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International trade and economic growth in Croatia

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ABSTRACT

This article argues that Croatia's growth over the past two decades is deeply related to the dynamics of international trade. Under the premise that what is bought and sold in global markets reflects the economy's fundamentals, we show that the rate of growth compatible with equilibrium in the balance-of-payments, i.e. the dynamic Harrod trade multiplier, is a good predictor of the country's actual long-run growth rate. For this purpose, we apply a state–space model and the Kalman smoother to obtain time-varying parameter estimates of the exports and imports functions. We use these estimates to investigate the determinants of international non-price competitiveness. Bayesian Model Averaging (BMA) and Weighted Average Least Squares (WALS) techniques are combined to tackle model selection uncertainty. It is shown that R&D investments and human capital accumulation are the most important explanatory variables. The success of the European Union's (EU) integration process depends on the capacity of its new members to achieve a balanced-growth path. Being the last country to join the union, the experience of this single country is particularly relevant to understand possible development alternatives for the region. We conclude by highlighting the policy relevance of our findings to the evaluation of Croatia's catching-up performance as part of the EU.

1. Introduction

Croatia declared independence on June 25, 1991, a year after the parliamentary elections that resulted in the dissolution of its previous association with former Yugoslavia. A war was fought from 1991 to 1995 leaving a significant number of people dead and many more displaced (BBC, 2003). The conflict had a devastating impact on various sectors, leading to a sharp decline in production, disruption of supply chains, and widespread economic instability. Still, since the 2000s, the country has undertaken a process of economic transition to rebuild the economy and move to a market-based system. Croatia has implemented reforms to attract foreign investment and promote private-sector development. It became a member of the World Trade Organisation (WTO) in 2000, joined the Central European Free Trade Agreement (CEFTA) in 2003, and finally entered the European Union (EU) as a member state in 2013. This strategy has allowed for an increase in the ratio between domestic to EU per capita output from 0.45 in 1995 to 0.65 in 2020, suggesting some catching up in living standards (World Bank, 2023).

The first two decades of the twenty-first century are crucial for understanding Croatia's transformative journey from post-war recovery to EU membership. During this period, the country experienced significant socio-economic and political changes, including the impact of the 2008 financial crisis, the boom in tourism, and critical policy shifts. Additionally, it embeds an ongoing process of demographic transition and regional stability issues while providing rich data for evaluating economic indicators and policy outcomes. Its study offers unique insights into the past and present of this transition economy and comparative insights for other countries, especially those considering EU integration or sharing economic drivers like tourism.

Our contribution to the empirical literature on economic growth in transition countries is twofold. Using quarterly data from 2000 to 2020, we examine whether the growth rate compatible with equilibrium in the balance-of-payments – the dynamic Harrod (1933) trade-multiplier – is a robust predictor of the country's long-term growth rate. This is an innovative step given the lack of such an analysis for Croatia, despite empirical support for such a relationship in single and country groups, including former socialist states (Kvedaras, 2005) and China (Felipe and Lanzafame, 2020). We rely on state–space models and the Kalman smoother for trade equations estimation, following the methodology proposed by Felipe and Lanzafame (2020). Their approach allows for time-varying estimates, providing an advantage over more standard methods. It is shown that the model accurately predicts the long-term growth rate, offering a fresh perspective that considers the amplifying effects of exports on growth. Especially noteworthy is the differentiation between goods and services in our analysis, owing to tourism's significant role in this economy. We also explore the changing landscape of non-price competitiveness after Croatia's EU accession, providing evidence confirming EU membership's positive impacts.

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As a second empirical contribution, we delve into the determinants influencing the growth rate compatible with equilibrium in the balance-of-payments. Using Bayesian Model Averaging (BMA) and Weighted Average Least Squares (WALS), we identify key drivers such as Research and Development (R&D) investment relative to GDP and human capital accumulation. Our findings indicate that these factors and demographic variables are critical to understanding Croatia's long-term economic performance. To the best of our knowledge, this paper is the first to empirically test the relevance of the trade-multiplier for Croatia, shedding light on the interactions between supply and demand in international trade. Our estimates provide valuable insights into the processes of structural change and offer implications for macroeconomic forecasting in growth models.

The remainder of the paper is organised as follows. Section 2 presents some stylised facts about the Croatian economy, emphasising recent trends in international trade. Section 3 revisits the multisectoral version of the dynamic Harrod trade-multiplier and present our estimation strategy. Section 4 applies time-varying parameter estimation techniques to assess the relevance of the theoretical model in explaining long-run growth in the country. Section 5 brings our BMA and WALS estimations of the determinants of non-price competitiveness. Some final considerations follow.

2. Some stylised facts

After joining the WTO in 2000 and before the great financial crisis in 2008, Croatia registered significant growth in the trade of goods and services. Fig. 1 (a) reports, in blue, the trajectory of exports, in red, those of imports, while the black line stands for GDP. Panel (b) provides the growth rates of each of them. Total exports rose from 11.8 billion Euros in 2000 to 19.2 billion in 2008, with an average annual growth rate of 6.3%. In this period, goods exports grew faster than services. At the same time, total imports grew faster than exports, doubling from 11.7 billion Euros in 2000 to over 24 billion in 2008, with an average expansion of 9.5% per year. The composition of trade between goods and services is depicted in diagrams (c)–(f). It is important to note that the trade deficit in the exchange of goods contrasts with a surplus from the service sector. Still, until the onset of the financial crisis, the surplus from services did not compensate for the deficit from the goods sector, resulting in a deterioration in the current account.

The global trade volume experienced a sharp decline in 2008 due to the financial crisis, and Croatia was no exception. As evident in panels (d) and (f), exports and imports contracted significantly during this period. However, the import contraction was more severe, which can be attributed to a deeper domestic recession than the global downturn. While the global GDP contracted by 1.9%, the EU experienced a sharper decline of 4.3%, and Croatia's economy shrank by 7.2%. In monetary terms, exports fell to 16.3 billion Euros in 2009, driven mainly by a decline in service exports. Conversely, total imports plummeted to 18.8 billion Euros, primarily due to a reduction in goods imports. When examining the two sectors—goods and services—separately, we find the decline in goods imports was more pronounced than in goods exports. Conversely, the contraction in service exports exceeded that of service imports.

As the income of its main trading partners recovered faster than domestic demand, Croatian exports strengthened accordingly, resulting in a significantly lower trade deficit in goods and a surplus in services. In 2014, total exports and imports began to grow, supported by improved domestic and international macroeconomic conditions and easier access to the common market and EU funds after entering the union in 2013. By 2014, exports reached the pre-crisis level, registering 26.9 billion Euros in 2019, an average annual growth rate of 5.2%. After the great financial crisis, goods exports expanded at an average annual rate of 6.2%, reaching 13.0 billion Euros in 2019. On the other hand, services presented a slightly less robust performance and reached 13.9 billion Euros. When it comes to imports, pre-crisis levels were only recovered in 2017. Imports of goods grew at an average annual rate of 4.3% in 2019, amounting to 23.0 billion Euros, while services expanded 3.3% per year, reaching a modest 4.9 billion in 2019.

Over the whole period, the sum of exports and imports over GDP, a broad measure of economic openness, jumped from around 0.75 in 2000 to above one just before the COVID-19 crisis. The same indicator for the EU as a whole moved from 0.7 to 0.95. Although goods trade has grown faster in recent years, services, especially tourism, continue to be of central importance to Croatia. This sector reflects a natural comparative advantage as the country continues integrating with the EU. Additionally, EU funds to support regional development have often been channelled into the service sectors like tourism infrastructure, boosting the quality and quantity of services offered. The grey bar on panel (c) indicates that half of the total exports are still related to the services sector and are mainly responsible for covering the trade deficit in goods in the balance of payments.

There is a certain consensus that EU integration has generally had a positive effect on Croatia's competitiveness (e.g. Ranilović, 2017; Buturac et al., 2019). In fact, after 2013, Croatia's GDP has grown consistently, as shown in panels (a) and (b). However, regarding patterns of specialisation, there is some evidence suggesting that Croatia has been less successful in adopting new technologies and attracting investment compared to the other EU members (see Kovač et al., 2012). Focusing on manufacturing industry competitiveness, Stojčić et al. (2012) concluded that the country should pursue a process of structural change capable of improving the quality of export products rather than on price competitiveness. Still, the number of studies formally assessing the impact of international specialisation on growth in this country is quite limited. A possible framework that allows us to capture the multifaceted nature of trade dynamics, especially in the context of long-term impacts and non-price factors such as R&D and human capital is the dynamic Harrod trade multiplier. The following section presents it as a possible alternative framework for this endeavour.

3. Underlying framework and estimation strategy

The relationship between trade and economic performance has been, for a long time, subject to considerable interest in economics (e.g. Feder, 1983; Feenstra and Romalis, 2014). The literature on export-led growth has consistently estimated price and income elasticities in export functions as well as investigated alternative development-enhancing channels associated with exports (see, for example, Berg et al., 2012; Freund and Pierola, 2012; Tang et al., 2015). Exports are particularly important because they are the only component of demand that can pay for the import requirements of growth. When output rises, imports must also increase to satisfy consumption and investment needs. This fact does not mean that all production is tradable. A significant part of the economy might not be exposed to trade. However, if the economy does not obtain sufficient export earnings to pay for the import content of the other expenditure components, then demand will have to be constrained. In the short term, the country may grow faster than the growth rate compatible with equilibrium in the current account, especially when international conditions are favourable. Still, in the long term, imbalances cannot be persistently increasing.

The central proposition of the dynamic trade-multiplier is that such an adjustment in the balance-of-payments does not happen through prices but rather in terms of income, such that growth becomes balance-of-payments constrained. Countries in the EU fit this framework well, given that they trade in US dollars or Euros.[1] The Frankfurt-based

[1] A long-time policy of the Croatian National Bank was to keep fluctuations of its national currency, the Kuna (HRK), against the Euro within a relatively stable range, remaining at a near-constant 7.5 HRK/Euro. Croatia joined the EU Exchange Rate Mechanism on 10 July 2020 with an exchange rate nominal band of ±15.0%. On 12 July 2022, the EU Council approved the accession of Croatia to the Euro area on 1 January 2023. Prices for goods and services will be indicated in Euro and Kuna until 31 December 2023.

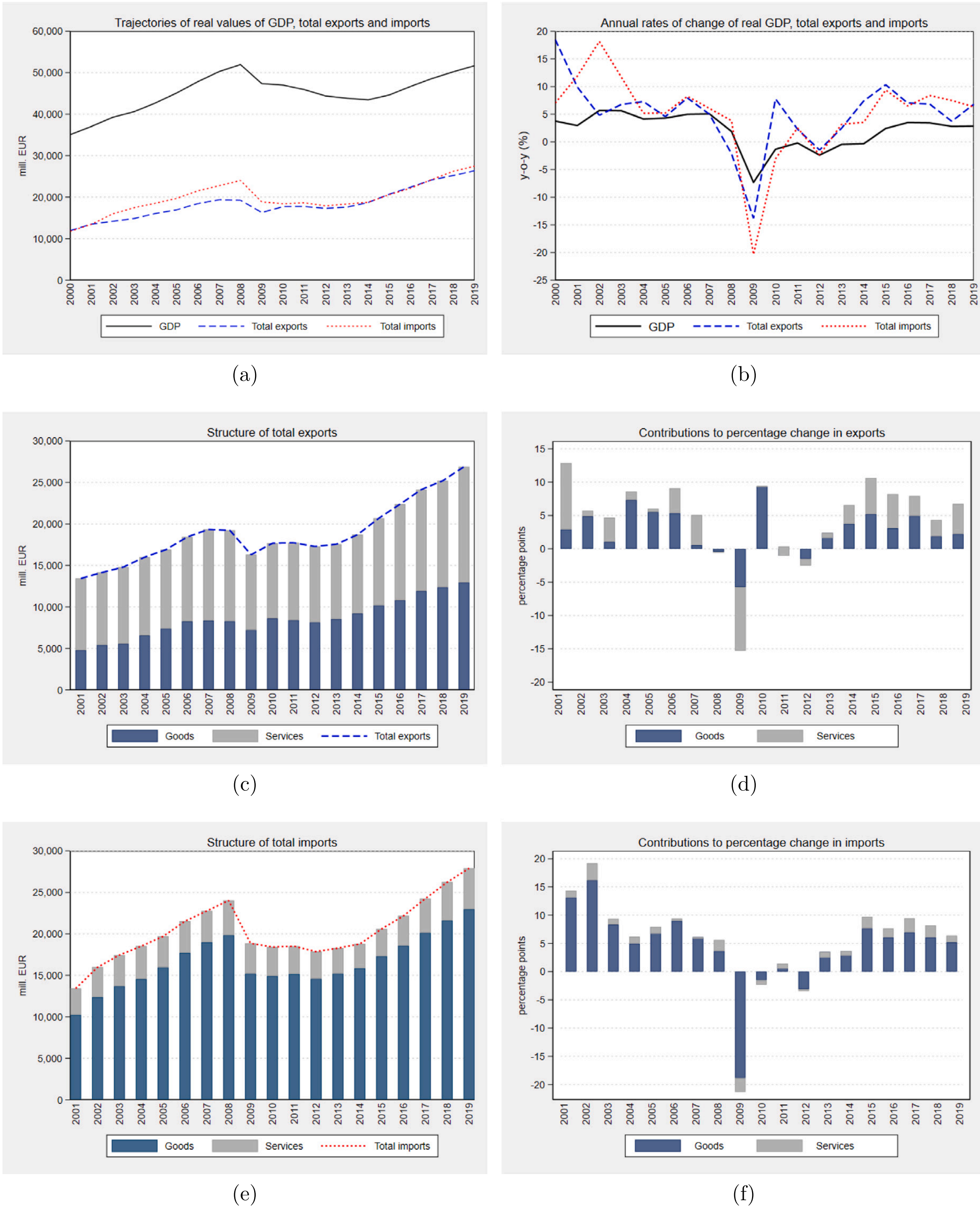


Fig. 1. Trajectories of GDP, exports and imports in Croatia, 2001–2019, constant 2015 Euros. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

European Central Bank (ECB) manages the latter and has substituted national currencies. The United States is the only country that can buy from the rest of the world in a fully controlled domestic currency. While the roots of the trade-multiplier go back to Harrod (1933), the dynamic version of the model was developed by Thirlwall (1979) and extended to a multisectoral framework by Araújo and Lima (2007). From a theoretical point of view, we rely on this latter study to frame our estimation strategy. Our choice is justified because their specification is compatible with a differentiation between goods and services, which fits well in the case of Croatia.

