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Does value chain integration dampen producer price developments? Evidence from the European Union

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22/2020 July

This project has received funding from the European Union Horizon 2020 Research and Innovation action under grant agreement No 822781

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This is a draft version. The final paper will be published in a forthcoming issue of The World Economy.

June 2020

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Abstract

We draw on trade theory to empirically explore the effects of value chain integration on producer price dynamics. Using the EU as an example of an integrated area, we construct measures of backward and forward linkages with intra- and extra-EU trading partners at the country-sector level. We find that especially upstream integration and EU-accession dampen inflation. The results for downstream integration indicate a price-increasing relationship. We propose novel EU integration indicators and offer insights to both theory and applied research. We also add to the policy debate on the price effects of (dis-)integration of EU countries.

Keywords: inflation; EU integration; Single Market; producer prices; value chains

JEL: E31, F15, O52

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1 INTRODUCTION

Economic integration, in particular through value chain trade, should help cutting prices. Prices of goods and services should fall because of increased competition and a more efficient allocation of resources in an integrated economic area (Melitz & Ottaviano, 2008). In addition, increased market integration is thought to lead to a decoupling of domestic demand and production capacity, thereby limiting the possibility that inflation rises as domestic demand builds up (Goldberg and Verboven 2005, Dexter, Levi, and Nault 2005).

This paper sets out to test this conjecture. It uses the Single Market of the EU as an example of an economically integrated area. We study value chains acting as transmission channels through which Single Market integration affects producer prices at the sector level. We use a novel set of indicators to capture different aspects of value chain trade integration. The analysis controls for other layers of integration: Eurozone membership and the effect of EU accession. These capture additional legal and institutional aspects of market integration. Hence, the paper empirically extends previous research, which either focused on inputs, such as raw materials, or differences between broadly defined sectors such as tradables and nontradables.

The contribution to the literature is threefold:

First, the paper establishes an empirical link between the cumulated effects of trade integration along value chains and producer price dynamics. Trade theory predicts that greater trade openness is accompanied by falling prices (Melitz and Ottaviano 2008). This would imply that economic integration goes also along with lower inflation rates. Recent theorising and empirical analyses of trade have explained firm level price dynamics either through firm productivity on the supply-side (Luttmer, 2007; Melitz, 2003) or final consumer preferences on the demand side (Foster & Potts, 2006). While there is some evidence for a few countries that trade openness reduces prices (Chen, 2009), little is known on how such direct effects cumulate along value chains. The accession to a large common market triggers a restructuring of supply relations and changes preferences, which we use in this paper to study this underexposed aspect of market integration. The analysis distinguishes between forward and backward integration and also controls for possible endogeneity issues with respect to EU-accession. Hence, the results contribute to the development of a better understanding of the impact of market integration on macroeconomic price dynamics (Angeloni et al., 2006).

Second, we address the issue of quantifying value chain integration, thus contributing to the toolset of applied economic research. We explicitly consider both upstream and downstream effects over the value chain. In upstream relationships, prices are determined by prices of inputs incorporated in production. In downstream relationships, prices may be affected by complementarities between inputs or non-constant returns to scale. Our analysis considers both channels. We draw on the World Input-Output Database (WIOD) to construct measures of both backward and forward linkages at the country-sector level for the period 2000-2014. This allows for a nuanced discussion of the effects of integration on producer prices. In addition, we control for EU-accession, which affects institutions as well as policy decisions and joining the Eurozone, which implies entering a pegged exchange rate regime. Thus, we propose a comprehensive, novel and easily reproducible set of EU market integration indicators.

Third, this paper is policy relevant. One of the arguably biggest achievements of the EU is the establishment of the Single Market, which it defines as '[…] *one territory without any internal borders or other regulatory obstacles to the free movement of goods and services. A functioning Single Market stimulates competition and trade, improves efficiency, raises quality, and helps cut prices.* […]' (Cit. DG Growth).[1] Yet, an empirical test that market integration helps cutting prices is yet lacking, even though this question is highly relevant for the debate about economic integration and value chain trade (dis-)integration processes.

2 PRODUCER PRICES, TRADE AND MARKET INTEGRATION IN THE EU

Theory predicts a negative effect of trade on prices. As markets become bigger and product variety and the number of firms increases, competition rises, and firms gain lower mark-ups. Increasing market efficiency implies a dampening effect on prices (Melitz & Ottaviano, 2008).

A first descriptive analyses of producer price inflation hints at significant heterogeneity between sector types and countries. Starting with sector specific price indices Figure 1 splits the economy into broadly defined nontradable and tradable sectors (Sachs and Larraine 1993; see Annex). The main benefits of the Single Market unfold through the trade of commodities. If market integration indeed has a taming effect on producer price inflation, one would expect that in economies in which the tradeable sector has a larger share in value added producer price inflation should be lower. However, the data show heterogeneous price developments across countries and sectors (see also Annex). Price increases tend to be higher in CEE countries than in Core European or countries in Southern Europe. The price developments of tradables and nontradables are remarkably similar in the bulk of countries of the sample. However, especially in Finland, Romania, Latvia, Slovakia and the Czech Republic the producer prices of nontradables seem to increase faster than in tradables.[2]

Figure 1 about here

At a first glance, the data shows that the relationship between market integration and price dynamics is less straightforward than suggested by stylised theory. It is influenced by several factors that need to be considered in the analysis of trade integration and producer price dynamics. Even though price increases in the nontradable sector seem to be higher, no systematic pattern of the magnitude of price differentials arises. We observe considerable heterogeneity across countries. Price increases have been higher in the New Member States that have accessed the EU later. One may expect that these countries are not yet as well integrated in the Common Market

[1] See https://ec.europa.eu/growth/single-market_en (accessed on 28 June 2019).

