005, *95* (3), 724–738.

Inklaar, Robert, Ryan Marapin, and Kaira Gräler, "Tradability and sectoral productivity differences across countries," WorkingPaper 195, GGDC oct 2023.

Rogoff, Kenneth, "The Purchasing Power Parity Puzzle," *Journal of Economic Literature*, June 1996, *34* (2), 647–668.

Appendix

Table of Contents

A Log-linearization **39**

A.1 The reduced system of equation 39

A.2 The symmetric steady state 40

A.3 The system of log-linearized equations 41

A.4 Solution 42

B Parameters and real exchange rate dynamics **43**

B.1 Traded sector - Balassa-Samuelson effect 44

B.2 Non-Traded sector 45

B.3 Capital flow 46

C Additional Panel Regression Results **46**

D Online Appendix Materials **49**

D.1 Data Sources 49

A Log-linearization

We approximating the system of equations defined in Section 2.7 around the symmetric steady state to derive the analytical solution presented in Section 3. This section is structured as follows: first, we reduce the system of equations; second, we compute the symmetric steady state; third, we approximate the reduced system of equations around this symmetric steady state; fourth, we derive the analytical solution for the nominal exchange rate.

A.1 The reduced system of equation

The system of equations defined in Section 2.7 can be reduced as follows:

labor market clearing

$$(1-\alpha)\, P_{T,H} A_{T,H} L_T^{-\alpha} = \Psi_T C^{\sigma} L_T^{\phi},$$

$$(1-\alpha)\, P_{T,F}^{*} A_{T,F} \left(L_T^{*}\right)^{-\alpha} = \Psi_T^{*} \left(C^{*}\right)^{\sigma} \left(L_T^{*}\right)^{\phi},$$

$$(1-\alpha)\, P_N A_{N,H} L_N^{-\alpha} = \Psi_N C^{\sigma} L_N^{\phi},$$

$$(1-\alpha)\, P_N^{*} A_{N,F} \left(L_N^{*}\right)^{-\alpha} = \Psi_N^{*} \left(C^{*}\right)^{\sigma} \left(L_N^{*}\right)^{\phi}.$$

Goods market clearing

$$\begin{aligned} A_{T,H} L_T^{1-\alpha} &= (1-n)\, v \left(\frac{P_{T,H}}{\tilde{P}_{T,H}}\right)^{-\psi} \left(\frac{\tilde{P}_{T,H}}{P_T}\right)^{-\lambda} \Omega P_T^{-\mu} C \\ &\quad + n v \left(\frac{P_{T,H}}{S\tilde{P}_{T,H}^{*}}\right)^{-\psi} \left(\frac{\tilde{P}_{T,H}^{*}}{P_T^{*}}\right)^{-\lambda} \Omega \left(P_T^{*}\right)^{-\mu} C^{*}, \end{aligned}$$

$$\begin{aligned} A_{T,F} \left(L_T^{*}\right)^{1-\alpha} &= (1-n)\, v \left(\frac{SP_{T,F}^{*}}{\tilde{P}_{T,F}}\right)^{-\psi} \left(\frac{\tilde{P}_{T,F}}{P_T}\right)^{-\lambda} \Omega P_T^{-\mu} C \\ &\quad + n v \left(\frac{P_{T,F}^{*}}{\tilde{P}_{T,F}^{*}}\right)^{-\psi} \left(\frac{\tilde{P}_{T,F}^{*}}{P_T^{*}}\right)^{-\lambda} \Omega \left(P_T^{*}\right)^{-\mu} C^{*}, \end{aligned}$$

$$\begin{aligned} A_{N,H} L_N^{1-\alpha} &= (1-\Omega)\, P_N^{-\mu} C + (1-v) \left(\frac{P_N}{\tilde{P}_{T,H}}\right)^{-\psi} (1-n) \left(\frac{\tilde{P}_{T,H}}{P_T}\right)^{-\lambda} \Omega P_T^{-\mu} C \\ &\quad + (1-v) \left(\frac{P_N}{\tilde{P}_{T,F}}\right)^{-\psi} n \left(\frac{\tilde{P}_{T,F}}{P_T}\right)^{-\lambda} \Omega P_T^{-\mu} C, \end{aligned}$$

$$A_{N,F}\left(L_N^*\right)^{1-\alpha} = (1-\Omega)\left(P_N^*\right)^{-\mu} C^* + (1-v)\left(\frac{P_N^*}{\tilde{P}_{T,H}^*}\right)^{-\psi}(1-n)\left(\frac{\tilde{P}_{T,H}^*}{P_T^*}\right)^{-\lambda}\Omega\left(P_T^*\right)^{-\mu} C^*$$
$$+(1-v)\left(\frac{P_N^*}{\tilde{P}_{T,F}^*}\right)^{-\psi} n\left(\frac{\tilde{P}_{T,F}^*}{P_T^*}\right)^{-\lambda}\Omega\left(P_T^*\right)^{-\mu} C^*.$$

Balance of payment

$$P_{T,H}\left(\frac{P_{T,H}}{S\tilde{P}_{T,H}^*}\right)^{-\psi}\left(\frac{\tilde{P}_{T,H}^*}{P_T^*}\right)^{-\lambda}\left(P_T^*\right)^{-\mu} C^*(1+\theta) = SP_{T,F}^*\left(\frac{SP_{T,F}^*}{\tilde{P}_{T,F}}\right)^{-\psi}\left(\frac{\tilde{P}_{T,F}}{P_T}\right)^{-\lambda} P_T^{-\mu} C.$$