Empirical evidence supporting this model exists for single and country groups (e.g. Bagnai, 2010; Gouvêa and Lima, 2013; Kvedaras et al., 2020), including former socialist states (Kvedaras, 2005), among others (for a recent review, see Blecker, 2022). From an empirical point of view, we rely on the methodology developed by Felipe and Lanzafame (2020), who estimated the dynamic trade-multiplier for China. They are the first to use time-varying parameter estimation techniques to obtain the income elasticities of exports and imports. Their procedure comes with the advantage of allowing us to obtain a measure of non-price competitiveness (ρ) that changes over time and is compatible with the theoretical model, offering an upper hand with respect to more standard econometric techniques.[2]

3.1. The dynamic Harrod trade-multiplier

Suppose an economy divided in n sectors. The rate of growth of aggregate exports (x) and imports (m) are given by:

$$x_t = \sum_{i=1}^{n} \theta_{i,t} x_{i,t} \tag{1}$$

$$m_t = \sum_{i=1}^{n} \Omega_{i,t} m_{i,t} \tag{2}$$

where θ_i and Ω_i are the shares of each sector in international trade while x_i and m_i are the respective sectoral magnitudes.

They are such that:

$$\begin{aligned} x_{i,t} &= x_i\left(rer_t, z_t\right),\ x_{i\ rer} > 0,\ x_{i\ Z} > 0,\ x_i(0,0) = 0 \\ m_{i,t} &= m_i\left(rer_t, y_t\right),\ m_{i\ rer} < 0,\ m_{i\ Y} > 0,\ m_i(0,0) = 0 \end{aligned} \tag{3}$$

where rer stands as variations in the real exchange rate, z is the rate of growth of the main trading partners' income, and y corresponds to the rate of domestic income growth. A more depreciated exchange rate reduces the cost of domestically produced goods and services in foreign markets while increasing the price of those produced abroad. Therefore, it leads to higher exports and lower imports. The reader might ask whether the terms-of-trade should also be included in (3). We show in Appendix A.2 that they have moved together with rer over time in Croatia, thus making redundant its inclusion. On the other hand, a growing output is related to increasing demand. Therefore, as the income of the rest of the world increases, exports expand accordingly. Analogously, as domestic income increases, Croatian households and firms demand more goods and services from other countries.

Equilibrium in trade, which for our purposes stands as *proxy* for equilibrium in the balance-of-payments, rules out the possibility of ever-increasing trade deficits or surpluses:

$$x_t = rer_t + m_t \tag{4}$$

which means that exports and imports must grow approximately at the same pace.

Substituting (3) into Eqs. (1) and (2), inserting the resulting expressions into Eq. (4) and rearranging, we obtain the rate of growth of output compatible with equilibrium in the balance-of-payments (y_{BP}). In a macroeconomic context, the parameter y_{BP}, representing the growth rate compatible with equilibrium in the balance of payments, offers significant economic insights. An equilibrium in the balance of payments implies that a country can sustain its current rate of economic activity without incurring imbalances in its financial interactions with the rest of the world. The y_{BP} parameter serves as a threshold or target for policymakers. If the actual economic growth exceeds y_{BP}, the country may experience a worsening trade deficit, which could put downward pressure on its currency and lead to a financial crisis if the imbalance becomes too large. Conversely, if economic growth is below y_{BP}, it may indicate that the country is not fully utilising its productive potential and could be amassing foreign reserves unnecessarily, leading to other types of economic distortions such as inflation. Understanding the y_{BP} parameter can offer policymakers a valuable tool for gauging the sustainability of their growth strategies. By maintaining growth at a rate compatible with y_{BP}, a country can ensure a more stable and sustainable economic trajectory in the long term.

Under Purchasing Power Parity (PPP), the relative price of tradable goods across countries $rer_t = 0$. Assuming for simplicity that $x_i(\cdot)$ and $m_i(\cdot)$ are linear, it follows[3]:

$$y_{BP,t} = \rho_t z_t \tag{5}$$

where

$$\rho_t = \frac{\sum_{i=1}^{n} \theta_{i,t} \phi_{i,t}}{\sum_{i=1}^{n} \Omega_{i,t} \pi_{i,t}} \tag{6}$$

is a measure of non-price competitiveness of a country or region with $\phi_i = \partial x_i / \partial z$ and $\pi_i = \partial m_i / \partial y$ standing as the sectoral income elasticities of exports and imports, respectively. For values of $\rho > 1$ the economy is growing faster than the rest of the world, whereas for $\rho < 1$ it is falling behind. The ratio between trade elasticities is supposed to capture supply characteristics of international specialisation patterns, ranging from technical sophistication and quality of goods and service (see McCombie and Thirlwall, 1994).

In the aggregate case, there is no differentiation between sectors, i.e. $n = 1$, and Eq. (6) is reduced to:

$$\rho_t = \frac{\phi_t}{\pi_t} \tag{7}$$

Hence, to obtain the growth rate compatible with equilibrium in the balance-of-payments, we only need to estimate the aggregate income elasticity of exports and imports. This is done by specifying a state–space model and applying Kalman filtering techniques.

3.2. Estimation strategy

We are ready to describe our estimation strategy to test whether the theoretical framework described so far is appropriate for studying growth trajectories in Croatia. In our study, we go a step further by adopting an innovative approach that utilises time-varying parameter estimation techniques. Traditional static models assume that elasticities remain constant over time, which may not hold in an ever-changing global economic landscape. The use of time-varying parameters enables us to capture the dynamics of income elasticity of exports and imports as they evolve. This provides a more realistic representation of the economy's adaptability to external shocks and policy interventions.

As a result, we can compute an indicator of non-price competitiveness that is sensitive to temporal variations, thereby offering a more accurate understanding of how non-price competitiveness evolves over time. Furthermore, these time-varying estimates allow us to compute the growth rate compatible with equilibrium in the balance of payments (y_{BP}) in a dynamic manner, enabling us to examine how closely it

[2] In Appendix A.1, we provide a comprehensive derivation of the static and dynamic versions of the theory. We show in more detail the mechanism behind both of them. As one of the reviewers pointed out, when Thirlwall's (1979) paper was first published, there were several early criticisms and lively debates. One was concerned with whether or not the trade multiplier was merely a tautology. McCombie (2019) provides an overview and recent assessment of the debate. He shows it rests on a fundamental confusion between the mathematical calculation of the elasticity and its econometric estimation.

[3] The assumptions of linearity and Purchasing Power Parity (PPP) are commonly used in economic models. Still, they come with their limitations that readers should be aware of. The assumption of linearity implies that it can be represented as a straight line. While this simplifies the modelling and interpretation of results, it may fail to capture more complex, non-linear relationships that could exist in real-world scenarios. On the other hand, PPP assumes that the same basket of goods will cost the same when converted to a common currency. This is a useful way to compare the value of currencies and the cost of living between countries. However, it does not account for transaction costs, transportation costs, taxes, or differences in the quality of goods. Additionally, PPP assumes that goods are identical across countries, which may not always be true. By incorporating these assumptions, our model benefits from simplification and easier interpretation. Therefore, results derived from such models should be interpreted as approximations and not as exact predictions.

aligns with the actual growth paths. This introduces an additional layer of sophistication to our analysis, providing a comprehensive toolset for policymakers aiming to understand the interplay of growth and balance of payments over time. We begin by defining two state–space models, one for exports and one for imports, each model consisting of two *state* and one *space* equations:

$$x_t^T = \sigma_t rer_t + \phi_t z_t^T + \varepsilon_{x,\,t}$$
$$\sigma_t = \sigma_{t-1} + \varepsilon_{\sigma,\,t} \tag{8}$$
$$\phi_t = \phi_{t-1} + \varepsilon_{\phi,\,t}$$

$$m_t^T = \eta_t rer_t + \pi_t y_t^T + \varepsilon_{m,\,t}$$
$$\eta_t = \eta_{t-1} + \varepsilon_{\eta,\,t} \tag{9}$$
$$\pi_t = \pi_{t-1} + \varepsilon_{\pi,\,t}$$

where η and σ are the time-varying price elasticities of imports and exports, respectively; as before ϕ and π are the correspondent income elasticities; while ε are independent normally distributed errors with zero mean and constant variance. Income elasticities capture non-price factors that affect exports and imports, while the effect of price competition on trade is reflected in price elasticities. Hence, systems (8) and (9) allow us to separate between these two effects. Theory predicts that the price element will be either not statistically significant or very small, such that income is the adjustment variable bringing the rate of growth to the one compatible with equilibrium in the current account.

The superscript T indicates that series have been purged from short-run fluctuations using the Corbae and Ouliaris (2006) filter. The Corbae–Ouliaris filter stands out for its flexibility in choosing the polynomial order for detrending, better asymptotic properties, and minimised end-point bias, especially when compared to commonly used filters like the Hodrick–Prescott or Baxter–King filters. It also offers more accurate identification of cyclical patterns due to better frequency domain specificity and is sensitive to structural breaks in time series data. These features make it a robust and versatile tool for economic time-series analysis.

To obtain the time-series of the state variables, we opt for a smoothing approach over filtering techniques for two compelling reasons. Smoothing methods provide more accurate and robust trend estimates by utilising the entire dataset, thereby mitigating issues like end-point bias commonly associated with filtering approaches. Additionally, smoothing offers better interpretability and flexibility in model assumptions, crucial for our dynamic analysis of non-price competitiveness. These benefits make smoothing a methodologically sound choice for the objectives of our research (see Sims, 2001. A comparison between filtered and smoothed estimates of the imports function can be found in Appendix A.3).

4. Testing the trade-multiplier

This section delineates our data sources and presents two sets of estimations aimed at unpacking the trade-multiplier effect in Croatia. Initially, we explore elasticities without separating the exports of goods and services, i.e., $n = 1$. Subsequently, we partition these categories ($n = 2$), assessing the robustness of the multiplier and spotlighting the pivotal role of tourism services in Croatia. Finally, we show that deviations of the actual growth rate from the one compatible with equilibrium in the balance-of-payments are a zero-mean reverting process. In other words, we establish that the trade-multiplier serves as a linchpin for long-term growth.[4]

[4] An empirical literature that goes back to Thirlwall (1979) has differentiated between two formulations of the trade multiplier. The first does not specify an export function and is referred to as a "weak" version. The second corresponds to the one used in this article, called the "strong" multiplier. Still, Appendix A.4 briefly discusses the main differences between them and empirically shows that our estimates of y_{BP} are fundamentally the same.