[2] The price indices have been calculated in a stepwise procedure. First, we define deterministic industry weights, and calculate the share of tradables and nontradables for the entire period analysed (2000-2014). The total deflated value added produced by each sector is computed and then weighted by the overall value added. Second, these time- and country-invariant industry weights are used to compute the aggregate shares of tradables and nontradables. Due to missing values in some countries' samples, the sections T (Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use) and U (Activities of extraterritorial organisations and bodies) are not considered. Third, the deflators are recalculated so that they use the year 2000 as the common base. These indices then allow comparing the price dynamics of both tradables and nontradables. To illustrate the differences, we use the geometric average over time to show annualised inflation rates.

as countries with longer membership. Conceptually, this suggests that the distinction of tradability based on direct trade linkages is not conclusive when studying price dynamics.

To explore the general conjecture that EU integration reduces prices, we need to consider that the EU seeks to guarantee the free movement of goods and services within its four freedoms (Canoy & Smith, 2008; Pelkmans et al., 2014). It aims to create a regulatory level playing field for trade and entrepreneurship (Böheim & Friesenbichler, 2016; Hölscher & Stephan, 2009), which has been found to reduce uncertainty, transaction costs and hence price volatility (Koren & Tenreyro, 2007). These beneficial effects of Single Market integration have a direct dimension, which is reaped trough intensified trade relationships between member states, and indirectly through a cumulative effect along value chains. However, this indirect effect will depend on the geographic distribution of supply relationships along the value chain. If these are concentrated inside the common market or become more integrated in the common market over time, then the economic effects of integration may be amplified due to cumulated reductions in transaction costs by a common legal framework. If, on the other hand, such an integration does not take place or is even reversed if, for instance, exporters located inside the Single Market seek to penetrate markets outside, then these integration effects on price dynamics may be more limited. Trade effects on producer price dynamics will therefore depend on the geographic distribution of supply relationships and related trade linkages along the value chain.

Another aspect to consider is whether relationships in a value chain are up- or downstream. They may be complementary, but qualitatively different. In downstream relationships the choices of export markets made by companies depends more strongly on consumer preferences, regulations and the capability of firms to provide unique value propositions to customers in specific markets. For instance, the European Commission sets EU-wide quality or safety standards for the Single Market reflecting consumer concerns. The same holds for non-EU markets. Yet, in upstream relationships the choice of suppliers will rather depend on their capabilities or specific resource endowments which they can offer. These different aspects may influence or even offset trade effects related to market integration on producer prices. For instance, if scarce resources not available in the Single Market are needed to produce a specific output and global demand drives prices for these resources up, one would expect this effect to dominate any value chain integration effect. Distinguishing between forward- and backward integration, i.e. the cumulated trade integration effects related to down- and upstream supplier relationships in the value chain, allows us to paint a more nuanced picture of trade effects on prices. This approach goes beyond the mere aggregate trade openness indicators, which macroeconomic models typically use.

That being said, the expected effects of the different integration measures on prices are ambiguous: As countries accede the Single Market, the economic integration through value chains may intensify due to reduced transaction costs and the common legal framework. In the case of forward linkages, this might imply lower prices due to lower trade costs and more competition among suppliers. However, literature shows that export market entry costs vary within the national firm distribution with productive firms being more likely to export than less productive firms (Melitz, 2003). Since forward linkages in non-EU countries can be assumed to involve higher entry costs than linkages within the Single market, extra-EU ties might be a sign of very productive, competitive firms that are globally active. In the case of backward linkages, lower costs of sourcing within the EU might be translated into lower prices levels. When sourcing from other EU members gets easier in comparison to sourcing from non-EU countries, trade linkages might be redirected to and solidify within EU members states.

Summing up, the literature offers insights on market integration and price dynamics in an EU context. Market integration theory assumes lower price dynamics with increasing economic integration. In the EU, great strides have been made to create a deeply integrated area, the Single Market, which should substantially lower regulatory uncertainty and therefore price dynamics. Empirical evidence indicates that trade openness causes producer prices to decline (Chen, 2009), especially through lower intermediate prices (Loupias & Sevestre, 2013). However, trade data does not capture the regional disintegration of the production process. Manufacturing or services activities done abroad are combined with those performed at home. As a result, the foreign value added content has increased vastly since the 1990s, which export data does not measure (Feenstra, 1998). The focus of studies analysing price dynamics is increasingly shifting away from imports and exports towards toward value chain trade (Dorrucci et al., 2019). In the following empirical analysis, we use this argument to construct a structural indicator that considers intra-EU and extra-EU trade. In addition, the indicators rely on value chain trade, which allows us to control for the fragmentation of production other than mere imports and exports.

3 DATA AND INDICATORS

3.1 Composition of value chain integration into the Single Market

To capture the structure of production, we draw on input-output data which quantifies the flows of goods and services between countries and industries (Timmer et al., 2014). We use a novel set of trade-based measures of integration in the EU which on the one hand keep apart the geographic distribution of value chain linkages, and that on the other hand distinguish between up- and downstream relationships in the value chain. To compute either value chain indicator, we use data at the industry-level from the World Input-Output Database (WIOD) covering the period 2000-2014 (Dietzenbacher et al., 2013). We do not consider domestic sourcing or consumption. To calculate an industry's level of upstream value chain integration, i.e. backward linkages, we use the value-added share of imported intermediate goods along the value chain. This value-added share is split into the share of a sector's use of intermediary goods along the value chain from other EU member states (Backward EU) and non-EU countries (Backward Non-EU) in the industry's (total induced) value added.

The backward-integration indicator hinges on the partitioning of the induced value added (IVA). The IVA is defined as

$$IVA = vLf \quad (1)$$

Where vector f denotes a sector's value of final demand in a given country and year, v is the value-added per unit of production (diagonal matrix) and L stands for the Leontief inverse. The Leontief inverse incorporates the structure of direct and intermediate inputs for the production process meeting the final demand. The vector IVA contains the value-added shares of all industries and countries required to produce the considered output at the sector-country level (Johnson & Noguera, 2012). These are split into the domestic and the foreign value-added shares. The foreign value-added share is partitioned again to calculate the EU and non-EU share of foreign IVA (which sum up to 100%). Finally, the backward-integration indicator is obtained by subtracting the EU share from the non-EU share, i.e. a potential 'surplus' or 'shortage' of backward integration within the Single Market is calculated as the difference between the EU share of foreign IVA and the non-EU-share of foreign IVA. In other

words, greater upstream integration is measured by more value added which is sourced from countries within the EU in relation to non-EU countries.