Prices

$$1 = \left[\Omega P_T^{1-\mu} + (1-\Omega) P_N^{1-\mu}\right]^{\frac{1}{1-\mu}},$$

$$1 = \left[\Omega\left(P_T^*\right)^{1-\mu} + (1-\Omega)\left(P_N^*\right)^{1-\mu}\right]^{\frac{1}{1-\mu}},$$

$$P_T = \left[(1-n)\tilde{P}_{T,H}^{1-\lambda} + n\tilde{P}_{T,F}^{1-\lambda}\right]^{\frac{1}{1-\lambda}},$$

$$P_T^* = \left[n\left(\tilde{P}_{T,F}^*\right)^{1-\lambda} + (1-n)\left(\tilde{P}_{T,H}^*\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}},$$

$$\tilde{P}_{T,H} = \left[vP_{T,H}^{1-\psi} + (1-v) P_N^{1-\psi}\right]^{\frac{1}{1-\psi}},$$

$$\tilde{P}_{T,F}^* = \left[v\left(P_{T,F}^*\right)^{1-\psi} + (1-v)\left(P_N^*\right)^{1-\psi}\right]^{\frac{1}{1-\psi}},$$

$$\tilde{P}_{T,F} = \left[v\left(SP_{T,F}^*\right)^{1-\psi} + (1-v) P_N^{1-\psi}\right]^{\frac{1}{1-\psi}},$$

$$\tilde{P}_{T,H}^* = \left[v\left(\frac{P_{T,H}}{S}\right)^{1-\psi} + (1-v)\left(P_N^*\right)^{1-\psi}\right]^{\frac{1}{1-\psi}}.$$

A.2 The symmetric steady state

We would like to have a steady state where all relative prices are unity:

$$\begin{aligned} 1 &= P = P^* = S \\ &= P_N = P_{T,H} = P_T = \tilde{P}_{T,H} = \tilde{P}_{T,F} \\ &= P_N^* = P_{T,F}^* = P_T^* = \tilde{P}_{T,F}^* = \tilde{P}_{T,F}^*. \end{aligned}$$

This is achieved when

$$(1-\alpha)\, A_{T,H} L_T^{-\alpha} = \Psi_T C^{\sigma} L_T^{\phi},$$

$$(1-\alpha)\, A_{T,F} \left(L_T^*\right)^{-\alpha} = \Psi_T^* \left(C^*\right)^{\sigma} \left(L_T^*\right)^{\phi},$$

$$(1-\alpha)\, A_{N,H} L_N^{-\alpha} = \Psi_N C^{\sigma} L_N^{\phi},$$

$$(1-\alpha)\, A_{N,F} \left(L_N^*\right)^{-\alpha} = \Psi_N^* \left(C^*\right)^{\sigma} \left(L_N^*\right)^{\phi},$$

$$A_{T,H} L_T^{1-\alpha} = (1-n)\, v\Omega C + n v\Omega C^*,$$

$$A_{T,F} \left(L_T^*\right)^{1-\alpha} = (1-n)\, v\Omega C + n v\Omega C^*,$$

$$A_{N,H} L_N^{1-\alpha} = (1 - v\Omega)\, C,$$

$$A_{N,F} \left(L_N^*\right)^{1-\alpha} = (1 - v\Omega)\, C^*,$$

$$(1-n)\, C^* = nC.$$

We further assume that $A = A_{T,H} = A_{T,F} = A_{N,H} = A_{N,F}$, $\Psi = \Psi_T = \Psi_N = \Psi_T^* = \Psi_N^*$, $n = 1 - n = 1/2$, and $\theta = 0$. Then, conditions below must be satisfied at this initial steady state:

$$\frac{A}{v\Omega} = \frac{C}{L_T^{1-\alpha}},$$

$$\frac{A}{1 - v\Omega} = \frac{C}{L_N^{1-\alpha}}.$$

A.3 The system of log-linearized equations

By taking the first order approximation of the system of equations in Section around the symmetric steady state in Section we can derive the system of 11 linear equations for $\hat{P}_{T,H}$, $\hat{P}_{T,F}^*$, $\hat{P}_N$, $\hat{P}_N^*$, $\hat{L}_T$, $\hat{L}_T^*$, $\hat{L}_N$, $\hat{L}_N^*$, $\hat{C}$, $\hat{C}^*$, and $\hat{S}$:

$$\hat{P}_{T,H} + \hat{A}_{T,H} = \hat{\Psi}_T + \sigma\hat{C} + (\alpha + \phi)\, \hat{L}_T,$$

$$\hat{P}_{T,F}^* + \hat{A}_{T,F} = \hat{\Psi}_T^* + \sigma\hat{C}^* + (\alpha + \phi)\, \hat{L}_T^*,$$

$$\hat{P}_N + \hat{A}_{N,H} = \hat{\Psi}_N + \sigma\hat{C} + (\alpha + \phi)\,\hat{L}_N,$$

$$\hat{P}^*_N + \hat{A}_{N,F} = \hat{\Psi}^*_N + \sigma\hat{C}^* + (\alpha + \phi)\,\hat{L}^*_N,$$

$$\hat{A}_{T,H} + (1-\alpha)\,\hat{L}_T = \frac{1}{2}\left\{\frac{v\Omega}{1-v\Omega}\left[\hat{C} + \hat{C}^* + \Gamma\left(\hat{S} - 2\hat{P}_{T,H}\right)\right] + \frac{1-v\Omega}{\Omega}\left(\Xi - \Gamma\right)\left(\hat{P}_N + \hat{P}^*_N\right)\right\},$$