4.1. Data and empirical analysis

Our study utilises seasonally and calendar-adjusted data from Q1 2000 to Q2 2020. Data from the 1990s is intentionally omitted due to significant structural breaks caused by numerous political and economic system changes, which renders it unreliable. Time series are sourced from the Eurostat database and are expressed in constant 2015 Euros. We employ the difference between the EU-27 and Croatia as a *proxy* for the global output. This choice is substantiated by the fact that a significant portion — approximately 70% — of Croatia's trade in goods and services is conducted within the EU. Given this significant share, we believe that using the EU-27 as a proxy provides a highly representative and meaningful lens through which to view Croatia's global trade activities. Appendix A.4 provides some robustness checks using the GDP of the rest of the world instead. The real exchange rate is computed by deflating the nominal exchange rate of the Croatian Kuna against the Euro using the Harmonised Index of Consumer Prices (HICP), both of which are obtained from the Croatian National Bank.[5]

Fig. 2 illustrates the income elasticity of imports (π) and exports (ϕ). Exports are more income-elastic than imports, that is, $\phi > \pi$. The ratio between them, denoted by ρ, indicates that Croatia has been growing faster than its EU counterparts on average. However, this trend has not been consistent over time. Key periods of deviation occur following Croatia's accession to CEFTA in 2003 and the EU in 2013, during which growth rates surged before reverting to the average. In both cases, growth rates returned to the average after some years, suggesting that Croatia's convergence is not continuous.

Membership in CEFTA and the EU have had profound impacts on Croatia's trade. CEFTA enhanced industrial trade between member states, enabling Croatia to access foreign technologies and thereby positively affecting domestic productivity. Unfortunately, this positive trajectory was disrupted by the crash of the Lehman Brothers in the United States. In the years that followed the 2008 financial crisis, we observed a return to $\rho \approx 1$, meaning that the country's performance converged to the average one of its trade partners. EU membership, conversely, has offered Croatia significant technological and R&D advancements, elevating its non-price competitiveness.

With Croatia's accession to the EU in 2013, there was a significant increase in non-price competitiveness, pointing to the positive effects of having free access to EU markets. EU membership often acts as a catalyst for adopting new technologies and engaging in R&D activities for member states, given the collaborative nature of the union and the availability of funding for such projects. Countries that invest more in R&D are better positioned to adapt to changes in the global economic landscape, adopt new technologies, and shift towards high-value-added sectors. This can mean a transition from traditional industries to more technology-intensive sectors, which usually offer higher profit margins and are more resilient to economic downturns. For Croatia, EU membership has provided several avenues for enhancing its technological capabilities and R&D initiatives. Meeting environmental or product safety criteria required investment in new technologies and R&D efforts to improve processes and products, making them compliant and competitive. These adaptations often lead to more efficient production techniques, higher quality products, and ultimately, increased competitiveness in both domestic and international markets.

[5] The Harmonised Index of Consumer Prices (HICP) is a measure of inflation and price stability in the EU and European Free Trade Area. Developed by Eurostat, the HICP provides a consistent and comparable measure of consumer price trends across countries. The index is used for various policy purposes, including by the ECB to assess inflation against its targets. Unlike the Consumer Price Index (CPI), the HICP does not include owner-occupied housing costs and varies in other ways to ensure cross-country comparability. Overall, it serves as a key economic indicator for policymakers and economists interested in assessing economic performance and making international comparisons.

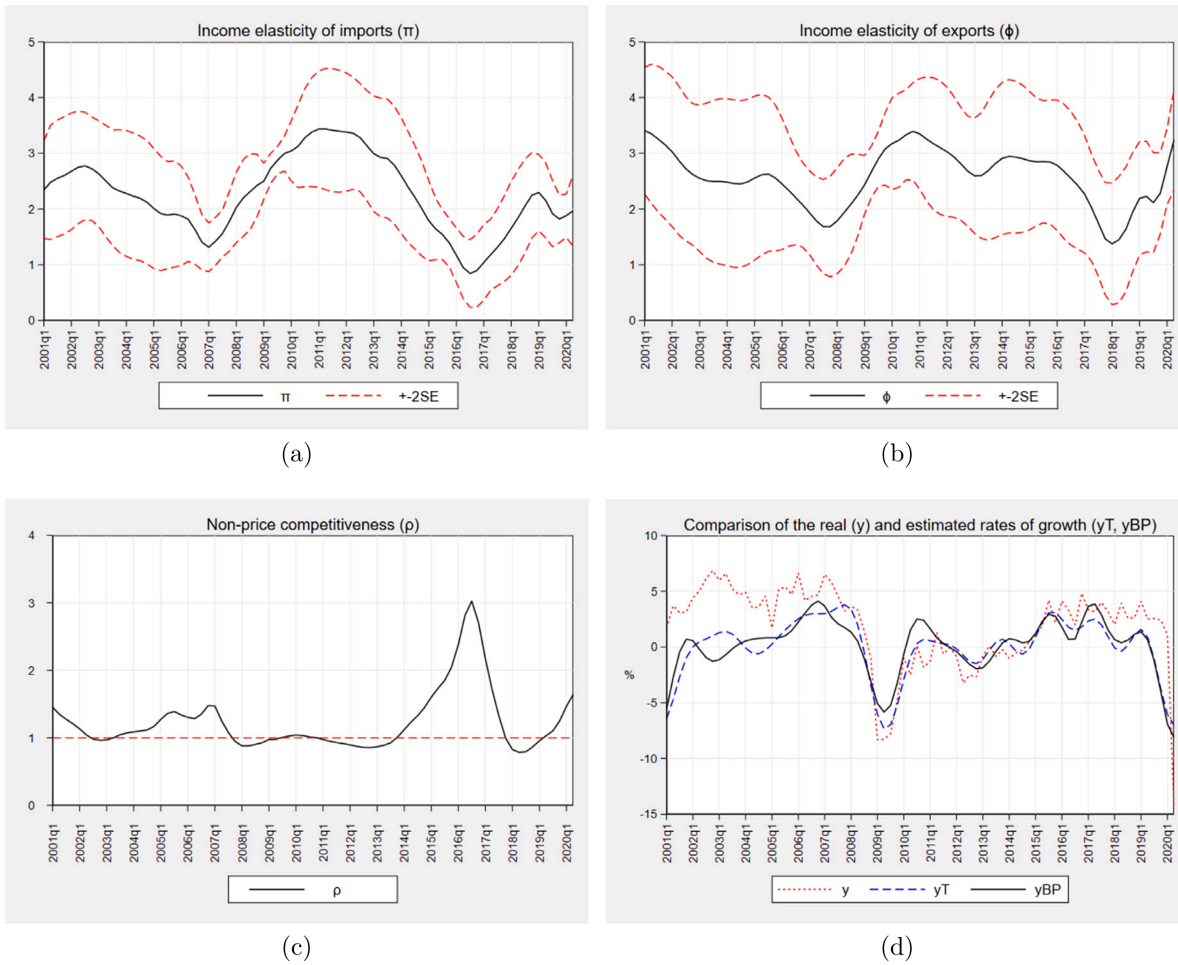


Fig. 2. Time-varying estimates of the trade elasticities, non-price competitiveness, and a comparison between actual and predicted growth rates. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The benefits came not only in the possibility of accessing superior inputs and technologies but also with a significant increase in the potential market for Croatian products. In the past seven years, the country has consolidated itself as a tourist hub and has experienced the emergence of an expressive automotive industry. In addition, data from the Croatian Bureau of Statistics (CBS) compiled by the CNB indicates a marked increase in exports of medicinal and pharmaceutical products that registered a peak of almost 10% of total exports in 2017.

We conclude this initial set of findings by comparing actual and estimated growth rates, as shown in Fig. 2(d). This provides a visual taste of the empirical relevance of the dynamic-trade multiplier in explaining the economic performance of the country in question. While we will return to this point, for the moment, it is enough to notice that the continuous black line and the dotted blue one most of the time move together. Our estimates suggest price effects are either non-statistically significant or minimal and close to zero. They are reported in the Appendix A.5. These findings confirm one of the central insights of the trade-multiplier: the role of price competitiveness in determining exports and imports is only minor. They are also in line with Mervar and Payne (2007) and Bobić (2010), who showed more significant income than price effects, both in exports and imports.

4.2. Disaggregating between goods and services

The Croatian economy heavily depends on service activities, especially tourism, reflected in its high share in total exports. Hence, we give one step forward and divide trade between goods (G) and services (S), i.e. $n = 2$. From Eq. (6), we have that, in this case, the income elasticity of exports and imports is equal to the weighted sum of the respective elasticity in each sector:

$$\begin{aligned} \phi_t &= \theta_{G,t}\phi_{G,t} + \theta_{S,t}\phi_{S,t} \\ \pi_t &= \Omega_{G,t}\pi_{G,t} + \Omega_{S,t}\pi_{S,t} \end{aligned} \tag{10}$$

Therefore, now we have four state–space models – two for exports and two for imports – each model consisting of two state and one space equations.

$$\begin{aligned} x_{i,t}^T &= \sigma_{i,t} rer_t + \phi_{i,t} z_t^T + \varepsilon_{x_i,\,t} \\ \sigma_{i,t} &= \sigma_{i,t-1} + \varepsilon_{\sigma_i,\,t} \\ \phi_{i,t} &= \phi_{i,t-1} + \varepsilon_{\phi_i,\,t} \end{aligned} \tag{11}$$

$$\begin{aligned} m_{i,t}^T &= \eta_{i,t} rer_t + \pi_{i,t} y_t^T + \varepsilon_{m_i,\,t} \\ \eta_{i,t} &= \eta_{i,t-1} + \varepsilon_{\eta_i,\,t} \\ \pi_{i,t} &= \pi_{i,t-1} + \varepsilon_{\pi_i,\,t} \end{aligned} \tag{12}$$

where $i = \{G, S\}$. By assessing the multisectoral version of the model, we can provide insights into how policymakers could increase the country's competitiveness and growth rate by supporting the exports of sectors with higher income elasticity. In other words, a more favourable change in the structure of Croatian exports or imports will affect the long-term growth rate in line with the balance-of-payments equilibrium growth rate (Romero and McCombie, 2016, 2018).

Fig. 3 reports the sectoral income elasticities of exports and imports. Our results show that services are more income-elastic than goods,

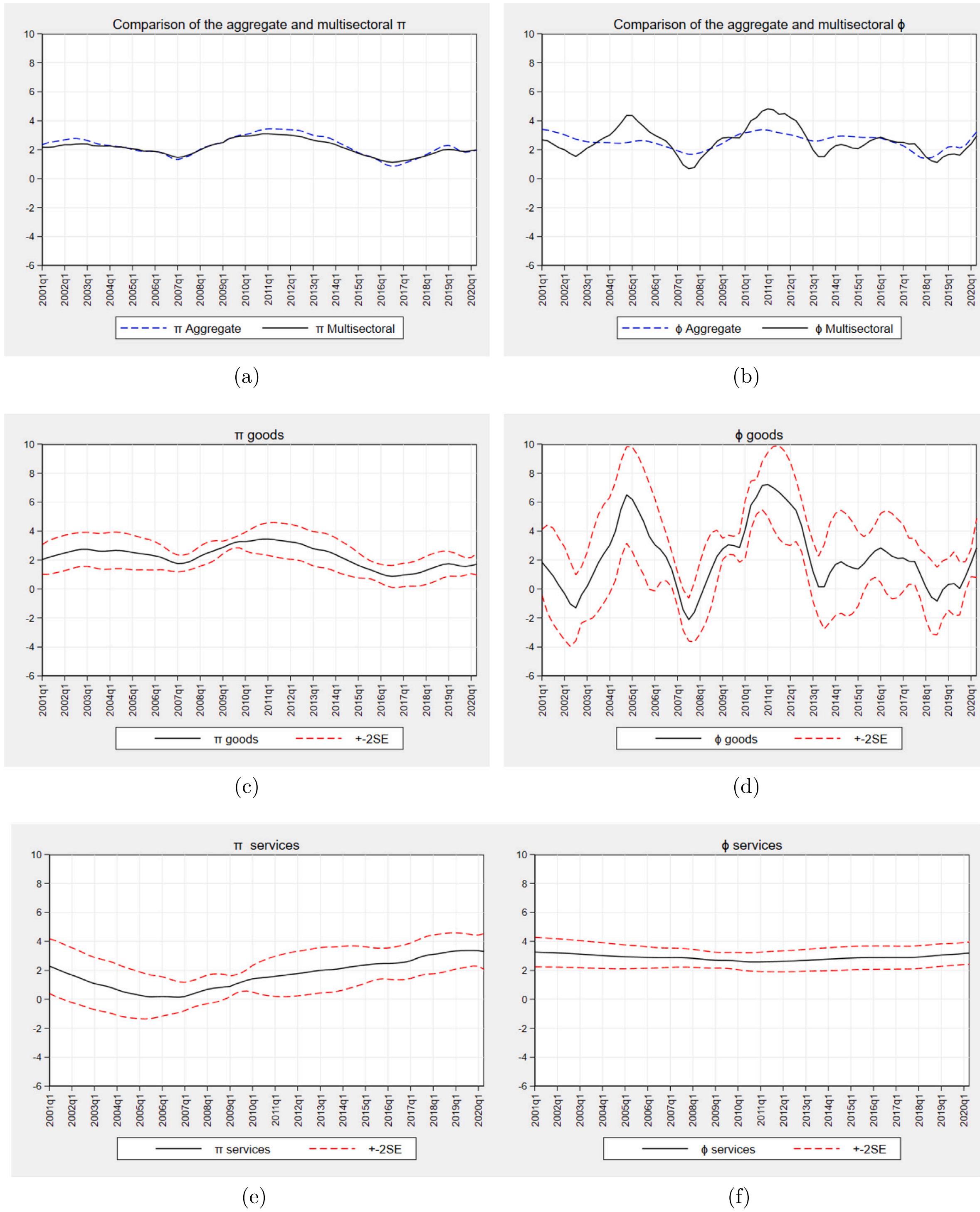
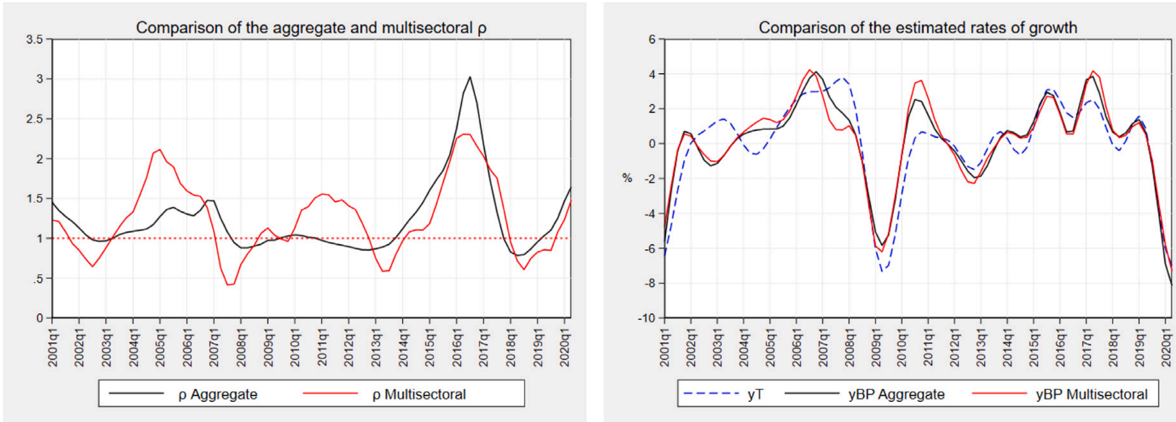