To compute the forward integration indicator, we again start from the IVA formula, but here the computation of the indicator relies on the partitioning of the final demand vector. In a first step, the value added induced by foreign (EU and non-EU) countries is calculated according to equation (1). Next, only the valued added induced by final demand from other EU members is considered. Then, only the value added induced by final demand from non-EU-countries is computed. Based on this we can calculate the share of IVA by final demand from other EU members in IVA by final foreign demand as well as the respective share including only non-EU members. Last and analogously to backward integration, forward integration is then defined as the differences of the IVA share which is used either in another EU Member State or in an extra-EU country. If an industry's demand in EU Member States outweighs its demand in non-EU countries, the indicator is positive.

Both the forward and backward integration indicators are 'surplus' indicators exclusively focusing on the participation in international value chains up- and downstream of any given sector in a country. To demonstrate the composition of the integration indicators, we compare the forward integration indices of the manufacturing sector in Germany and Bulgaria in 2000 and 2014 (see Table 1). These countries have very different legacies, suggesting different developments with respect to integration over time. The starting point is the induced value-added share generated in manufacturing that is finally consumed in foreign countries (IVA-share by final demand in EU- and non-EU-countries), which increased in Germany from 54% to 71%. Out of that, in Germany the IVA-share by final demand in EU, i.e. share of value added which was consumed in other EU Member States in the total induced value added consumed in foreign countries, fell from 54% in the year 2000 to 44% in 2014. In comparison, at the same time in Bulgaria the share of IVA which was consumed in foreign countries increased in total from 15% to 59%. Out of that, the IVA-share by final demand in EU increased from 52% in the year 2000 to 58% in 2014, while non-EU share decreased from 78% to 42%. The yearly forward integration indicator is now calculated as the difference of these two, i.e. the IVA-share by final demand in EU and IVA-share by final demand in non-EU . Hence, for Germany the indicator amounted to approximately eight percent in 2000, and then turned negative (-12%) in 2014. This implies that in terms of sales markets extra-EU destinations became – in relative terms - more important for German manufacturing than intra-EU destinations. In contrast, during the same period in Bulgaria the IVA-share by final demand in EU gained importance compared to the IVA-share by final demand in EU, which indicates greater (relative) degrees of forward integration into the Single Market.

Table 1 about here

The picture that emerges for the integration of the manufacturing sector can be summarised as follows. The relative importance of international demand for manufactured goods has increased in either country, but in Bulgaria relatively more so than in Germany, which already started with high shares of foreign demand in 2000. Interestingly, for Germany the relevance of final demand from other EU countries has lost some of its relative importance in favour of third countries, while EU Members gained shares in Bulgarian manufacturing. This means that German exporters have become more integrated in global markets while at the same time they have gradually

become less integrated in EU markets. The Bulgarian economy has become more export oriented in a process that was predominantly driven by the integration in EU markets. Certainly, Bulgaria was not an EU Member State in 2000. To render this comparison feasible, in this example we use a hypothetical integration scenario, which is based on the EU28 in 2014. However, the indicators used in the subsequent regression analysis are based on trade with other EU Member States and countries prior to their accession are therefore not considered.

The dynamics of the backward and forward integration indicator may differ from country to country. Since the indicator is defined as a 'surplus' (i.e. the difference between EU and non-EU linkages), the development of the integration indicator is driven by its components. Figure 2 shows the backward and forward integration indicators for the Member States in the sample. The results are mixed. Almost all economies are more backward than forward integrated. Albeit there is cross country variance, some Old Member States such as Austria, Belgium or Germany have increasingly turned to extra-EU trading partners. New Member States of more recent accession waves such as Slovenia, Slovakia or the Czech Republic have in turn increasingly integrated into the EU. Overall, these figures suggest a slightly lower extent of forward integration when compared to EU sourcing, and mirror, to a certain extent, countries' positioning in the value chain.

Figure 2 about here

3.2 Legal and institutional EU integration indicators

To capture additional aspects of European integration besides the value chain integration, we next define two qualitative market integration indicators:

- Integration may refer to wider regulatory aspects, which are mirrored by the Community Acquis and empirically captured by changes in the EU-membership status, i.e. accession to the EU.
- Integration may refer to a common monetary policy, i.e. by being a Eurozone member.

Administrative integration: The Community Acquis

Changes in the EU membership status or the EU-accession, respectively, is likely to affect producer price inflation. In the period analysed, there were several enlargement rounds. EU accession requires countries to implement the Community Acquis, and different stages of membership have different effects on the institutional environment. There is evidence that EU membership improves the institutional quality, and generates a more competitive and fairer playing field for firms (Böheim & Friesenbichler, 2016; Dimitrova, 2010; Hölscher & Stephan, 2009). This is likely to lead to less economic volatility (Koren & Tenreyro, 2007), especially via the channel of uncertainty-reducing trade agreements (Limão & Maggi, 2015). As a result EU-membership can dampen inflation (Janger & Schmidt-Dengler, 2010).

The *Community Acquis* is measured by a dummy variables taking on the value of one if a country is an EU Member State, and zero otherwise (Böheim & Friesenbichler, 2016). The Membership Status variable is constructed using official information on the accession process provided by the European Commission.

Monetary integration: The Eurozone

An additional aspect of economic integration concerns the Euro, which can be seen as a pegged exchange rate. Monetary integration reaches beyond the trade-based definition of the Single Market and is a deeper form of economic integration. It is possible that the common monetary policy of the European Central Bank affects producer price inflation. The idea relies on a strand of macroeconomic research on currency areas, which argues that the benefits of a common currency are mainly due to the abolishment of exchange rate fluctuations. This implies a reduction in risk and transaction costs and an increase in price transparency. This was thought to facilitate intra-currency area trade, and, in some EU Member States, better monetary policies (De Grauwe, 2018; Mundell, 2001; Obstfeld, 2001).