$$\hat{A}_{T,F} + (1-\alpha)\,\hat{L}^*_T = \frac{1}{2}\left\{\frac{v\Omega}{1-v\Omega}\left[\hat{C} + \hat{C}^* - \Gamma\left(\hat{S} + 2\hat{P}^*_{T,F}\right)\right] + \frac{1-v\Omega}{\Omega}\left(\Xi - \Gamma\right)\left(\hat{P}_N + \hat{P}^*_N\right)\right\},$$

$$\hat{A}_{N,H} + (1-\alpha)\,\hat{L}_N = \hat{C} - \Xi\hat{P}_N,$$

$$\hat{A}_{N,F} + (1-\alpha)\,\hat{L}^*_N = \hat{C}^* - \Xi\hat{P}^*_N,$$

$$\left(\hat{C}^* - \hat{C}\right) + (\Gamma - 1)\left(\hat{S} + \hat{P}^*_{T,F} - \hat{P}_{T,H}\right) + \frac{1-v\Omega}{v\Omega}\Xi\left(\hat{P}^*_N - \hat{P}_N\right) + \hat{\theta} = 0, \tag{37}$$

$$\hat{S} = \frac{1-v\Omega}{v\Omega}\left(\hat{P}^*_N - \hat{P}_N\right),$$

$$-\frac{1-v\Omega}{v\Omega}\left(\hat{P}_N + \hat{P}^*_N\right) = \hat{P}_{T,H} + \hat{P}^*_{T,F}.$$

A.4 Solution

Nominal exchange rate By solving the system of the linear equations in Section 3, we can derive the solution for the nominal exchange rate:

$$\begin{aligned}
\hat{S} &= \frac{1-v\Omega}{v\Omega}\left(\hat{P}^*_N - \hat{P}_N\right) \\
&= \frac{1-v\Omega}{v\Omega}\frac{(1-\alpha)\left[1+\sigma\left(\Gamma-1\right)\right] + (\alpha+\phi)\frac{v\Omega}{1-v\Omega}\Gamma}{\Lambda}\left[(1+\phi)\left(\hat{A}_{N,H} - \hat{A}_{N,F}\right) + (1-\alpha)\left(\hat{\Psi}^*_N - \hat{\Psi}_N\right)\right] \\
&\quad -\frac{1-v\Omega}{v\Omega}\frac{\left[(1-\alpha)\,\sigma + (\alpha+\phi)\right](\Gamma-1)}{\Lambda}\left[(1+\phi)\left(\hat{A}_{T,H} - \hat{A}_{T,F}\right) + (1-\alpha)\left(\hat{\Psi}^*_T - \hat{\Psi}_T\right)\right] \\
&\quad -\frac{\left[(1-\alpha)\,\sigma + (\alpha+\phi)\right]\left[\frac{1-v\Omega}{v\Omega}(1-\alpha) + (\alpha+\phi)\,\Gamma\right]}{\Lambda}\hat{\theta},
\end{aligned}$$

Real exchange rate

$$\hat{Q} = -\hat{S}.$$

Relative labor supply in Non-Traded

$$\begin{aligned}\hat{L}_N^* - \hat{L}_N &= \frac{1-\sigma\Xi}{(1-\alpha)\sigma+(\alpha+\phi)}\frac{v\Omega}{1-v\Omega}\hat{S} \\ &+\frac{1-\sigma}{(1-\alpha)\sigma+(\alpha+\phi)}\left(\hat{A}_{N,F}-\hat{A}_{N,H}\right) \\ &-\frac{1}{(1-\alpha)\sigma+(\alpha+\phi)}\left(\hat{\Psi}_N^*-\hat{\Psi}_N\right).\end{aligned}$$

Relative labor supply in Traded

$$\begin{aligned}\hat{L}_T^* - \hat{L}_T &= \frac{1-v\Omega(1+\Gamma)}{(1-\alpha)-[(1-\alpha)-(\alpha+\phi)\Gamma]v\Omega}\left(\hat{A}_{T,H}-\hat{A}_{T,F}\right) \\ &+\frac{(1+\phi)\sigma v\Omega\Gamma}{\{(1-\alpha)-[(1-\alpha)-(\alpha+\phi)\Gamma]v\Omega\}[(1-\alpha)\sigma+(\alpha+\phi)]}\left(\hat{A}_{N,H}-\hat{A}_{N,F}\right) \\ &-\frac{(1-\alpha)\sigma v\Omega\Gamma}{\{(1-\alpha)-[(1-\alpha)-(\alpha+\phi)\Gamma]v\Omega\}[(1-\alpha)\sigma+(\alpha+\phi)]}\left(\hat{\Psi}_N-\hat{\Psi}_N^*\right) \\ &+\frac{v\Omega\Gamma}{(1-\alpha)-[(1-\alpha)-(\alpha+\phi)\Gamma]v\Omega}\left(\hat{\Psi}_T-\hat{\Psi}_T^*\right) \\ &-\Gamma\frac{\sigma(1-\alpha)+(\alpha+\phi)[1-(1-\sigma\Xi)v\Omega]}{\{(1-\alpha)-[(1-\alpha)-(\alpha+\phi)\Gamma]v\Omega\}[(1-\alpha)\sigma+(\alpha+\phi)]}\frac{v\Omega}{1-v\Omega}\hat{S}.\end{aligned}$$