Fig. 3. Time-varying estimates of the sectoral income elasticities of exports and imports.

while exports continue to have a higher income elasticity than imports. Panels (a) and (b) allow us to compare π and ϕ of the aggregate and multisectoral model. Notice that the income elasticity of imports is mainly responding to what happens in the goods sector because the share of services in Croatia's total imports is relatively small. Moreover, the response of imports to changes in domestic income seems more stable than the reaction of exports to foreign demand. Volatility in the latter is much related to the behaviour of goods exports. Panels (c)–(f) show that the income elasticity of imports of goods and services, as well as the elasticity of exports of services, are relatively stable if compared to ϕ of goods. The described trends indicate that the latter underwent several structural changes during the observed period, of which the most significant were joining WTO, CEFTA, the great financial crisis, and finally entering the EU. From panel (d), it is evident that goods' exports shape the dynamics of ϕ, making it more volatile.

Finally, Fig. 4 allows us to compare actual and estimated growth rates. First, on panel (a), we report our estimated non-price competitiveness indicator (ρ) for the aggregate and multisectoral cases. As suggested in our previous discussion, the estimated income elasticity of goods exports introduces significantly more volatility into the system, explaining the higher fluctuations of the continuous black line with respect to the dotted blue one. Still, the ratio between the trade



(a) (b)

Fig. 4. A comparison between filtered and predicted long run rates of growth. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

elasticities fluctuates around one, with two clear accelerating growth periods: the first after the country joined CEFTA in 2003 and the second after joining the EU in 2013. The black line on panel (b) stands for the growth trend (y^T), while the blue and red dotted lines indicate the growth rate compatible with equilibrium in the balance-of-payments. They are very close to one another, highlighting the relevance of the underlying theoretical framework in explaining growth trajectories in this country.

We have argued throughout this paper that ϕ and π reflect deep non-price competitiveness elements of the underlying productive structure. As a major industry in the Croatian economy, there are several channels through which services, in general, and tourism, in particular, may positively impact ρ.[6] Even though traditionally regarded as a low-tech, labour-intensive sector, modern tourism involves a wide range of private and public infrastructure such as airports, harbours, roads, and related high-tech activities, including information and telecommunications (Nowak et al., 2007; Holzner, 2011; Ghalia and Fidermuc, 2015; for empirical tests of the tourism-led growth hypothesis using Croatian data, see Payne and Mervar, 2010). Moreover, the tourism sector has the potential to stimulate other economic activities through direct, indirect, and induced effects. For example, Faber and Gaubert (2019) find that tourism causes large and significant local economic gains relative to less touristic regions, partly driven by positive spillovers on manufacturing. This holds mainly if the industry uses products and services produced within the local economy, thereby providing additional income (Brida et al., 2016; Wickramasinghe and Naranpanawa, 2022).

Of course, there are several potential problems related to the industry or relying on it as an engine of development. Pattullo (2005) documents the contradictions of exploitative tourism with little long-term economic gains and no human or cultural benefits. Along similar lines, Bürgisser and Di Carlo (2023) argue that excessive reliance on international tourism for growth comes with additional severe pitfalls. Tourist-dependent countries are highly vulnerable to exogenous shocks such as the recent outbreak of COVID-19, and the sector continues to rely on precarious seasonal forms of employment. In the next Section, we will return to this point when investigating the determinants of non-price competitiveness. For now, we limit ourselves to documenting the empirical relevance of the multisectoral version of the trade-multiplier.

4.3. *The anchor of long run growth*

While informally showing in Figs. 2 and 4 that the actual long-run growth rate and the one estimated by our model are visually close to each other, a more formal test is required to assess whether this is indeed the case. We aim at testing if deviations from the growth rate compatible with equilibrium in the balance-of-payments are a zero-mean reverting process. Define $Y = y - y_{BP}$. The discussion above is consistent with two testable hypotheses:

- Hypothesis I: Y is a zero-mean stationary process.
- Hypothesis II: y_{BP} does not differ significantly from y^T.

To verify the first condition, we proceed in two steps. First, we show that Y is stationary. As reported in Tables 1 and 2, both the Augmented Dickey–Fuller (ADF) and the non-parametric Phillips–Perron (PP) test reject the null of a unit root, suggesting that series are I(0). Thus, it is possible to conclude that the difference between actual and predicted growth rates reverts to the mean. We continue by estimating the following Autoregressive process:

$$Y_t = \alpha_0 + \sum_{i=1}^{l} \alpha_i Y_{t-i} + \varepsilon_{Y,i}$$

with $l = 1, 2, 3$. As long as

$$H_0 : \ \alpha_0 = 0$$

deviations from y_{BP} have zero-mean. The aggregated and disaggregated version of the model indicate that only the first lag of Y is statistically significant. Altogether, they show that we are dealing with a zero-mean stationary process. The actual growth rate in Croatia tends to be equal, on average, to the one compatible with equilibrium in the balance-of-payments. Short-term divergences between the two rates do not last, neither are they very persistent.

Finally, the last condition is verified by regressing:

$$y_{BP,t} = \beta_0 + \beta_1 y_t^T + \varepsilon_{y,t}$$

under

$$H_0 : \beta_0 = 0, \ \beta_1 = 1$$

If restricted and unrestricted estimates are not significantly different, we conclude y_{BP} is equivalent to y^T. The last part of Tables 1 and 2

[6] Tourism in Croatia includes summer vacations and people looking for health-dental care. The lack of clear and unified definitions of health tourism makes it difficult to include it in tourism statistics. Generally, national statistics fail to accommodate travel to another country for medical care. The European Parliament Committee on Transport and Tourism identifies Croatia as a medical tourism destination (Mainil et al., 2017). Its development was part of the Tourism Development Strategy until 2020 and has been further included in the Sustainable Tourism Development Strategy until 2030 (see Croatian Ministry of Tourism, 2013, 2022).

Table 1
Testing the robustness of aggregate y_{BP} as a centre of gravity.

Hypothesis I: Mean reverting			
Unit root test Y			
ADF		PP	
t	Prob.	Adj.-t	Prob.
−3.449995	0.0121	−3.449995	0.0121
Hypothesis I: Zero-mean			
Dependent variable: Y_t			
Explanatory	OLS	OLS	OLS
Y_{t-1}	0.702693***	0.5080941***	0.568462***
Y_{t-2}	–	0.136628	0.058197
Y_{t-3}	–	–	0.126570
α_0	0.333432	0.297219	0.261141
Hypothesis II			
Dependent variable: $y_{BP,t}$			
Explanatory	Restriction	Restriction	OLS
y_t^T	1	1	0.845402***
β_0	–	0	0.143834
Wald F-stat.	11.18021	6.290154	–

*, **, ***, stand for 10%, 5%, and 1% of significance, respectively.

Table 2
Testing the robustness of multisectoral y_{BP} as a centre of gravity.

Hypothesis I: Mean reverting			
Unit root test Y			
ADF		PP	
t	Prob.	Adj.-t	Prob.
−7.798369	0.0000	−6.909660	0.0000
Hypothesis I: Zero-mean			
Dependent variable: Y_t			
Explanatory	OLS	OLS	OLS
Y_{t-1}	0.723715***	0.619305***	0.613328***
Y_{t-2}	–	0.114342	0.052676
Y_{t-3}	–	–	0.094749
α_0	0.283748	0.252435	0.228707
Hypothesis II			
Dependent variable: $y_{BP,t}$			
Explanatory	Restriction	Restriction	OLS
y_t^T	1	1	0.801137***
β_0	–	0	0.204383
Wald F-stat.	13.79943	7.954126	–

*, **, ***, stand for 10%, 5%, and 1% of significance, respectively.

indicates this is indeed the case. Such a result aligns with the proposition that the balance-of-payments equilibrium condition determines the long-term performance from which economies can deviate only in the short run.

5. Investigating the determinants of non-price competitiveness

An important question remains: what are the determinants of non-price competitiveness? This variable is somewhat equivalent to the so-called "Solow residual", given that it has proven critical to long-run growth but was initially assumed to be exogenous to the model. Our purpose in this Section is to provide an initial assessment of this problem. Finding causal relationships goes beyond the scope of this paper. We group several potential determinants based on theory to document robust correlations. We will regress ρ in $t+1$ against our set of explanatory variables in t to avoid endogeneity through reverse causality. Still, our exercise should not be interpreted in a causal sense but rather as robust associations.

5.1. Estimation strategy

Felipe and Lanzafame (2020) were the first to empirically address the question above by using a state–space model and the Kalman filter to obtain aggregate time-varying estimates of non-price competitiveness in China. In a second step, they applied the Bayesian Model Averaging (BMA) estimator to explain y_{BP} and π. Their findings highlighted the role of structural change, capital accumulation, and the composition of aggregate demand in economic prosperity. Building on their efforts, a useful set-up for investigating the determinants of non-price competitiveness is as follows:

$$\ln \rho_{t+1} = \beta \ln \rho_t + \gamma W_t + \epsilon_t \tag{13}$$

where W stands as a vector of control variables, β and γ are the coefficients associated with the explanatory variables, and ϵ represents the error term.[7] We differentiate ourselves in two ways. First, we focus the analysis on ρ instead of y_{BP}. This is preferable because the former corresponds to a proper measure of catching-up and falling-behind dynamics. Croatia will grow faster or slower than the rest of the world, conditional to this variable being $\gtrless 1$. Second, as reported in Fig. 4, we obtained an aggregate estimate of non-price competitiveness and a multisectoral version differentiating goods and services. They allow us to assess inter- and intra-sectoral dynamics simultaneously to some extent.