The main objective of the European Central Bank is to maintain price stability in the Euro area. It aims at inflation rates of below, but close to, 2% over the medium term. There was a series of changes of the monetary policy regimes that were implemented in the Euro area in the last decades. However, studies find that there appears to be relatively little instability of the euro-area inflation (O'Reilly & Whelan, 2005). Inflation persistence has been found to be the main explanatory factor, with other macroeconomic determinants, such as country-specific shocks in aggregate demand followed by cost-push shocks having lesser explanatory power (Angeloni & Ehrmann, 2007). This largely suggests that there is no systemic effect of being a member of the Eurozone on macroeconomic consumer price inflation. However, these studies differ from the present contribution in the level of analysis. They aim at explaining aggregate inflation rates, and not sector specific producer price inflation.

Common monetary policy is measured by Eurozone membership, which is captured by a dummy variable taking on the value of one if an economy is part of the Eurozone, and zero otherwise. The variable is constructed using official information on the accession process provided by the European Central Bank. The viable can be interpreted as the effect of a pegged exchange rate. Drawing on inflation literature, we expect a coefficient close to zero and statistically insignificant.

3.3 Additional determinants of inflation

Macroeconomics provides a framework for studying price levels and international value chain trade, and related price dynamics are considered in adjustment mechanisms.

There is a long history of research on the interplay of prices and *international trade*, distinguishing between an open and a closed sector of the economy with different price setting mechanisms (Balassa, 1964; Kravis & Lipsey, 1982; Samuelson, 1994). This literature considers only direct trade linkages. Since no systematic pattern between openness, defined by direct trade linkages, and price dynamics was found in the data presented above, we use an indicator of openness along the value chain. This indicator, in line with the value chain approach, considers all trade linkages along the value chain to classify the degree of a sector's openness. This trade openness indicator is therefore defined as the share of value added which is traded or consumed internationally along the value chain (*FOREIGN*) to control for level effects.

Additional determinants of sectoral price developments can be derived from the *macroeconomic environment*, such as aggregate demand developments (Angeloni & Ehrmann, 2007). These are captured by the GDP trend-based output gap, a relative measure of demand and supply conditions of the domestic economy. The output gap

is defined as the difference between actual GDP and potential GDP. If the output gap is negative, the actual output is less than its potential output, which is a symptom of a weak macro-economy indicating deflationary tendencies. If it is positive, the macro-economy performs better than its long run trend, which is associated with economic boom periods. The output-gap also mirrors the real interest rate gap, which is the difference between the observed real interest rate - that is, the nominal short-term interest rate minus expected inflation - and the natural rate of interest. Hence the output-gap provides a measure for monetary policy, and is preferable to other cyclical measures such as GDP growth (Cúrdia et al., 2015). Thus, overall a positive relationship between the output-gap and sector specific price increases is expected (Fischer et al., 2002). The *output gap* indicator used is retrieved from the AMECO database. The indicator was re-scaled by factor hundred to make the magnitude of the coefficient comparable.

Moreover, there may be other cyclical components affecting producer price inflation. These are typically determined on international markets, such as trading platforms for commodities or foreign exchange. Especially price increases, as opposed to price decreases, are (partly) being passed through to domestic buyers (Browne and Cronin 2010; Campa and Goldberg 2005, Breitung and Roling 2015). A *commodity* price index obtained from the Hamburg Institute of International Economics (HWWI) is used (HWWI 2015, total index Euro, B). This index considers price developments of a wide range of raw materials, crude oil, cotton, coffee or sugar, thus covering a variety of raw materials.[3]

A Eurostat indicator controls for the real effective *exchange rate* posing an import and export weighted rate of effective exchange rates that considers a total of 42 countries.[4] The index captures one element of a country's cost competitiveness. A rise in the index means a loss of competitiveness. Following the same pass-through logic and the scaling of the index as with commodities, we expect the exchange rate index to be positively associated with inflation (Aisen & Veiga, 2006; Campa & Goldberg, 2005; Friesenbichler, 2018). Over and above yearly fluctuations, we consider time effects capturing global trends which affect all countries in the sample. We define dummy variables of three-year periods for 2000-2002, 2003-2005, 2006-2008, 2009-2011 and 2012-2014.

Table 2 provides descriptive statistics of the variables used in the regression analysis. Additional information is provided in the Annex.

Table 2 about here

4 REGRESSION ANALYSIS AND DISCUSSION

4.1 Specifications

Our starting point is the semilogarithmic price equation

[3] See http://hwwi-rohindex.de/index.php?id=8875&L=1 (retrieved on 19 January 2019).

[4] See https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/price-and-cost-competitiveness_en (retrieved on 19 January 2019),

$$\ln(P_{ijt}) = \mu_i + \mu_j + \mu_t + BW_{ijt}'\beta_1 + FW_{ijt}'\beta_2 + FOREIGN_{ijt}'\beta_3 + X_{it}'\beta_4 + u_{ijt}, \quad (1)$$

where $\ln(P_{ijt})$ denotes the producer price index of a sector j in country i at time t based on Eurostat's deflators.[5] We control for the degree of international value chain participation, and therefore for the domestic production, in the regression analysis separately. Backward (BW_{ijt}) and forward (FW_{ijt}) integration as well as on the degree of trade openness ($FOREIGN_{ijt}$) in country i, sector j at time t are calculated using WIOD data. Thus, the coefficients of interest are β_1, β_2 and β_3 respectively. In addition, we consider several sets of control variables at the country level (X_{it}), where β_4 denotes the corresponding vector of coefficients. Industry, country and year fixed effects (μ_i, μ_j, μ_t) control for unobserved shocks and u_{ijt} denotes the error term varying over i, j and t.