Relative price of raw traded inputs

$$\begin{aligned}\left(\hat{P}_{T,H}-\hat{P}_{T,F}^*\right) &= \\ \frac{(1-\alpha)\sigma}{\left[(1-\alpha)+\frac{v\Omega}{1-v\Omega}(\alpha+\phi)\Gamma\right][\sigma(1-\alpha)+(\alpha+\phi)]}&\left[(1+\phi)\left(\hat{A}_{N,H}-\hat{A}_{N,F}\right)-(1-\alpha)\left(\hat{\Psi}_N-\hat{\Psi}_N^*\right)\right] \\ -\frac{1}{(1-\alpha)+\frac{v\Omega}{1-v\Omega}(\alpha+\phi)\Gamma}&\left[(1+\phi)\left(\hat{A}_{T,H}-\hat{A}_{T,F}\right)-(1-\alpha)\left(\hat{\Psi}_T-\hat{\Psi}_T^*\right)\right] \\ +\frac{(\alpha+\phi)[\sigma(1-\alpha)+(\alpha+\phi)]\Gamma-(1-\alpha)\sigma[(1-\alpha)+(\alpha+\phi)\Xi]}{\left[(1-\alpha)+\frac{v\Omega}{1-v\Omega}(\alpha+\phi)\Gamma\right][\sigma(1-\alpha)+(\alpha+\phi)]}&\left(\hat{P}_N^*-\hat{P}_N\right).\end{aligned}$$

B Parameters and real exchange rate dynamics

In this section, we aim to explore how economic conditions influence the impact of the fundamental drivers of the trend on the real exchange rate. Specifically, we examine how the coefficients in equation (30) vary with changes in the underlying deep parameters, α,Υ and ϕ.

$$\begin{aligned}\hat{Q} &= \frac{\Upsilon-1}{\Theta}\left[(1+\phi)\left(\hat{A}_{T,H}-\hat{A}_{T,F}\right)-(1-\alpha)\left(\hat{\Psi}_T-\hat{\Psi}_T^*\right)\right] \\ &-\frac{\Upsilon}{\Theta}\left[(1+\phi)\left(\hat{A}_{N,H}-\hat{A}_{N,F}\right)-(1-\alpha)\left(\hat{\Psi}_N-\hat{\Psi}_N^*\right)\right] \\ &+\frac{(1-\alpha)+(\alpha+\phi)\Upsilon}{\Theta}\hat{\theta},\end{aligned}$$

where

$$\Theta := (1-\alpha)(\mathrm{Y}-1) + 2\left[(1-\alpha) + (\alpha+\phi)\mathrm{Y}\right]\mathrm{Y} > 0.$$

B.1 Traded sector - Balassa-Samuelson effect

B.1.1 Impact of relative technology in the Traded sector: $\hat{A}_{T,H} - \hat{A}_{T,F}$

Increase in the capital share (more decreasing returns to scale): α This reduces the impact of $\hat{A}_{T,H} - \hat{A}_{T,F}$:

$$\frac{d\left[\frac{(\mathrm{Y}-1)(1+\phi)}{\Theta}\right]}{d\alpha} = -\frac{(\mathrm{Y}-1)^2(2\mathrm{Y}-1)(1+\phi)}{\left[(1-\alpha)(3\mathrm{Y}-1) + 2(\alpha+\phi)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the elasticity of substitution: Y As long as the elasticity of substitution is large such that

$$\mathrm{Y} > 1 + \sqrt{\frac{1+\phi}{\alpha+\phi}},$$

this reduces the impact of $\hat{A}_{T,H} - \hat{A}_{T,F}$:

$$\frac{d\left[\frac{(\mathrm{Y}-1)(1+\phi)}{\Theta}\right]}{d\psi} = -\frac{2(1+\phi)\left[(\alpha+\phi)(\mathrm{Y}-1)^2 - (1+\phi)\right]}{\left[(1-\alpha)(3\mathrm{Y}-1) + 2(\alpha+\phi)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the inverse of the labor elasticity: ϕ This reduces the impact of $\hat{A}_{T,H} - \hat{A}_{T,F}$:

$$\frac{d\left[\frac{(\mathrm{Y}-1)(1+\phi)}{\Theta}\right]}{d\phi} = -\frac{(1-\alpha)(2\mathrm{Y}-1)(\mathrm{Y}-1)^2}{\left[(1-\alpha)(3\mathrm{Y}-1) + 2(\alpha+\phi)\mathrm{Y}^2\right]^2} < 0.$$

B.1.2 Impact of relative labor wedge in the Traded sector: $\hat{\Psi}_T - \hat{\Psi}_T^*$

Increase in the capital share (more decreasing returns to scale): α This reduces the impact of $\hat{\Psi}_T - \hat{\Psi}_T^*$:

$$\frac{d\left[\frac{(\mathrm{Y}-1)(1-\alpha)}{\Theta}\right]}{d\alpha} = -\frac{2(\mathrm{Y}-1)\mathrm{Y}^2(1+\phi)}{\left[(1-\alpha)(3\mathrm{Y}-1) + 2(\alpha+\phi)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the elasticity of substitution: ψ As long as the elasticity of substitution is large such that

$$\psi > 1 + \sqrt{\frac{1+\phi}{\alpha+\phi}},$$

this reduces the impact of $\hat{\Psi}_T - \hat{\Psi}_T^*$:

$$\frac{d\left[\frac{(\mathrm{Y}-1)(1-\alpha)}{\Theta}\right]}{d\mathrm{Y}} = -\frac{2(1-\alpha)\left[(\alpha+\phi)(\mathrm{Y}-1)^2 - (1+\phi)\right]}{\left[(1-\alpha)(3\mathrm{Y}-1) + 2(\alpha+\phi)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the inverse of the labor elasticity: ϕ This reduces the impact of $\hat{\Psi}_T - \hat{\Psi}_T^*$:

$$\frac{d\left[\frac{(\mathrm{Y}-1)(1-\alpha)}{\Theta}\right]}{d\phi} = -\frac{2\left(1-\alpha\right)\left(\mathrm{Y}-1\right)\mathrm{Y}^2}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]^2} < 0.$$