While economic theory provides valuable information on the empirical model specification, it offers little guidance about the "true" data-generating process. This fact creates a fundamental problem of model uncertainty, given that it is unclear *a priori* which explanatory variables must be included or which functional forms are appropriate. For instance, excluding a subset of regressors comes with a trade-off between bias and precision. To tackle such an issue, we use the BMA and WALS estimators – developed by Leamer (1978) and Magnus et al. (2010) – based on the implementation package in De Luca and Magnus (2011). These model-averaging techniques provide a coherent way of making inference on the regression parameters by considering the uncertainty due to both the estimation and the model selection steps. The basic idea of BMA is that we need first to estimate the parameters of interest conditional on each model in the model-space, later computing the unconditional estimate as a weighted average of the former. Its key ingredients are the sample likelihood function and the prior distributions on both the regression parameters of the model and the model-space. On the other hand, WALS relies on preliminary orthogonal transformations of the auxiliary regressors and their parameters. It dramatically reduces the computational burden, allowing a more transparent concept of ignorance about the role of the auxiliary regressors (see also Magnus and Durbin, 1999; Danilov and Magnus, 2004).[8]

Prior to applying Bayesian Model Averaging (BMA) and Weighted Average Least Squares (WALS), we undertook several diagnostic tests to ensure the robustness of our subsequent analyses. To examine the stationarity of our time-series data, we employed the Augmented Dickey–Fuller (ADF) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests.

[7] Given that $y_{BP} = \rho z$, the reader might notice some similarities between Eq. (13) and conventional estimations of the so-called growth equation. However, our approach comes with two important differences. First, we are dealing with the growth rate compatible with equilibrium in the balance-of-payments, which was shown to predict actual growth trends quite well. Second, we assess the impact of a set of explanatory variables on non-price competitiveness, as in the dynamic Harrod trade-multiplier.

[8] Based on a classical linear regression framework, these estimators divide explanatory variables into two subsets: focus and auxiliary. The former consists of regressors with solid theoretical support, while the latter corresponds to additional variables whose inclusion is less certain. The number of possible models to be considered equals 2^k, where k is the number of auxiliary regressors. We assume all variables are auxiliary for completeness, resulting in a model-space up to 65536 models.

For identifying unit roots, the ADF test was again applied. Finally, to test for cointegration among the variables, we utilised the Johansen cointegration test. Ensuring the stationarity of our variables and understanding their cointegration relationships are crucial for the validity of our BMA and WALS models. These steps are particularly important as both techniques generally require that the data be stationary to produce unbiased and consistent parameter estimates.

5.2. Data and controls

We select several potential determinants of non-price competitiveness, dividing them into four main groups:

- R&D investments.
- Sectoral composition of the economy.
- Education and demography.
- EU integration and Foreign Direct Investment (FDI).

The importance of R&D for long-run growth has been extensively discussed in the literature and does not require a lengthy explanation. Authors such as Albaladejo and Martínez-García (2015) and Iglesias-Sánchez et al. (2020), in particular, have investigated the role of innovation in the context of a tourist-based economy. R&D efforts allow for the expansion of infrastructure, transportation networks, accommodation facilities, the social media's impact on the profile of tourists, and the variety of attractions can be broadened to increase the tourism carrying capacity. Moreover, innovative efforts are recognised as an explanatory variable of non-price competitiveness in trade-multiplier studies (e.g. Fagerberg, 1988; Cimoli and Porcile, 2014). Here, they are captured by the share of R&D investment in GDP. We further disaggregate this variable between business enterprises, education institutions, and the government. They give us a clearer picture of the differences in the origin of investments to develop and improve new products or services. Data is quarterly and comes from Eurostat.

A long tradition in development economics suggests that the economy's sectoral composition matters for economic performance. This strand of research includes contributions in the balance-of-payments constrained growth literature (see Araújo and Lima, 2007; Araújo, 2013; Gouvêa and Lima, 2013). Some authors, for instance, have made the case that, historically, manufacturing has functioned as the main engine of economic development (e.g. Kaldor, 1966; Szirmai, 2012; Szirmai and Verspagen, 2015), exhibiting strong unconditional convergence in labour productivity (as in Rodrik, 2013). Others have argued that this role corresponds to modern activities such as financial and information industries (Jayaratne and Strahan, 1996; for a critical view, see Stockhammer, 2004). More recently, empirical studies have identified the existence of thresholds for the finance-growth nexus (see Law et al., 2013). We thus include in our regressions the share in GDP of these three sectors and government activities, using quarterly data from CNB. To further control for changes in the composition of capital between tangible and intangible assets (e.g. Pagano, 2014), we introduce the share of intangibles as reported by the Croatian Financial Agency (FINA). In this case, data is annual, and we rely on "low to high" frequency quadratic polynomial interpolation methods to obtain quarterly series.[9]

More conventional approaches have highlighted that human capital and demographic transitions are essential when explaining economic prosperity (Lucas, 1988; Klemp and Weisdorf, 2018). Different measures and indices of human capital have been built over the years. Here we limit ourselves to include the average years of schooling in the population as reported in human development reports by United Nations. Regarding demography, we consider two main dimensions: the young-age dependency ratio (YADR) and the old-age dependency ratio (OADR). The former is the population ages 0–15 divided by the population ages 16–64. The latter follows a similar rationale and takes those above 65 years old over the working-age population. Eurostat reported series are annual; hence, once more, we rely on quadratic polynomial interpolation methods to obtain quarterly data.

As for our last group of controls, we include three variables to capture the role of FDI and the EU integration process to non-price competitiveness. Regarding the latter, we use data from CNB that differentiates between EU funds for current payments (EUCP) and those directed for capital investments (EUK). Funds allocated from the EU are reported in the current or capital accounts. The differentiation between types of transactions is based on the data of the Ministry of Finance. Foreign direct investments include equity capital, reinvested earnings and debt relations between ownership-related residents and non-residents. Direct investments are investments whereby a foreign owner acquires a minimum of 10% interest in the equity capital of a company, regardless of whether a resident invests abroad or a non-resident invests in Croatian residents. It has been argued that FDI is critical to international economic development because it creates stable and long-lasting links between economies. It might also be an essential channel for transferring technology between countries and promoting international trade through access to foreign markets.

Given the existing evidence indicating that the level of the exchange rate influences resource allocation and, thus, might impact non-price competitiveness, especially in developing countries (Rodrik, 2008; for a review, see Demir and Razmi, 2021), we control for this effect including the logarithmic of the real exchange rate (RER) from the CNB. As shown in the previous Section, our estimates of the trade equations already controlled for price effects and the respective price elasticities are not statistically significant. However, we still have to investigate whether there is a development channel from price to non-price competitiveness. It might be helpful to think in the following terms. A more depreciated exchange rate impacts trade because it becomes easier to export and more expensive to import. For example, Rodrik (2008) argues explicitly that if sustained over time, such a depreciation may compensate for problems of asymmetric information and allow for processes of learning-by-doing or learning-by-exporting in developing economies (see also Eichengreen, 2007; Dávila-Fernández and Oreiro, 2023; for empirical evidence on the political economy of RER, see Ugurlu and Razmi, 2023). In this case, quality is expected to improve slowly, and the exchange rate level might influence ρ.

5.3. Estimations and results

A regressor is considered robust if the t ratio > 1 in absolute value or when the posterior inclusion probability (pip) > 0.5. This is roughly equivalent to requiring a ratio of the posterior mean over the standard deviation = 1, which in frequentist statistics implies that the regressor improves the power of the regression (see Masanjala and Papageorgiou, 2008). Following Magnus et al. (2010), we report both BMA and WALS estimates but regard the latter as superior for two main reasons. From a theoretical point of view, it obtains a better risk profile and, in particular, avoids unbounded risk. It is practically superior because the space over which we need to perform model selection increases linearly rather than exponentially.

[9] The quadratic polynomial is formed by taking sets of three adjacent points from the source series and fitting a quadratic. The average of the high-frequency points matches the low-frequency data observed. One point before and one point after the period currently being interpolated provides the three points. The two periods are taken from the one side where data are available for endpoints. This is a purely local method. The resulting interpolation curves are not constrained to be continuous at the boundaries between adjacent periods. Hence, the method is better suited to situations where relatively few data points are being interpolated and the source data is fairly smooth.

Table 3
Determinants of aggregate ρ.

Explanatory	Dependent variable: Non-price competitiveness (aggregate $\ln \rho_{t+1}$)									
	BMA			WALS		BMA			WALS	
	Coef.	t	pip	Coef.	t	Coef.	t	pip	Coef.	t
R&D Tot$_t$	0.4512143	1.53	0.79	0.1680777	0.77	–	–	–	–	–
R&D Buss$_t$	–	–	–	–	–	0.0218518	0.23	0.11	−0.0908556	−0.31
R&D Educ$_t$	–	–	–	–	–	0.0609429	0.31	0.16	0.4819205	1.26
R&D Gov$_t$	–	–	–	–	–	3.658776	2.92	0.96	1.660551	1.13
Manuf$_t$	−0.0106667	−0.58	0.35	−0.0519442	−3.30	−0.0068282	−0.50	0.26	−0.0471896	−2.80
Info$_t$	0.0012109	0.11	0.08	−0.0346131	0.98	0.0003567	0.04	0.07	−0.0339231	−0.96
Finan$_t$	0.0032923	0.18	0.12	−0.0072147	−0.12	0.0010868	0.10	0.08	−0.0212958	−0.39
Gov$_t$	0.003133	0.25	0.14	0.0440369	1.65	0.001414	0.21	0.11	0.0551325	2.02
Intan. Share$_t$	0.0098904	0.49	0.28	0.0440756	1.87	−0.0001237	−0.01	0.10	0.0339674	1.09
Educ$_t$	0.1172111	1.15	0.72	0.3439847	3.04	0.0369685	0.68	0.52	0.3920368	3.23
YADR$_t$	0.0092726	0.15	0.19	0.1971072	2.08	−0.0026381	−0.07	0.26	0.1986147	2.13
OADR$_t$	−0.0435361	−1.33	0.74	−0.0797021	−3.36	−0.0010585	−0.09	0.15	−0.0850811	−2.81
EUK$_t$	0.0062727	0.20	0.13	0.099525	2.10	0.0045255	0.25	0.12	0.1023553	2.27
EUCP$_t$	−0.0012733	−0.06	0.09	−0.0147227	−0.27	0.0019383	0.12	0.09	0.0017337	0.03
FDI$_t$	0.0000209	0.03	0.07	−0.0008037	−0.35	−2.93e−06	−0.01	0.06	−0.002011	−0.87
ln RER$_t$	0.094053	0.14	0.11	−0.9870608	−0.58	0.7123318	0.56	0.31	−1.72822	−0.90
$\ln \rho_t$	0.9386208	24.01	1.00	0.8721317	21.65	0.9892427	24.00	1.00	0.8681643	20.61
Const.	−1.139541	−0.51	1.00	−6.493692	−2.36	−1.781353	−1.01	1.00	−6.802969	−2.55
k_1		1			1		1			1
k_2		14			14		16			16
q		–			1.0000		–			1.0000
c		–			0.6931		–			0.6931
kappa		–			38.7		–			42.3
Model Space		16384			–		65536			–

A regressor is considered robust if the t ratio on its coefficient is greater than one in absolute value or if the posterior inclusion probability (pip) > 0.5.

5.3.1. Aggregate measure of non-price competitiveness

Table 3 reports our findings for the aggregate ρ determinants. Our estimates show that by all means, R&D is the most important explanatory force of non-price competitiveness in Croatia. Research investments over GDP have an elasticity of 0.45 that masks different magnitudes depending on the source of innovation. For example, we do not find a statistically significant coefficient for private innovation investments, contrasting with the government sector, which has an elasticity between 1.66 and 3.65. Furthermore, we found mixed results for innovation in educational institutions. In this case, our estimates differed from zero only in WALS regressions. Croatian R&D as a share of GDP has oscillated between 0.8 to 1%, well below EU standards. At the beginning of the 2000s, the business sector was responsible for 43% of all innovation efforts, followed by universities at 35%, while the remaining 22% was associated with the public sector. After the great financial crisis in 2007, the education share fell continuously, reaching its lowest value in 2016. It has recovered since then, stabilising around 30%. On the other hand, government research efforts peaked in 2012, registering 28% of all R&D investments, falling to around 20% by the end of the series. By 2020, half of all innovation spending came from the private sector.

Moving on to our second block of explanatory variables, we find limited evidence of specific sectors having a determinant role in this dimension of competitiveness. Estimated parameters are not statistically significant in BMA regressions while manufacturing, information, and government are significant in WALS models but with small coefficients. In all cases, the obtained elasticity is lower than |0.05|. Something similar happens concerning the composition of capital between tangent and intangible assets. We can reject the null hypothesis that coefficients are equal to zero only for WALS. Still, the estimated elasticity is relatively small, ranging between 0.03 and 0.04. Even though the share of intangibles has more than doubled from 3% to 7% over the period under analysis, its contribution to non-price competitiveness seems to be minor.

Demography and education are critical variables in explaining ρ. Specifically, an additional year of schooling corresponds to a 0.11 to 0.39% increase in non-price competitiveness. However, ageing appears to negatively impact economic performance, albeit to a smaller extent. Over the two decades analysed, Old-Age Dependency Ratios (OADRs) increased from 24 to 31. Although the effect size is small, it should not be disregarded. According to estimates from the OECD (2023), Croatia's OADR is projected to reach 65 by 2075, a figure comparable to Italy and only ten points below Japan, both well-known ageing countries.