Taking first differences leads to our main specification for estimating the effects of market integration dynamics on the producers' inflation rates:

$$INFL_{ijt} = \Delta\ln(P_{ijt}) = \Delta\mu_t + \Delta BW_{ijt}'\beta_1 + \Delta FW_{ijt}'\beta_2 + \Delta FOREIGN_{ijt}'\beta_3 + \Delta X_{it}'\beta_4 + \Delta u_{ijt}, \quad (2)$$

where the sectoral producer price inflation ($INFL_{ijt} = \Delta\ln(P_{ijt})$) is defined as $[\ln(P_{ijt}) - \ln(P_{ijt-1})]$. This approach follows established literature on impact of trade agreements and price dynamics (e.g., Chen et al., 2009). We address concerns about non-stationarity and unit-roots and estimate the inflation rate in logarithmic growth rates. We implement Fisher-type panel unit-root tests, which involves fitting an augmented Dickey–Fuller regression for each panel. The null hypothesis is that all panels contain a unit root, which is rejected by the test results. Also, a Levin-Lin-Chu panel unit-root test rejects the null hypothesis of a unit root in favour of the alternative hypothesis of stationary data (Choi, 2001). Robust standard errors are estimated in all specifications.

Column (1) and (2) in Table 3 present the regression results of the integration indicators without (1) and with (2) time fixed effects. In columns (4) and (5) the macroeconomic control variables and the Eurozone membership are added. The regression results in columns (5), (6), (7) and (8) follow the same approach but use the first differences of producer price inflation. In other words, in these regressions we use the changes in the producer price inflation rate as dependent variable. Hence, these results are to be interpreted differently. Instead of explaining changes in inflation as above, these specifications study the impact of changes in the explanatory variables on the change of inflation rates. The estimates of specification (1) to (8) consider only Member States. Regression (9) and (10) expand the sample by observations of accession countries prior to full EU membership and implements an instrumental variable regressions (2SLS) which include EU accession as an endogenous variable.

Table 3 about here

4.2 Estimation results and discussion

All variables are estimated in first differences, which is why the coefficients are to be interpreted as effects of changes in integration indicators on producer price inflation. The results show that backward integration into EU

[5] The indicator used is B1G_PD10_EUR; "Price index (implicit deflator), 2010=100, euro".

value chains has a significant negative impact on producer price inflation in all specifications. This indicates an inflation dampening effect of a deeper upstream integration in the Single Market (Dexter et al., 2005). The coefficients are therefore in line with integration effects suggested by "new new trade theory", which expects that more value chain trade dampens price levels and in periods of adjustments lower inflation dynamics (Chen, 2009; Melitz & Ottaviano, 2008). Economically integrated areas such as the EU provide an economic environment with less uncertainty and therefore more economic stability. This lowers coordination costs translating to more modest price dynamics (Koren & Tenreyro, 2007). This finding supports the value chain dynamics observable in Europe in the period analysed. Many Central and Eastern European countries have become important trading partners in regional value chains in Europe. German firms often take a central position controlling the regional value chains. This increased fragmentation of production within the EU has brought about lower cost pressures on producers located upstream in the value chain (Amador et al., 2015; Friesenbichler et al., 2018).[6]

The coefficients for the forward integration indicator are positive but tend to be weaker than those of the backward integration. They are insignificant in two specifications, (3) and (4), which include the yearly macroeconomic developments. By and large, there seems to be a dominating price increasing effect of forward value chain trade integration in the EU. Indeed, the same reasons (e.g. lower transaction costs) for negative effects of intra-EU trade on producer price inflation in case of backward integration should also apply for forward integration However, while for backward integration the negative effects dominate, the opposite holds for forward integration.

Both integration indicators measure net effects, which is why the underlying dynamics within the EU are important. There are several reasons for dominating negative or positive effects on producer price inflation. Figure 1 illustrates that countries in Central and Eastern Europe have experienced particularly high producer price dynamics. This was driven by wage dynamics as part of their catching-up process (Amador et al., 2015). At the same time, the value chain integration of these countries has increased substantially, while many Old Member States, such as Germany or Austria, have increased their global market presence (Friesenbichler et al., 2018). This development may be the reason for the different signs of the backward and forward integration coefficients.

The self-selection of productive and less productive firms being active at the global or local market might also play a role. Less productive firms tend to serve mainly the local market (Melitz & Ottaviano, 2008), which is why it is likely associated with greater cost pressure. A similar argument hinges on economies of scale and scope, which was highlighted as being one of the big potentials of the full regulatory implementation of the Single Market by several empirical studies (Pelkmans et al., 2014; Wolfmayr et al., 2019). The main trading partners of EU-based firms such as the USA, China, or Japan are both larger and might better integrated from an economic and regulatory perspective, which results in lower adaptation costs and producer price dynamics. However, cost dynamics may not only stem from regulatory inefficiencies but can be due to differences in demand structures. In a global comparison, the EU Single Market has, on average, a highly sophisticated customer base. Hence,

[6] See also https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Innovation/Globalization%20in%20transition%20The%20future%20of%20trade%20and%20value%20chains/MGI-Globalization%20in%20transition-The-future-of-trade-and-value-chains-Full-report.ashx (accessed on 26th January 2020).

compared to some of Europe's trade partners the demand structure in Europe may simply require firms to serve a quality segment which exhibits higher cost dynamics.

Overall, underlying firm strategies and demand structures play an important role in explaining the net effects of Single Market integration on producer price inflation presented above. The present data is well-suited to describe value chain integration at an aggregate, sectoral level, but can hardly explain these underlying fine-grained dynamics. This is better observable at the product or firm level and thus, clearly indicates a limitation of the chosen approach. More research with micro-data is needed to shed light on these underlying mechanisms.

The effects of backward and forward integration hinge on differences in the independent variables which focus on the EU Single Market. Hence, these effects come to a halt once full integration has been achieved. Also, we define backward and forward integration as differences between intra-EU and extra-EU value chain trade. The overall increase of worldwide value chain trade is unlikely to affect the empirical outcomes, because the increase in global trade does not necessarily affect the value chain shares on which the integration indicators rely.