B.2 Non-Traded sector

B.2.1 Impact of relative technology in the Non-Traded sector: $\hat{A}_{N,H} - \hat{A}_{N,F}$

Increase in the capital share (more decreasing returns to scale): α This reduces the impact of $\hat{A}_{N,H} - \hat{A}_{N,F}$:

$$\frac{d\left[\frac{\mathrm{Y}(1+\phi)}{\Theta}\right]}{d\alpha} = -\frac{\mathrm{Y}(\mathrm{Y}-1)(2\mathrm{Y}-1)(1+\phi)}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the elasticity of substitution: ψ This reduces the impact of $\hat{A}_{N,H} - \hat{A}_{N,F}$:

$$\frac{d\left[\frac{\mathrm{Y}(1+\phi)}{\Theta}\right]}{d\psi} = -\frac{\left(1+\phi\right)\left[\left(1-\alpha\right)+2\left(\alpha+\phi\right)\psi^2\right]}{\left[\left(1-\alpha\right)\left(3\psi-1\right)+2\left(\alpha+\phi\right)\psi^2\right]^2} < 0.$$

Increase in the inverse of the labor elasticity: ϕ This reduces the impact of $\hat{A}_{N,H} - \hat{A}_{N,F}$:

$$\frac{d\left[\frac{\mathrm{Y}(1+\phi)}{\Theta}\right]}{d\phi} = -\frac{\left(1-\alpha\right)\mathrm{Y}\left(\mathrm{Y}-1\right)\left(2\mathrm{Y}-1\right)}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]^2} < 0.$$

B.2.2 Impact of relative labor wedge in the Non-Traded sector: $\hat{\Psi}_N - \hat{\Psi}_N^*$

Increase in the capital share (more decreasing returns to scale): α This reduces the impact of $\hat{\Psi}_N - \hat{\Psi}_N^*$:

$$\frac{d\left[\frac{\mathrm{Y}(1-\alpha)}{\Theta}\right]}{d\alpha} = -\frac{2\mathrm{Y}^3(1+\phi)}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the elasticity of substitution: ψ This reduces the impact of $\hat{\Psi}_N - \hat{\Psi}_N^*$:

$$\frac{d\left[\frac{\mathrm{Y}(1-\alpha)}{\Theta}\right]}{d\psi} = -\frac{\left(1-\alpha\right)\left[\left(1-\alpha\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]^2} < 0.$$

Increase in the inverse of the labor elasticity: ϕ This reduces the impact of $\hat{\Psi}_N - \hat{\Psi}_N^*$:

$$\frac{d\left[\frac{\mathrm{Y}(1-\alpha)}{\Theta}\right]}{d\phi} = -\frac{2\left(1-\alpha\right)\mathrm{Y}^3}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^2\right]^2} < 0.$$

B.3 Capital flow

Increase in the capital share (more decreasing returns to scale): α This increases the impact of $\hat{\theta}$:

$$\frac{d\left[\frac{(1-\alpha)+(\alpha+\phi)\mathrm{Y}}{\Theta}\right]}{d\alpha} = \frac{\mathrm{Y}\left(\mathrm{Y}-1\right)\left(1+\phi\right)}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^{2}\right]^{2}} > 0.$$

Increase in the elasticity of substitution: ψ This reduces the impact of $\hat{\theta}$:

$$\frac{d\left[\frac{(1-\alpha)+(\alpha+\phi)\mathrm{Y}}{\Theta}\right]}{d\mathrm{Y}} = -\frac{\left(\alpha+\phi\right)\left[2\left(\alpha+\phi\right)\mathrm{Y}+4\left(1-\alpha\right)\right]\mathrm{Y}+\left(1-\alpha\right)\left[2\left(1-\alpha\right)+\left(1+\phi\right)\right]}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^{2}\right]^{2}} < 0.$$

Increase in the inverse of the labor elasticity: ϕ This increases the impact of $\hat{\theta}$:

$$\frac{d\left[\frac{(1-\alpha)+(\alpha+\phi)\mathrm{Y}}{\Theta}\right]}{d\phi} = \frac{\left(1-\alpha\right)\mathrm{Y}\left(\mathrm{Y}-1\right)}{\left[\left(1-\alpha\right)\left(3\mathrm{Y}-1\right)+2\left(\alpha+\phi\right)\mathrm{Y}^{2}\right]^{2}} > 0.$$

C Additional Panel Regression Results

To verify the robustness of the baseline RER regressions we consider estimations with additional financial and fiscal variables are explanatory variables. We show here the models after considering the addition of each new variable relative to the baseline. A summarized version with the initial and final models are found above at the beginning of the appendix.