Increases in the Youth Age Dependency Ratio (YADR) are associated with up to 0.19% greater non-price competitiveness. Unfortunately, given Croatia's shrinking population, demographic trends are expected to negatively impact long-term economic performance. This can happen through at least two mechanisms. First, a declining workforce suggests shrinking markets, deterring investment and thereby inhibiting dynamic economies of scale. This leads to decreased labour productivity, which may undermine non-price competitiveness. Second, an older workforce might be less receptive to innovation or the adoption of new technologies, leading to similar detrimental effects on ρ.

Finally, we present some evidence of the positive effects of joining the EU on Croatia. A visual inspection of Fig. 2 shows that between 2013 and 2016, ρ increased from 1 to 3, returning to its initial value by 2018. This period was characterised by Croatia gaining free access to EU markets, inputs and technologies from the union. At least in what concerns our WALS estimates, we find that an increase of 1 percentage point in the funds received from Brussels to capital investment leads to 0.1% higher ρ. The magnitude of the coefficient is moderate but relatively robust throughout WALS estimations, as we will show later on. This result contrasts with the estimated elasticity of EUCP and FDI, both non-statistically significant. Such a result suggests that the European Union has somehow successfully contributed to Croatia's long-run growth through capital projects. On the other hand, we do not find significant effects from relative prices to non-price competitiveness. That is, a more depreciated or appreciated real exchange does not appear as an important factor behind Croatia's economic performance.

5.3.2. Disaggregate measure of non-price competitiveness

We repeat our exercise for our multisectoral version of ρ. Table 4 presents our main findings. While they fundamentally confirm our

Table 4
Determinants of multisectoral ρ.

Explanatory	Dependent variable: Non-price competitiveness (multisectoral $\ln \rho_{t+1}$)									
	BMA			WALS		BMA			WALS	
	Coef.	t	pip	Coef.	t	Coef.	t	pip	Coef.	t
R&D Tot_t	1.289467	2.11	0.91	1.275003	3.61	–	–	–	–	–
R&D $Buss_t$	–	–	–	–	–	0.5567174	0.67	0.43	1.209907	2.26
R&D $Educ_t$	–	–	–	–	–	0.3327062	0.50	0.28	1.951413	3.19
R&D Gov_t	–	–	–	–	–	1.62925	0.72	0.42	−0.1321769	−0.06
$Manuf_t$	−0.0136062	−0.50	0.28	−0.0720673	−2.74	−0.0091899	−0.42	0.22	−0.0744433	−2.83
$Info_t$	−0.0025453	−0.11	0.09	−0.0648508	−1.17	−0.0003265	−0.02	0.07	−0.0706011	−1.34
$Finan_t$	0.1996001	1.31	0.71	0.2719815	2.93	0.061367	0.47	0.25	0.2995833	2.99
Gov_t	−0.0765272	−1.22	0.67	−0.0530771	−1.29	−0.0253217	−0.46	0.25	−0.0397916	−0.85
Intan. $Share_t$	0.0032983	0.15	0.15	−0.0022029	−0.06	0.0065875	0.30	0.16	0.0207775	0.47
$Educ_t$	0.0835823	0.51	0.35	0.5806244	3.21	0.0284237	0.26	0.17	0.6873193	3.65
$YADR_t$	0.0285735	0.24	0.17	0.4688072	2.98	0.0170513	0.20	0.14	0.5169696	3.33
$OADR_t$	−0.0703029	−1.57	0.81	−0.1250459	−3.52	−0.020382	−0.49	0.29	−0.1641247	−3.64
EUK_t	−0.0029588	−0.08	0.11	0.1020273	1.40	−0.0007827	−0.03	0.10	0.1003039	1.35
$EUCP_t$	0.0060046	0.13	0.10	0.0661214	0.69	0.004228	0.11	0.10	0.089252	0.94
FDI_t	−0.0027825	−0.62	0.35	−0.0085307	−2.21	−0.0020956	−0.50	0.26	−0.009652	−2.53
ln RER_t	−0.3219329	−0.20	0.13	−4.43008	−1.58	−0.0888425	−0.07	0.09	−6.78763	−2.20
$\ln \rho_t$	0.9347116	20.60	1.00	0.8753474	21.20	0.9284951	18.89	1.00	0.8602276	20.91
Const.	−0.598293	−0.16	1.00	−12.39821	−2.79	−0.6804094	−0.25	1.00	−12.12143	−2.80
k_1		1		1			1		1	
k_2		14		14			16		16	
q		–		1.0000			–		1.0000	
c		–		0.6931			–		0.6931	
kappa		–		37.4			–		39.6	
Model Space		16384		–			65536		–	

A regressor is considered robust if the t ratio on its coefficient is greater than one in absolute value or if the posterior inclusion probability (pip) > 0.5.

previous insights, this step is necessary to assess their robustness and comes with important novelties. For instance, R&D remains one of the main determinants of non-price competitiveness. The obtained elasticity is significantly higher, around 1.28. This could reflect that we can now capture variation in ρ within and between goods and services. However, the picture becomes blurred when we disaggregate between sources of innovation spending. In all BMA regressions, neither business, education, nor the government delivered significant coefficients. In the WALS case, business and education-related R&D investments appear as major forces, with an elasticity of 1.2 and 1.95, respectively. This highlights that the factors driving competitiveness in goods and services are not uniform and should be considered separately for effective policymaking.

The message we take is that innovation is undoubtedly a crucial force in explaining long-run economic performance in Croatia. Still, private and public actors' separate contributions in this process deserve further reflection. We will come back to this point in our robustness checks. Furthermore, we notice that innovation goes hand in hand with increases in years of schooling. According to our WALS estimates, an additional year at school is related to 0.58 to 0.68% higher non-price competitiveness. A well-educated workforce and investments in innovation are behind the development and differentiation of goods and services. As this process allows for improvements in non-price conditions, firms are better prepared to respond to increases in foreign demand, thus, resulting in higher ρ.

Controlling for differences between trade in goods and services allows us to appreciate the role of the economy's sectoral composition. We want to highlight that finance becomes an important determinant of ρ. An increase of one percentage point of the financial sector on GDP improves from 0.06 to 0.29% non-price related competitiveness attributes. A possible interpretation that these coefficients were not significantly different from zero in the previous case can be related to the nature of tourism activities. The removal of barriers to travel, including the easing of entry requirements and the adoption of open skies policies, are directly related to the expansions of a financial structure capable of accommodating supply and demand for travel. Such effects became visible once we allowed differentiation between goods and services in our non-price competitiveness indicator. Demographic variables continue to be an essential force driving ρ. Compared to the aggregate case, YADR and OADR show more substantial effects. For instance, we document that a one-point increase in the old-age dependency ratio might reduce long-term economic performance by up to 0.16%. At the same time, a similar rise in the YADR is related to an improvement of 0.51% in non-price conditions.

Last but not least, WALS regressions confirm that entering the EU was followed by an enhancement of long-term economic performance. An increase of one percentage point of EU funds allocated to capital investment increased our indicator of non-price competitiveness by 0.1%. Still, such a result is not robust to the BMA estimator. Moreover, we do not find support for the idea that a more depreciated RER can foster long-run growth, at least not through the channel investigated in this Section. On the contrary, in our multisectoral setup, WALS regressions indicate that the effect is strongly negative. Such a result makes sense considering that Croatia imports technology from the EU while can freely export inside the union. A more depreciated RER implies accessing modern production techniques would become more expensive for Croatian enterprises and that this effect so far has more than compensated benefits from export channels.

Overall, the picture that emerges from our analysis is: Since the 2000s, the trajectory of the growth rate compatible with equilibrium in the balance-of-payments has been primarily influenced by the dynamics of innovation investments, educational institutions, and demography. As direct determinants of the productive structure, these variables have affected Croatia's long-run rate of growth through non-price competitiveness as captured by the ratio between the income elasticity of exports and imports.

5.4. Robustness checks

By estimating a set of BMA and WALS models of Eq. (13), we identified R&D investment, human capital accumulation, and demography as the most critical determinants of non-price competitiveness in Croatia.

Table 5
Determinants of aggregate ρ.

Explanatory	Dependent variable: Aggregate $\ln \rho_{t+1}$									
	Simple					Five-year moving average				
	BMA			WALS		BMA			WALS	
	Coef.	t	pip	Coef.	t	Coef.	t	pip	Coef.	t
R&D Buss$_t$	0.0626079	0.20	1.00	−0.0896068	−0.28	−0.9223327	−5.43	1.00	−0.8014096	−4.02
R&D Educ$_t$	0.7419675	2.04	1.00	0.797316	2.00	0.507156	3.32	1.00	0.5190757	2.30
R&D Gov$_t$	3.077719	2.62	1.00	1.95093	1.32	3.483126	5.31	1.00	2.546711	2.42
Educ$_t$	0.1992263	1.99	1.00	0.3967105	3.41	0.2802667	6.21	1.00	0.3473277	3.15
OADR$_t$	−0.0648974	−2.52	1.00	−0.098299	−3.18	−0.1322945	−5.42	1.00	−0.1491641	−4.21
EUK$_t$	0.0781736	1.52	1.00	0.114832	2.19	0.3241269	5.24	1.00	0.3651382	5.24
$\ln \rho_t$	0.9498073	23.48	1.00	0.9227724	21.62	0.8659321	20.26	1.00	0.8644468	20.70
Manuf$_t$	−0.0209669	−0.90	0.56	−0.0451359	−2.85	−0.024317	−1.96	0.90	−0.0348825	−2.57
Info$_t$	−0.0004694	−0.04	0.11	−0.0197621	−0.61	−0.0038271	−0.26	0.15	−0.0278766	−0.97
Finan$_t$	0.0062215	0.25	0.19	−0.0120473	−0.20	−0.1084022	−2.44	0.92	−0.0797639	−2.00
Gov$_t$	0.0122562	0.64	0.40	0.0499309	1.73	0.0492341	2.48	0.93	0.0543522	1.94
Intan. Share$_t$	0.0013067	0.11	0.12	0.0249499	0.81	−0.0002466	−0.03	0.13	0.0204379	0.97
YADR$_t$	0.0375176	0.46	0.28	0.1827993	2.03	0.0075209	0.23	0.16	0.0639667	0.90
EUCP$_t$	0.0015237	0.07	0.10	0.0223988	0.43	−0.0013918	−0.04	0.10	−0.0559421	−0.55
FDI$_t$	0.0000273	0.04	0.10	−0.0008841	−0.46	0.0017112	0.63	0.37	0.0024039	0.94
ln RER$_t$	−0.1176065	−0.13	0.14	−2.255241	−1.20	0.0625054	0.08	0.18	−0.3646789	−0.23
Const.	−2.643814	−1.01	1.00	−5.867409	−2.36	−0.9946815	−0.78	1.00	−2.351327	−1.21
k_1		8		8			8		8	
k_2		9		9			9		9	
q		–		1.0000			–		1.0000	
c		–		0.6931			–		0.6931	
kappa		–		6.9			–		15.2	
Model Space		512		–			512		–	

A regressor is considered robust if the t ratio on its coefficient is greater than one in absolute value or if the posterior inclusion probability (pip) > 0.5.

In this subsection, we aim to check the robustness of such results. This step is done in two different ways. First, our initial assessment does not differentiate between *focus* and *auxiliary* variables. The former consists of regressors with solid theoretical support, while the latter corresponds to those with less certain inclusion. The choice of excluding subsets of auxiliary variables is motivated by a trade-off between bias and precision (see Danilov and Magnus, 2004; De Luca and Magnus, 2011). We initially assumed all auxiliary to avoid our priors from influencing the outcome. However, using our results from Tables 3 and 4, we can give one step forward and explicitly differentiate two groups: R&D, Educ, OADR, EUK and $ln\rho$ are taken as focus regressors while the remaining continue to be auxiliary. The inclusion of EU capital investments is justified by our particular interest in Croatia's economic performance in the context of European integration.

As a second robustness check, we notice that the variations in non-price competitiveness are slow-motion processes regarding long-run dynamics. Given the nature of our data, we should not expect major effects to happen from one quarter to another. Hence, we also compute the five-year moving average of the correspondent time-series and re-estimate the model. Results are reported in Tables 5 and 6 for the aggregate and multisectoral cases, respectively. For variables in the focus group, we should look only at the t ratio for statistical significance, given that pip is always equal to one. While we believe the central message of our exercise is preserved, some interesting new features emerge. For instance, in all scenarios, R&D related to education positively and significantly impact non-price competitiveness. The elasticity varies from 0.5 to 3.25, the largest among the variables in our sample.