The coefficients for FOREIGN indicate a negative effect of the inflation indicator, but are only significant in the first specification, as well as in the instrumental variable regression (see below). The greater a sector's exposure to international trade along the value chain becomes the lower its increases in producer prices are. The coefficient of the openness indicator in the final specification is 0.09, which is approximately one standard deviation of the price increases in natural logs. Hence the effect of value chain openness is, on average, rather large, and offer evidence about the effects of international value chain trade over and above the previously used structural indicators relying on trade partners. The openness indicator turns positive and statistically insignificant in the specifications using the first differences of inflation as the dependent variable.

In the period observed, Cyprus, Estonia, Latvia, Lithuania, Slovenia and Slovakia joined the Eurozone. The coefficients for joining the Eurozone are only significant in specification (3) and (4) which estimate the effect of joining the Eurozone on inflation including macroeconomic control variables. The effect is negative. However, the signs change across specifications. This leads us to conclude that there tends to be a small, negative contribution of acceding the Eurozone to producer price inflation. This evidence at the sector level contrasts macroeconomic results for consumer price inflation, which has suggested that the Euro itself has not altered inflation rates (Dexter et al., 2005; Goldberg & Verboven, 2005).

The coefficient for the GDP trend-based output gap is positive and highly significant. This supports the notion that producer price inflation is pro-cyclical. This suggests that in a weak macroeconomic environment, when the output gap turns negative, there are deflationary tendencies. The other control variables also perform as expected. The signs of the coefficients of both the raw material index and the real foreign exchange are positive and statistically significant. The unreported time effects are statistically significant, too.

Moreover, there might be endogeneity issues with respect to accession countries. In the regressions (1) through (8) we have only considered EU Member States at given years. Hence, the sample changes with accession rounds. However, the data allow us to examine the effect of EU accession on producer price dynamics. Several countries in the sample, which begins in the year 2000, changed their membership status. These are Bulgaria, Cyprus, the Czech Republic, Estonia, Croatia, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia.

The focus of this study is to identify the effect of value chain trade participation in the Single Market on producer price inflation. Both producer price inflation and value chain trade are likely to be codetermined by EU membership. The backward integration indicator of accession countries increases from -0.04 in the years prior to accession to 0.09 after joining the EU. The forward integration indicator increases from -0.03 to 0.09. This mirrors an endogeneity issue, which we address in specification (9) and (10) by a two stage least square instrumental variable estimator.

In specification (9) we draw on previous work on the effects of EU accession (Böheim & Friesenbichler, 2016) and use ideological proximity as an instrumental variable. We argue that political views of Russia are likely to be negatively associated with the EU accession of Central and Eastern European countries. It is well documented that Russia has little political affiliation with the European Union and attempts to undermine its institutions (Galeotti, 2017; Llewellyn et al., 2019). To quantify this aspect, we use a voting similarity index of EU Member States with the Russia in the UN General Assembly (Voeten et al., 2009). The indicator draws on three categories of vote data: 1 = "yes" or approval for an issue; 2 = abstain, 3 = "no" or disapproval for an issue. Abstention is counted as half-agreement with a yes or no vote.[7] The index values in the sample range between 0.49 and 0.72. Its mean value is 0.61, with a standard deviation: of 0.05. The coefficient of voting similarity with Russia in the first stage is negative (ρ: -1.63) and highly significant (p-value: 0.00).

In specification (10) we use an additional exogenous variable to test the exogeneity of the instruments, an indicator of voice and accountability provided by the World Bank's World Governance Indicators (Kaufmann et al., 2011). This indicator captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association and free media. These are aspects that are covered by the Community Acquis, whose implementation is part of the accession process, but are unlikely to directly affect transaction costs and thus producer prices. The mean of this variable is 1.12 and the standard deviation is 1.35 (minimum: 0.30; maximum: 1.82). The coefficients obtained in the first stage regression are both highly significant (p-value: 0.00) and point into the expected directions. The coefficient for voting similarity with Russia is negative (ρ: -1.76), while it is positive for Voice and Accountability (ρ: 0.22).

The results show that EU enlargement had a dampening effect on sector specific price inflation. The coefficients of EU accession are highly significant and negative. The magnitude of this effect is slightly below the magnitude of backward integration. This is likely to be driven by the implementation of the Community Acquis as part of the accession process (Böheim & Friesenbichler, 2016), which brings about more regulatory certainty (Koren & Tenreyro, 2007). The coefficients of the other variables resemble those of the previous results.

The post-estimation tests support these regressions. We reject the concern of weak instruments, since the Anderson canonical correlation Lagrange multiplier statistic is highly significant (p-value: 0.00) and the Cragg-Donald Wald F statistic exceeds the 10% maximal instrumental variable size suggested by the Stock-Yogo test values (Stock & Yogo, 2002). Specification (9) is exactly identified. The Sargan test of specification (10) is highly

[7] For data access and further information about the indicators see https://dataverse.harvard.edu/dataset.xhtml?persistentId=hdl:1902.1/12379 and http://info.worldbank.org/governance/wgi/index.aspx#doc (accessed on 10 July 2019).

insignificant (p-value: 0.83). Hence, the instrumental variables can be interpreted as exogenous (Angrist & Pischke, 2008).

5 CONCLUSIONS

This paper explored the effect of the EU value chain integration on producer price dynamics at the sector level. Macroeconomic literature suggests an inflation reducing effect of international trade on price levels. Conceptually, this is supported by trade integration theory, which argues that price increases are more moderate in periods of market integration (Melitz & Ottaviano, 2008). This effect is thought to be particularly pronounced in the EU's Single Market, where great efforts have been made to create a deeply integrated economic area. Hence, the trade effects with respect to economic integration within the Single Market should exceed the effects with extra-EU partners.