Table 11: Model for the RER (all goods)

	Fixed effects					Random effects				
	(1a)	(1b)	(1c)	(1d)	(1e)	(2a)	(2b)	(2c)	(2d)	(2e)
$Lprod_T$	**0.296*****	**0.298*****	**0.263*****	**0.186*****	**0.185*****	**0.202*****	**0.195*****	**0.174*****	**0.095***	**0.167*****
	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
$Lprod_N$	-0.063	-0.062	-0.09	**-0.193*****	**-0.193*****	0.023	0.025	0.001	-0.05	**-0.165****
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
$RULC$	**0.188*****	**0.188*****	**0.22*****	**0.286*****	**0.291*****	**0.175*****	**0.175*****	**0.197*****	**0.232*****	**0.28*****
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
G	—	0.031	—	—	0.057	—	-0.049	—	—	0.043
		(0.08)			(0.1)		(0.09)			(0.1)
SG	—	—	**0.004****	—	0.003	—	—	0.003	—	0.004
			(0.002)		(0.002)			(0.002)		(0.002)
LR	—	—	—	0.002	0.001	—	—	—	0.0019	0.0011
				(0.002)	(0.002)				(0.002)	(0.002)
$R^2(adj.)$	0.71	0.71	0.68	0.63	0.64	0.69	0.69	0.66	0.9	0.77
N	262	262	252	214	214	262	262	252	214	214
HT						reject	reject	reject	reject	not reject

Notes: Dependant variable: log real exchange rate (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. G is the log of the general government's final consumption expenditure as a fraction of GDP expressed relative to the same quantity for the EU27. SG is the government surplus or deficit as a percentage of GDP in each country, relative to the EU27 analog. LR is a spread between the real long-run (10-year) bonds rate of each country relative to EU (EU19). The rates are made real by subtracting CPI inflation. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Table 12: Model for the RER for Traded goods

	Fixed effects					Random effects				
	(1a)	(1b)	(1c)	(1d)	(1e)	(2a)	(2b)	(2c)	(2d)	(2e)
$Lprod_T$	**0.28*****	**0.282*****	**0.241*****	**0.158*****	**0.157*****	**0.19*****	**0.185*****	**0.159*****	**0.084***	**0.14****
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
$Lprod_N$	-0.012	-0.011	-0.026	-0.1	-0.099	0.064	0.065	0.051	0.004	-0.074
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
$RULC$	**0.149*****	**0.149*****	**0.175*****	**0.242*****	**0.243*****	**0.139*****	**0.14*****	**0.157*****	**0.202*****	**0.233*****
	(0.04)	(0.04)	(0.03)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
G	—	0.031	—	—	0.071	—	-0.043	—	—	0.057
		(0.08)			(0.09)		(0.08)			(0.09)
SG	—	—	0.002	—	0	—	—	0.001	—	0
			(0.002)		(0.002)			(0.002)		(0.002)
LR	—	—	—	**0.003***	0.003	—	—	—	**0.0032***	0.0028
				(0.002)	(0.002)				(0.002)	(0.002)
$R^2(adj.)$	0.71	0.71	0.69	0.64	0.64	0.69	0.69	0.66	0.91	0.8
N	262	262	252	214	214	262	262	252	214	214
HT						reject	reject	reject	reject	not reject

Notes: Dependant variable: log real exchange rate (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. G is the log of the general government's final consumption expenditure as a fraction of GDP expressed relative to the same quantity for the EU27. SG is the government surplus or deficit as a percentage of GDP in each country, relative to the EU27 analog. LR is a spread between the real long-run (10-year) bonds rate of each country relative to EU (EU19). The rates are made real by subtracting CPI inflation. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

Table 13: Model for the RER for Non-traded goods

	Fixed effects					Random effects				
	(1a)	(1b)	(1c)	(1d)	(1e)	(2a)	(2b)	(2c)	(2d)	(2e)
$Lprod_T$	**0.321*****	**0.318*****	**0.275****	0.197	0.195	**0.19****	**0.191****	0.15	0.096	0.162
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.09)	(0.09)	(0.09)	(0.09)	(0.11)
$Lprod_N$	-0.147	-0.149	-0.195	**-0.387*****	**-0.388*****	0.001	-0.01	-0.031	-0.135	**-0.316****
	(0.13)	(0.13)	(0.14)	(0.14)	(0.14)	(0.11)	(0.11)	(0.11)	(0.11)	(0.13)
$RULC$	**0.317*****	**0.319*****	**0.361*****	**0.441*****	**0.45*****	**0.292*****	**0.296*****	**0.316*****	**0.344*****	**0.421*****
	(0.08)	(0.08)	(0.09)	(0.1)	(0.09)	(0.06)	(0.06)	(0.07)	(0.07)	(0.09)
G	—	-0.058	—	—	0.013	—	-0.143	—	—	-0.012
		(0.15)			(0.18)		(0.15)			(0.18)
SG	—	—	0.005	—	0.007	—	—	0.004	—	0.007
			(0.004)		(0.005)			(0.004)		(0.005)
LR	—	—	—	-0.001	-0.002	—	—	—	-0.0003	-0.0013
				(0.003)	(0.003)				(0.003)	(0.003)
$R^2(adj.)$	0.56	0.56	0.52	0.48	0.49	0.61	0.61	0.56	0.79	0.66
N	262	262	252	214	214	262	262	252	214	214
HT						reject	reject	reject	reject	not reject