On the other hand, government innovation efforts lose significance as we move to the multisectoral scenario that removes short-term fluctuations in the underlying data. Moreover, the elasticity of business R&D becomes either insignificant or negative. To us, it seems relatively clear that universities and education-related innovation centres play a significant role in the long-run economic performance of the country. Overall, estimated coefficients for business and government R&D are very sensitive to model selection. This fact might result from the limited collaboration among the network of Croatian companies (Raguž and Mehičić, 2017). Švarc (2006) argues that Croatia failed to capitalise on its inherited Yugoslav science base. It has not shifted from a socialist-style science policy to a modern one based on close collaboration between private and public sectors. Furthermore, there is some evidence suggesting the high intensity of financial constraints on business innovation activity (see Božić and Rajh, 2016). Further research on the topic is to be encouraged. Here we limit ourselves to pointing out that R&D investments as a share of GDP are a consistent and significant variable in explaining long-run growth in Croatia through a channel that has not been explored before in the literature: the trade multiplier.

Years of schooling continue to be a fundamental determinant of ρ. Concentrating on the estimates using a five-year moving average means that an extra year of schooling increases competitiveness by 0.3 to 0.5%. EU continues to make an essential contribution to long-run growth, with a coefficient varying between 0.5, in the aggregate, case to 0.1 when we differentiate between goods and services. Moreover, we would like to highlight the marked negative impact of ageing. An increase of one unit of the OADR is related to a reduction between 0.15 and 0.2% in growth through non-price competitiveness. This result is a major worrying reason for the country given that current demographic trends indicate Croatia's old-age dependency ratio could increase 20 points in the next thirty years, while the population is expected to shrink to 3.1 million by 2050, after reaching its peak of 4.7 million in 1991, according to Eurostat. Finally, the kappa value significantly drops from 37–42 intervals to 6–15. A considerable value of κ suggests parameters are prone to significant numerical errors. Hence, its reduction confirms an improvement in the quality of our last estimates.

5.5. Policy implications

To unpack our complex academic findings, we would like to offer a more layman's explanation to make results more accessible. The first big takeaway regards the role of R&D. When Croatia invests in new ideas and technologies, it becomes more competitive without lowering prices. Moreover, it matters who is doing this research. When the government appears as a critical player in the landscape, the impact

Table 6
Determinants of multisectoral ρ.

Explanatory	Dependent variable: Multisectoral $\ln \rho_{t+1}$									
	Simple					Five-year moving average				
	BMA			WALS		BMA			WALS	
	Coef.	t	pip	Coef.	t	Coef.	t	pip	Coef.	t
R&D Buss$_t$	1.392455	2.21	1.00	1.244056	2.27	0.1871999	0.53	1.00	0.1940053	0.52
R&D Educ$_t$	2.195576	2.74	1.00	2.20168	3.14	3.258273	7.45	1.00	2.969112	6.74
R&D Gov$_t$	−0.3826567	−0.17	1.00	−0.2838649	−0.12	−0.0597566	−0.03	1.00	−0.1292665	−0.08
Educ$_t$	0.6463173	1.99	1.00	0.7572293	4.08	0.4605805	2.35	1.00	0.5594721	3.29
OADR$_t$	−0.1699096	−3.00	1.00	−0.1814587	−3.78	−0.1855779	−3.16	1.00	−0.1905794	−3.44
EUK$_t$	0.0958581	1.00	1.00	0.0932772	1.10	0.1106645	0.88	1.00	0.1126577	0.93
$\ln \rho_t$	0.9217643	21.01	1.00	0.9188998	21.99	0.8163302	26.66	1.00	0.8323113	25.81
Manuf$_t$	−0.0758243	−1.66	0.82	−0.0781027	−2.96	0.04213	1.45	0.74	0.0122047	0.49
Info$_t$	−0.0096206	−0.28	0.16	−0.0672778	−1.24	−0.0083406	−0.25	0.16	−0.0589349	−1.03
Finan$_t$	0.2459939	2.06	0.91	0.2716205	2.88	0.2720948	3.96	1.00	0.258884	3.71
Gov$_t$	−0.0311805	−0.57	0.34	−0.0190761	−0.44	0.0009362	0.04	0.19	0.0202827	0.52
Intan. Share$_t$	0.0065958	0.24	0.15	0.0137052	0.28	0.0307506	0.72	0.42	0.0537825	1.48
YADR$_t$	0.4341158	1.55	0.79	0.5222237	3.39	0.1226741	0.68	0.41	0.222964	1.52
EUCP$_t$	0.024313	0.34	0.18	0.0990462	0.98	0.033421	0.27	0.16	0.0590813	0.26
FDI$_t$	−0.0063311	−1.16	0.67	−0.0077496	−2.29	−0.0209023	−3.11	0.98	−0.0196569	−3.23
ln RER$_t$	−7.03156	−1.35	0.73	−8.150289	−2.51	−5.50918	−2.54	0.96	−5.977423	−2.70
Const.	−9.320883	−1.39	1.00	−11.69121	−2.64	−2.461501	−0.49	1.00	−5.262335	−1.22
k_1		8		8			8		8	
k_2		9		9			9		9	
q		–		1.0000			–		1.0000	
c		–		0.6931			–		0.6931	
kappa		–		6.1			–		15.6	
Model Space		512		–			512		–	

A regressor is considered robust if the t ratio on its coefficient is greater than one in absolute value or if the posterior inclusion probability (pip) > 0.5.

in many scenarios is greater than private investments. Educational institutions have a bit of a mixed record here. These findings suggest that Croatia could improve its competitiveness significantly by investing more in R&D, especially since it lags behind the European Union in this regard. Surprisingly, specific industries like manufacturing and information technology do not seem to play a decisive role in making the country more qualitatively competitive. Dwelling on patents and copyrights, often called "intangible assets" suggests relevant effects, but their impact on competitiveness is small.

Moving to demographics, the more educated the population, the better Croatia does in the global market. One more year of schooling can boost the country's competitiveness by a noticeable margin. Still, there is a downside: an ageing population is bad news. As the country ages, it could become less competitive, a trend that needs careful attention considering projections for the future. Young people bring zest and new ideas, and our findings suggest that a younger population could make Croatia more competitive. Given that its population is shrinking, our findings suggest this could become a stumbling block for future economic growth.

Disaggregating innovative efforts between businesses, educational institutions, and the government reveals they play varied roles in driving this innovation-based competitiveness. The key takeaway is that one-size-fits-all policies may not work. The needs of the goods and services sectors can be quite different. Another standout finding is how pivotal education is. The more educated people are, the more competitive Croatia becomes. Imagine this as setting the stage for companies to compete better globally because they have smarter strategies and better quality rather than just lower prices. When it comes to the population's age, the impact on economic performance becomes even more pronounced in this deeper analysis. An ageing population can set economic performance back, while a younger one can give it a serious boost.

Becoming part of the European Union seems to have given Croatia a good bump in competitiveness, particularly when the EU funds are directed toward capital projects. This offers promising avenues for leveraging EU membership for future growth. Finally, our findings do not support that Croatia's currency matters much for its non-price competitiveness. The result is consistent with evidence suggesting Croatia is a net technology importer from the EU. A weaker currency means these imports become more expensive, potentially offsetting any gains from being able to export more cheaply. In a nutshell, if Croatia wants to be more competitive, instead of just making things cheaper, it should focus on government-led innovation, improve education, and pay attention to demographic trends, especially the age of its population.

In this more nuanced look, finance emerges as a significant player in boosting competitiveness, which was not apparent before. Think of this as the financial infrastructure that supports things like tourism, which becomes visible when we separate goods from services. Our refined analysis supports that being part of the European Union is generally good for Croatia's long-term economic health. However, the way these benefits manifest can be complex and is not consistently observed across all the methods we used for analysis.

6. Conclusions

This paper argued that Croatia's growth over the past twenty years is deeply related to what is bought and sold in international markets. Taking the dynamic Harrod trade-multiplier as the starting point, we applied the Kalman filter and state–space estimation methods to obtain time-varying parameters of the respective trade equations. As a result, we showed that the growth rate compatible with equilibrium in the balance-of-payments is a good predictor of Croatia's long-run growth rate. Furthermore, disaggregating exports and imports between goods and services allowed us to have a more precise measure of the income elasticities, which we showed could be interpreted as capturing the non-price competitiveness of the country.

Employing a set of BMA and WALS estimation techniques, we investigated the determinants of the ratio between the income elasticities of exports and imports, as obtained in the first part of the paper. We show that R&D investment as a proportion of GDP and human capital accumulation are the most important driving forces. Policymakers should not underestimate the importance of innovation efforts for economic prosperity. Demographic variables also play a

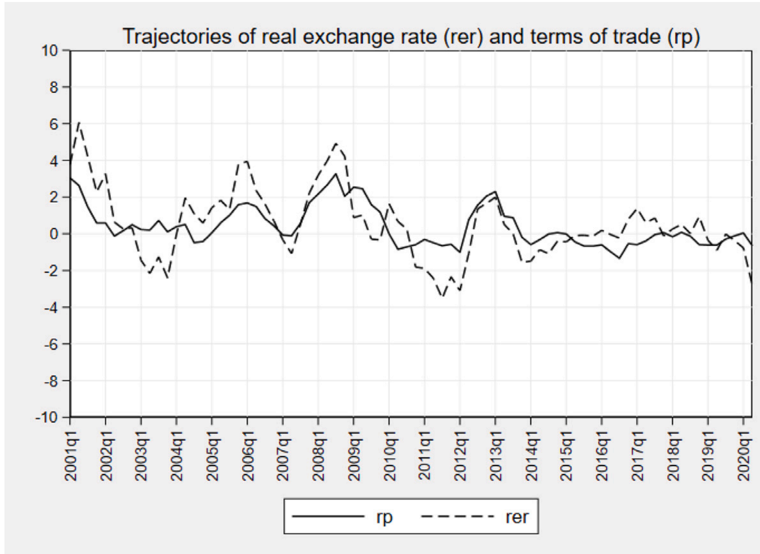


Fig. A.1. Real exchange rate (*rer*) *vs* terms-of-trade (*rp*).

relevant role in explaining the country's long-run economic performance. We innovatively explored an alternative channel through which those variables might affect long-run economic growth. The experience of several transition and developing countries suggests the existence of a limit to current-account imbalances beyond which the rate of growth of output must adjust to international liquidity conditions. We showed that Croatia's economic growth depends on how its productive structure responds to foreign and domestic demand changes. As income increases, economic decisions are increasingly influenced by quality, technological superiority and advanced services.

Croatia has been growing significantly faster than the rest of the EU, despite the adverse effects of the 2007 financial crisis, the European debt crisis, and the COVID-19 outbreak. The ratio between domestic to EU per capita output increased from 0.45 in 1995 to 0.65 in 2020. Overall, our findings confirm some catching up in living standards with the other members of the union. Still, averages hide significant time variations. We document two critical moments in this process. After the country joined CEFTA in 2003, we observed an increase a surge in growth that persisted until the great financial crisis in 2008. With the accession to the EU in 2013, there was again a significant increase in non-price competitiveness, pointing to the positive effects of having free access to EU markets. However, in both cases, growth rates returned to the average after some years, suggesting that convergence is not continuous.

If Croatia continues its catching-up process in the EU, it is crucial to develop domestic learning capabilities. Action includes rising overall educational levels and the interaction between firms and universities. Current R&D expenditures as a proportion of GDP are far below the 2% European average. The present paper identified that such an investment comes with high returns regarding non-price competitiveness that have not been fully realised or implemented. Each year that Croatia lags behind the R&D investment efforts and human capital accumulation of other nations, the longer it might take to close the income differences with the other EU members. Therefore, cooperation between academia and business should be prioritised and the process of demographic transition cannot be neglected.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Data availability

Eviews and Stata Workfiles available as Supplementary Material.

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Appendix A. Appendices

A.1. From the static to the dynamic trade-multiplier

What determines a country's growth rate and why countries grow at different rates has always been a central issue in economics. More traditional approaches have focused on the availability of resources and the supply of factors for production.

When it comes to economies that trade in foreign currency, the so-called trade-multiplier posits an additional mechanism that explores the interaction between demand and supply constraints relating them to international specialisation patterns.

Croatia fits well this last framework given that during the period of our analysis it used domestically the Kuna but traded mainly in US dollars or Euros.