Even though the EU claims that the Single Market is likely to dampen price dynamics and there is some older evidence that trade reduces production costs, this relationship has never been tested empirically for the EU as a whole. Moreover, the literature does not suggest differences between upstream and downstream integration on price dynamics, which is an additional aspect explored by our analysis. Our main variables measure value chain trade integration and capture both upstream and downstream integration. Using value chain indicators instead of imports and exports allows us to control for the fragmentation of production across countries and sectors which trade data cannot sufficiently capture. While international markets in general became more important since 2000, the developments with respect to EU value chain integration were mixed across countries, Old Member States have rather turned to extra-EU trading partners, while New Member States increasingly integrated into the EU. These indicators are used to estimate the effects of Single Market integration on producer price inflation.

The regression results show that industries which become more backward integrated show lower levels of producer price inflation. In other words, sectors which source more value added from EU trading partners exhibit lower increases of producer prices. The results of forward integration were weaker and pointed into the opposite direction than backward integration. The downstream effect is smaller and statistically less robust than the effect for upstream integration. We offer some possible explanations for these effects, including allocative efficiency, demand structures or regional and global shifts in value chains. However, more research at firm level is needed to address the underlying mechanisms.

We have used additional integration indicators to capture the effect of EU accession as a measure for administrative integration, and Eurozone membership measuring monetary integration. EU accession was thought to reduce producer price inflation, since it requires implementing the Community Acquis, the accumulated legislation, legal acts, and court decisions which constitute the body of European Union law.[8] The estimation captures the effect of acceding the EU. EU accession was found to lower producer price inflation, with a particularly strong effect of becoming a Member State (as opposed to gaining the status as an accession candidate). These results supports literature on trade uncertainty, which expects an inflation reducing effect of regulatory

[8] See https://en.wikipedia.org/wiki/European_Union_law (accessed on 26th January 2020.

integration (Koren & Tenreyro, 2007; Limão & Maggi, 2015). The estimates of being part of the Euro zone showed slightly negative, yet weakly significant results.

These results are relevant for economic policies from various perspectives. The findings put the statement that EU integration helps cutting prices into perspective. We paint a differentiated picture, in which backward integration dampens producer price dynamics, but forward integration may lead to higher producer price dynamics. This is directly relevant for the measurement of inflation and thus monetary policies. Indeed, the European Central Bank has recently expressed interest in value chain dynamics. Moreover, policy makers shape value chains by setting trade agreements affecting transaction costs of trading partners. If policies lead to a reversal of European value chain integration, which is likely for the United Kingdom that has left the EU, higher producer price inflation is an expected outcome.

ACKNOWLEDGEMENTS

For valuable comments and suggestions, we are grateful to Tomas Brännström, Francisco Caballero-Sanz, Peter Egger, Christian Glocker, Werner Hölzl, Isabelle Mejean, Harald Oberhofer, Michael Pfaffermayr and Philipp Schmidt-Dengler. We also would like to thank Anna Strauss, Nicole Schmidt and Stefan Weingärtner for their assistance with the data compilation. This research was partly financed by the European Commission, DG GROW within the Framework Service Contract No. ENTR/300/PP/2013/FC-WIFO under the project „Competitiveness drivers and obstacles, intra-EU linkages and European value chains in GVCs". We also acknowledge funding from the European Union Horizon 2020 Research and Innovation action under grant agreement No 822781 (GROWINPRO). The data that support the findings of this study are available at Eurostat at https://ec.europa.eu/eurostat. Additional indicators were derived from the following resources available in the public domain: http://www.wiod.org/database/wiots16.