Notes: Dependant variable: log real exchange rate (expenditure-weighted) expressed as the country i price level relative to EU15 (an increase is an appreciation). $RLprod_i$ is the log of the traded labor productivity relative to nontraded sector for country i ($realLabProd_{T,i,t}/realLabProd_{N,i,t}$) made itself relative with respect to EU15. $Lprod_T$ is the log of an aggregation of one-letter sectoral labor productivity of traded sectors using sectoral outputs as weights. $Lprod_N$ is an analog measure for nontraded sectors. $RULC_{it}$ is the log of an aggregation of sectoral level (single letter NACE rev. 2) nominal compensation of employees per hour worked for a country i as a ratio to the Producer Price Index and expressed relative to EU27. The nominal ULC involved in the calculations are sourced in euros for all countries. G is the log of the general government's final consumption expenditure as a fraction of GDP expressed relative to the same quantity for the EU27. SG is the government surplus or deficit as a percentage of GDP in each country, relative to the EU27 analog. LR is a spread between the real long-run (10-year) bonds rate of each country relative to EU (EU19). The rates are made real by subtracting CPI inflation. The data sample period is 1999-2020. Fixed effects is a panel regression with countries as cross-sections. Random effects is a random effects panel with countries as cross-sections. All standard errors (exept in cross section) are computed using a panel corrected standard errors method (Beck and Katz, 1995) under the assumption of period correlation (cross-sectional clustering). Standard errors are in parenthesis. The estimate of the constant is not reported. Rejection of the null in the Hausman test (HT) implies a statistical difference between the FE and RE, viewed as a preference for FE.

D Online Appendix Materials

Table 14: Disaggregated goods categories included in the RER calculations

T	Rice	N	Repair and hire of footwear	T	Passenger transport by air
T	Flours and other cereals	N	Actual rentals for housing	N	Passenger transport by sea and inland waterway
T	Bread	N	Imputed rentals for housing	T	Combined passenger transport
T	Other bakery products	T	Materials for the maintenance and repair of the dwelling	N	Other purchased transport services
T	Pizza and quiche	N	Services for the maintenance and repair of the dwelling	N	Postal services
T	Pasta products and couscous	N	Water supply	T	Telephone and telefax equipment
T	Breakfast cereals	N	Refuse collection	N	Wired telephone services
T	Other cereal products	N	Sewage collection	N	Wireless telephone services
T	Beef and veal	N	Other services relating to the dwelling n.e.c.	N	Internet access provision services
T	Pork	T	Electricity	N	Bundled telecommunication services
T	Lamb and goat	T	Natural gas and town gas	N	Other information transmission services
T	Poultry	T	Liquefied hydrocarbons (butane, propane, etc.)	T	Equipment for the reception, recording and reproduction of sound
T	Other meats	T	Liquid fuels	T	Equipment for the reception, recording and reproduction of sound and vision
T	Edible offal	T	Solid fuels	T	Portable sound and vision devices
T	Dried, salted or smoked meat	T	Heat energy	T	Other equipment for the reception, recording and reproduction of sound and picture
T	Other meat preparations	T	Household furniture	T	Photographic and cinematographic equipment and optical instruments
T	Fresh or chilled fish	T	Garden furniture	T	Personal computers
T	Frozen fish	T	Lighting equipment	T	Accessories for information processing equipment
T	Fresh or chilled seafood	T	Other furniture and furnishings	T	Software
T	Frozen seafood	T	Carpets and other floor coverings	T	Calculators and other information processing equipment
T	Dried, smoked or salted fish and seafood	N	Repair of furniture, furnishings and floor coverings	T	Pre-recorded recording media
T	Other preserved or processed fish and seafood-based preparations	T	Furnishing fabrics and curtains	T	Unrecorded recording media
T	Milk, whole, fresh	T	Bed linen	T	Other recording media
T	Milk, low fat, fresh	T	Table linen and bathroom linen	N	Repair of audio-visual, photographic and information processing equipment
T	Milk, preserved	N	Repair of household textiles	T	Major durables for outdoor recreation
T	Yoghurt	T	Other household textiles	T	Musical instruments and major durables for indoor recreation
T	Cheese and curd	T	Refrigerators, freezers and fridge-freezers	N	Maintenance and repair of other major durables for recreation and culture
T	Other milk products	T	Clothes washing machines, clothes drying machines and dish washing machines	T	Games and hobbies
T	Eggs	T	Cookers	T	Toys and celebration articles
T	Butter	T	Heaters, air conditioners	T	Equipment for sport, camping and open-air recreation
T	Margarine and other vegetable fats	T	Cleaning equipment	T	Garden products
T	Olive oil	T	Other major household appliances	T	Plants and flowers
T	Other edible oils	T	Small electric household appliances	T	Pets and related products
T	Other edible animal fats	N	Repair of household appliances	N	Veterinary and other services for pets
T	Fresh or chilled fruit	T	Glassware, crystal-ware, ceramic ware and chinaware	N	Recreational and sporting services
T	Frozen fruit	T	Cutlery, flatware and silverware	N	Cinemas, theatres, concerts
T	Dried fruit and nuts	T	Non-electric kitchen utensils and articles	N	Museums, libraries, zoological gardens
T	Preserved fruit and fruit-based products	N	Repair of glassware, tableware and household utensils	N	Television and radio licence fees, subscriptions
T	Fresh or chilled vegetables other than potatoes and other tubers	T	Major tools and equipment	N	Hire of equipment and accessories for culture
T	Frozen vegetables other than potatoes and other tubers	T	Small tools and miscellaneous accessories	N	Photographic services
T	Dried vegetables, other preserved or processed vegetables	T	Cleaning and maintenance products	N	Other cultural services
T	Potatoes	T	Other non-durable small household articles	T	Games of chance
T	Crisps	N	Domestic services by paid staff	T	Books
T	Other tubers and products of tuber vegetables	N	Cleaning services	T	Newspapers
T	Sugar	N	Hire of furniture and furnishings	T	Magazines and periodicals
T	Jams, marmalades and honey	N	Other domestic services and household services	T	Miscellaneous printed matter
T	Chocolate	T	Pharmaceutical products	T	Stationery and drawing materials
T	Confectionery products	T	Other medical products	T	Package holidays
T	Edible ices and ice cream	T	Therapeutic appliances and equipment	N	Education - HH
T	Artificial sugar substitutes	N	Medical services	N	Restaurants, cafes and dancing establishments
T	Sauces, condiments	N	Dental services	N	Fast food and take away food services
T	Salt, spices and culinary herbs	N	Paramedical services	N	Canteens
T	Baby food	N	General hospitals	N	Hotels, motels, inns and similar accommodation services
T	Ready-made meals	N	Mental health and substance abuse hospitals	N	Holiday centres, camping sites, youth hostels and similar accommodation services
T	Other food products n.e.c.	N	Speciality hospitals	T	Accommodation services of other establishments
T	Coffee	N	Nursing and residential care facilities	N	Hairdressing for men and children
T	Tea	T	New motor cars	N	Hairdressing for women
T	Cocoa and powdered chocolate	T	Second-hand motor cars	N	Personal grooming treatments
T	Mineral or spring waters	T	Motor cycles	T	Electric appliances for personal care
T	Soft drinks	T	Bicycles	T	Non-electrical appliances
T	Fruit and vegetable juices	T	Animal drawn vehicles	T	Articles for personal hygiene and wellness, esoteric products and beauty products
T	Spirits	T	Tyres	N	Prostitution
T	Wine	T	Spare parts for personal transport equipment	T	Jewellery
T	Beer	T	Accessories for personal transport equipment	T	Clocks and watches
T	Tobacco	T	Diesel	N	Repair of jewellery, clocks and watches
T	Narcotics	T	Petrol	T	Other personal effects
T	Clothing materials	T	Other fuels for personal transport equipment	N	Social protection
T	Garments for men	T	Lubricants	N	Life insurance
T	Garments for women	N	Maintenance and repair of personal transport equipment	N	Insurance connected with the dwelling
T	Garments for infants (0 to 2 years) and children (3 to 13 years)	N	Other services in respect of personal transport equipment	N	Insurance connected with health
T	Other articles of clothing and clothing accessories	N	Passenger transport by train	N	Insurance connected with transport
N	Cleaning, repair and hire of clothing	N	Passenger transport by underground and tram	N	Other insurance
T	Footwear for men	N	Passenger transport by bus and coach	N	FISIM
T	Footwear for women	N	Passenger transport by taxi and hired car with driver	N	Other financial services n.e.c.
T	Footwear for infants and children				