The static version of the model was initially proposed by Harrod (1933), and can be easily derived from a trade balance condition:

$$X = M \tag{A.14}$$

and a simple relationship describing the behaviour of imports (M), such that:

$$M = mY \tag{A.15}$$

where X are exports, Y stands for output, while m is the marginal propensity to import. Substituting Eq. (A.15) into (A.14) and rearranging, we have that:

$$Y = \frac{X}{m} \tag{A.16}$$

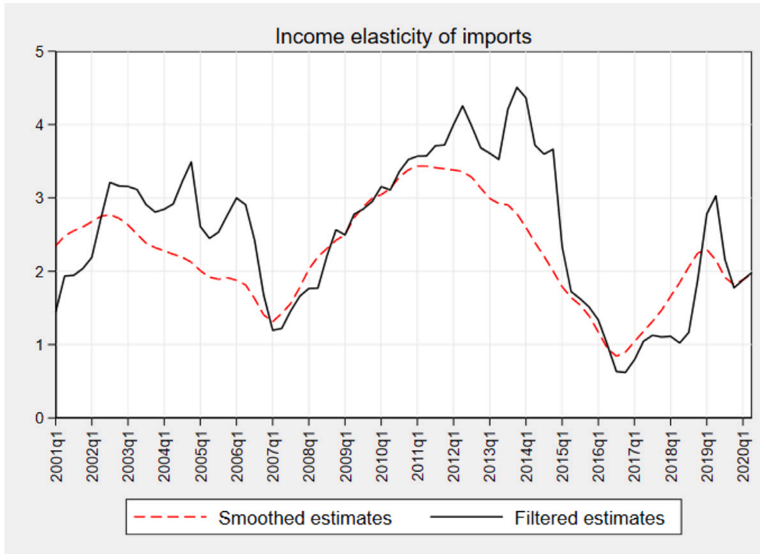


Fig. A.2. Filtered *vs* smoothed values of the income elasticity of imports.

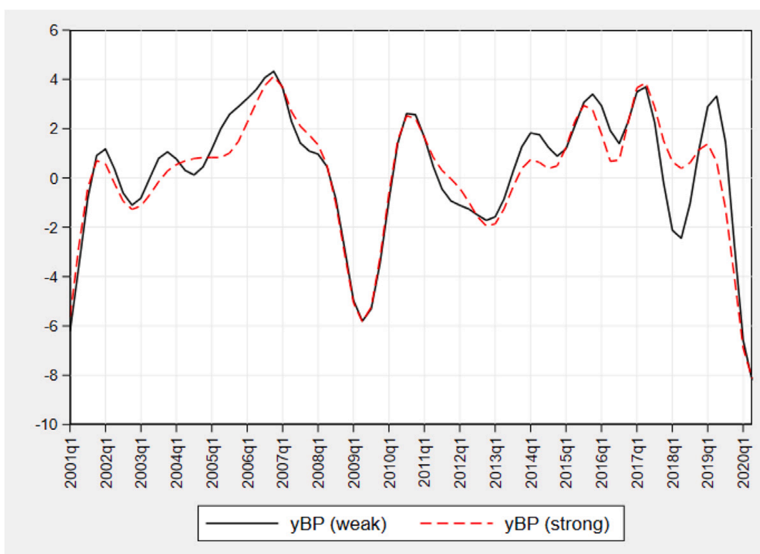


Fig. A.3. A comparison of projected values of y_{BP} obtained by the *weak* and *strong* tests of Thirlwall's law.

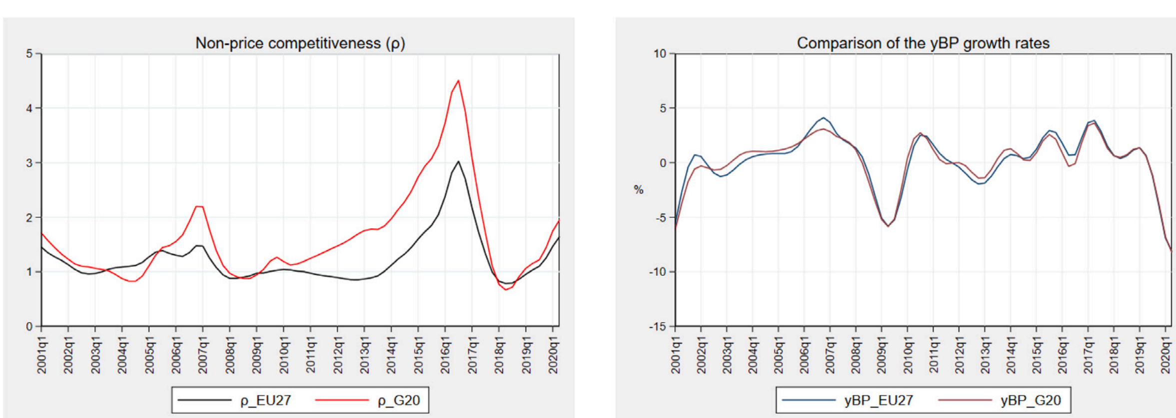
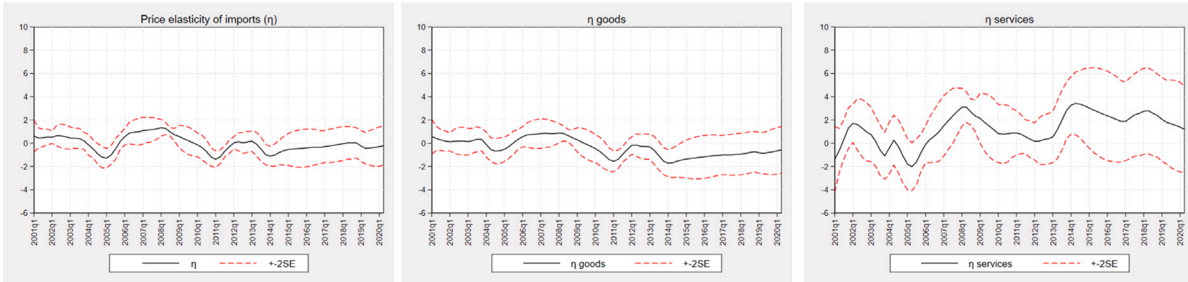
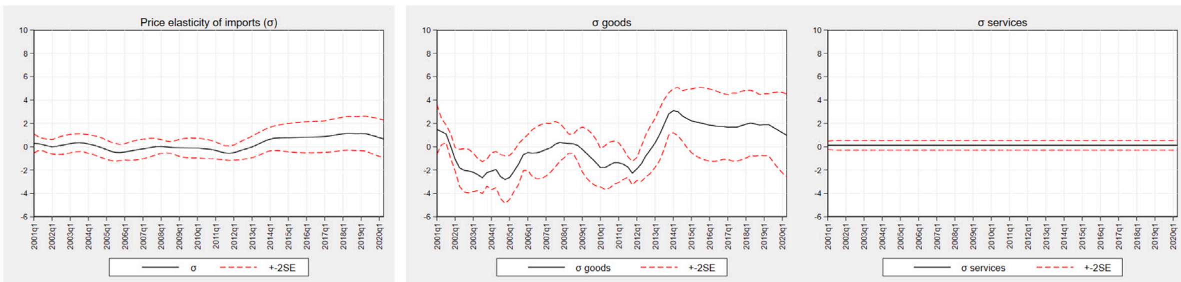


Fig. A.4. A comparison of ρ and y_{BP} obtained using EU vs G20 output in the export equation.



(a)



(b)

Fig. A.5. Estimated aggregate and sectoral price elasticities of (a) imports and (b) exports.

i.e. the trade-multiplier. The level of output compatible with equilibrium in trade – which in this case works as a *proxy* of the balance-of-payments – is equal to the level of exports divided by the marginal propensity to import.

The dynamic version of the model is derived from a generalisation of Eq. (A.15). Let us rewrite it as:

$$M = M(Y) \quad (A.17)$$

such that increases in output are related to higher demand, leading as a result to higher imports. Substituting this function into Eq. (A.14), equilibrium in the current account now requires:

$$X = M(Y) \quad (A.18)$$

Taking log derivatives of the expression above and rearranging, we obtain:

$$y = \frac{x}{\pi} \quad (A.19)$$

where y and x correspond to the rate of growth of output and exports, respectively, and $\pi = (\partial M/\partial Y)(Y/M)$ is the income elasticity of imports.

If instead, we assume exports depend on the level of output of the rest of the world (Z), that is:

$$X = X(Z) \quad (A.20)$$

it is not difficult to see that the rate of growth compatible with equilibrium in the balance-of-payments becomes:

$$y = \rho z \quad (A.21)$$

where $\rho = \phi/\pi$ and $\phi = (\partial X/\partial Z)(Z/X)$ is the income elasticity of exports. Growing faster than this rate would imply increasing balance-of-payments imbalances that are not sustainable in the long run. In Thirlwall (1979), Eq. (A.19) is referred to as the *weak* version of the multiplier while (A.21) stands for its *strong* formulation.

A.2. Real exchange rate and the terms-of-trade

Macroeconomic manuals usually present exports and imports as a function of exchange rates. The latter corresponds to the value of one country's currency in relation to another currency. Still, a critical reader may ask whether the terms-of-trade, i.e. the relative price of exports in terms of imports, is a more appropriate concept when measuring price competitiveness in international markets. The latter is defined as the ratio of export prices to import prices. It can be interpreted as the amount of import goods an economy can purchase per unit of export goods. Fig. A.1 reports the two series in Croatia from the 2000s. It shows that they have moved together over time. This fact justifies our choice to work with the commonly used and intuitive rer.

A.3. Filtered vs. smoothed estimated values of income elasticities

The values of the "state" variables can be estimated using the Kalman filter or the Kalman smoother. The most crucial difference between them is that, when using the filter, the recursive estimation of the state moves forward through the data while, with the smoother, the state moves backwards. Hence, the Kalman smoother uses all the information in the sample to calculate smooth estimates. On the other hand, the Kalman filter produces values that contain a variation component obtained using the "learning" method, instead of actual time variations in the behaviour of the economy (for a detailed assessment, the reader is invited to see Sims, 2001). Therefore, smooth estimates of component values – trend and cycle, seasonally adjusted – are more useful for visualisation and understanding. We report in Fig. A.2 an example of the two series for the income elasticity of imports. The dotted red line corresponds to the smoothed estimates, while the continuous black line stands for the filtered one. They confirm our previous discussion and justify our choice of working with the first of them.

A.4. Weak vs strong versions and the estimation of the exports equation

A distinction can be drawn between the dynamic trade-multiplier's "weak" and "strong" versions. From an initial balance-of-payments in equilibrium and assuming no change in relative prices, a country's balance-of-payments growth rate can be determined by the ratio of income elasticities multiplied by the growth rate of world income, i.e. the *strong* form of the model predicts that the country's growth rate will be:

$$y_{BP} = \frac{\phi}{\pi} z \quad (A.22)$$

Such a specification supposes that exports respond to foreign demand as in (3). When relative prices do not change, x is equal to the respective income elasticity multiplied by the rate of growth of the rest of the world.

Alternatively, we might choose not to specify a function for x. In this case, it immediately follows that:

$$y_{BP} = \frac{x}{\pi} \tag{A.23}$$

that stands as the *weak* form of the model. As a robustness check, we compare the estimation of both versions of the multiplier in the aggregate case. Fig. A.3 shows how the growth rate compatible with equilibrium in the balance-of-payments varies over time. Differences between the two suggest, among other things, that relative prices might have changed during that period. Still, we can see that such deviations are minimal and that relative prices did not significantly affect y_{BP}.

The reader might also wonder about the robustness of our results regarding the choice of variable z in the exports equation. Our estimates of the income elasticity of exports crucially depend on it. Most of our estimates use the EU 27 GDP, as approximately 70% of Croatia's trade happens within the European Union. As an alternative, we explore the possibility of using the output of the Group of 20 (G20). The G20 comprises most of the world's largest economies, including industrialised and developing countries, accounting for around 80% of global output and 75% of international trade. Given the frequency of our dataset, we make use of the Quarterly real GDP growth reported by the OECD. Fig. A.4 confirms the validity of Thirlwall's law. The panel on the left compares our indicator of non-price competitiveness in both scenarios. While the main trajectories are maintained, there is a difference in levels related to G20 economies growing faster than the EU over the period. Still, the diagram on the right shows that differences in the estimated y_{BP} are neglectable.

A.5. Price elasticities of exports and imports

We report in Fig. A.5 the estimated price elasticities and their confidence interval at 5%. It is possible to observe that they fluctuate around zero. The three panels in (a) correspond to the aggregated and disaggregated imports, while in (b), we have the correspondent elasticities for exports. Our findings confirm one of the central insights of the trade-multiplier: the role of price competitiveness in determining exports and imports is only minor. Results when we estimate aggregate and disaggregated trade equations are fundamentally the same. In the second case, we obtain more volatility, with price elasticity being more stable when not differentiating between goods and services. Still, considering that the exchange rate has been relatively stable in Croatia over the past two decades, it is safe to focus our analysis on non-price factors as the primary determinant of trade in the country.

Appendix B. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.strueco.2023.10.018.

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