D.1 Data Sources

The details on each variable source are the following:

Real Unit labor Costs This measure is calculated based on nominal unit labor costs data at the industry level and PPI indexes:

Nominal Unit labor Costs

Source: Eurostat - labor Productivity and unit labor costs at industry level (national accounts data —ESA 2010)
Name of database: `nama_10_lp_a21`
Indicator: D1_SAL_HW, Compensation of employees per hour worked. Euros.
Link: https://ec.europa.eu/eurostat/databrowser/product/page/NAMA_10_LP_A21

Producer Price Index

Source: IMF-International Finance Statistics
Name of database: `IMF-IFS`,
Indicator: PPPI_IX. Prices, Producer Price Index, All Commodities. Index
Link: https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b

The final three years for EU27 are missing in the IMF-IFS database and thus are extrapolated using the PPI growth for All Industry (except construction as in Table 3) from Eurostat:
Source: Eurostat
Name of database: `sts_inpp_a`,
Indicator: PCH_SM. Percent change with respect to last year.
Link: https://doi.org/10.2908/STS_INPP_A

Real labor productivity

Source: Eurostat - labor Productivity and unit labor costs at industry level (national accounts data)
Name of database: `nama_10_lp_a21`
Indicator: RLPR_HW, Real labor productivity per hour worked. Index.
Link: https://ec.europa.eu/eurostat/databrowser/product/page/NAMA_10_LP_A21

Sectoral Value Added

Source: Groningen Growth and Development Centre
Name of database: `PLD 2023`. Productivity Level Database.
Indicator: VA, Nominal Value Added, millions, local currency.
Link: https://www.rug.nl/ggdc/productivity/pld/releases/pld-2023

Sectoral labor Output per Hour

Source: Groningen Growth and Development Centre
Name of database: `PLD 1997`. Productivity Level Database.
Indicator: LP_SO, Sectoral Output per hour worked
Link: https://www.rug.nl/ggdc/productivity/pld/releases/pld-1997

Long-run Interest Rates Spread

Source: European Central Bank (ECB)
Name of database: Interest Rates Statistics (IRS).
Indicator: Long-term interest rate for convergence purposes - Debt security issued (10 years)
Link: https://data.ecb.europa.eu/data/datasets/IRS

Government deficit/surplus

Source: Eurostat
Name of database: gov_10dd_edpt1, Government deficit/surplus, debt and associated data
Indicator: TE, Total General Government Expenditure
Units: PC_GDP, percentage of GDP Link: https://doi.org/10.2908/GOV_10DD_EDPT1

Fiscal Expenditure

Source: Eurostat
Name of database: gov_10a_exp, General Government Expenditure by Function
Indicator: B9, Net Lending/Net borrowing of the General Government (sector: S13)
Unit: PC_GDP, percentage of GDP Link: https://doi.org/10.2908/GOV_10A_EXP