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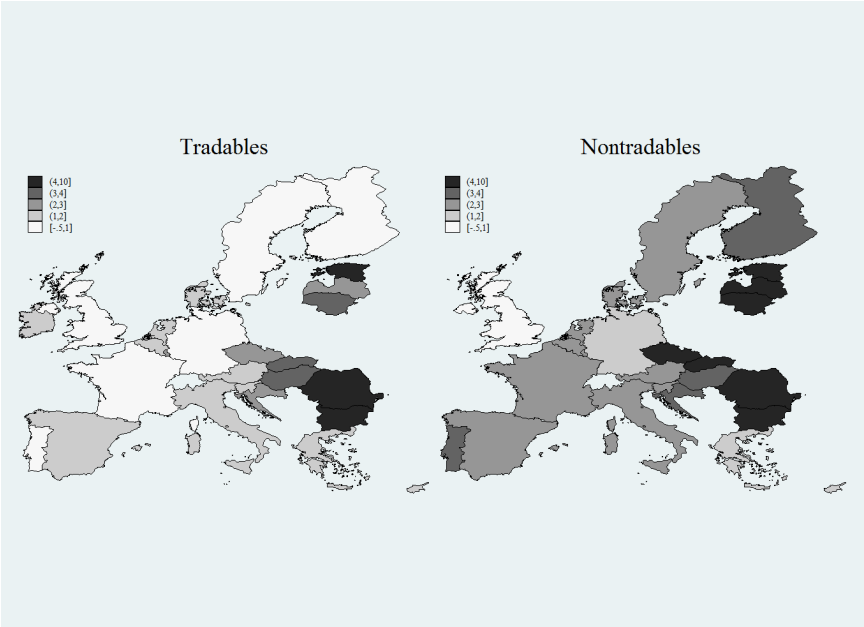
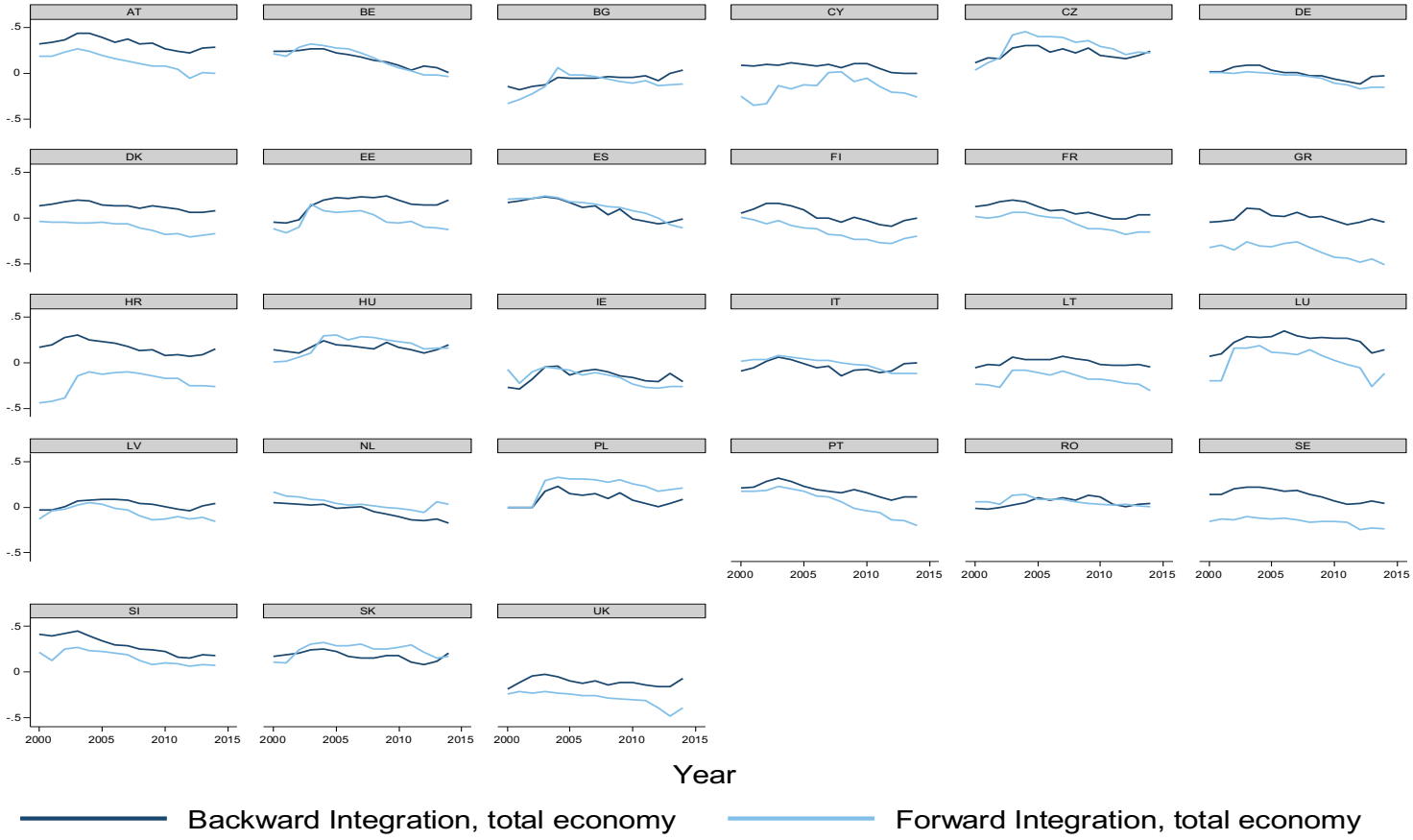
Tables and Figures

Figure 1: Annualised producer price inflation of tradables and nontradables across countries (2000-2014)



Source: Eurostat, Sachs and Larrain (1993), own calculations.
Note: This graph shows the annualised producer price inflation rates across EU Member States for the tradable and the nontradable sector between 2000 and 2014.

Figure 2: Backward and Forward Integration Indicators across Member States (total economy) and time



Source: WIOD Release 2016, own calculations.
Note: This graph shows the value added weighted backward and forward integration across EU Member States for the total economy over time. The forward indicator is defined as the surplus of final use of value added in other EU28 Member States over extra-EU countries. Backward integration is measured as the surplus of sourcing from industries in other EU28 Member States over extra-EU countries.

Table 1: Forward integration of manufacturing in Germany and Bulgaria (2000 and 2014)

	Year	Domestic	Foreign	EU	Non-EU	Integration
Germany	2000	45.7%	54.3%	53.8%	46.2%	7.7%
	2014	29.1%	70.9%	43.8%	56.2%	-12.3%
Bulgaria	2000	84.7%	15.3%	52.1%	47.9%	4.1%
	2014	41.3%	58.7%	57.6%	42.4%	15.2%

Source: WIOD Release 2016, own calculations.

Note: This table illustrates the forward integration indicators for Germany and Bulgaria in 2000 and 2014. The integration indicators are surplus indicators. These rely on the value-added share that is absorbed internationally. They are defined as the difference between the value-added share of foreign demand in EU Member States and in third (i.e. extra-EU) countries.

Table 2: *Descriptive statistics of price developments and its explanatory variables*

	Mean	**Median**	**S.d.**	**Min**	**Max**
Price change, nat.log	0.03	0.03	0.08	-0.75	0.74
FOREIGN	0.29	0.25	0.24	0.00	1.00
B.w. integration	0.06	0.08	0.21	-0.84	0.64
F.w. integration	0.00	0.00	0.25	-0.97	0.69
No candidate	0.01	0.00	0.12	0.00	1.00
Candidate	0.15	0.00	0.36	0.00	1.00
Member State	0.83	1.00	0.38	0.00	1.00
Eurozone	0.66	1.00	0.47	0.00	1.00
Output gap	0.27	-0.05	4.15	-13.38	19.94
Raw Materials	1.00	0.99	0.38	0.48	1.56
FX	1.01	1.00	0.08	0.76	1.33
Agreement with Russia	0.62	0.63	0.05	0.49	0.73
Voice and Accountability	1.12	1.10	0.35	0.30	1.83

Table 3: Regression results of effects on producer price inflation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Var.	INF	INF	INF	INF	INF, 1st diff	INF, 1st diff	INF, 1st diff	INF, 1st diff	INF	INF
B.w. integration	-0.06***	-0.05**	-0.08***	-0.07***	-0.10***	-0.11***	-0.10***	-0.11***	-0.08***	-0.08***
	(0.022)	(0.023)	(0.021)	(0.022)	(0.031)	(0.031)	(0.031)	(0.031)	(0.015)	(0.015)
F.w. integration	0.07***	0.04**	-0.00	0.01	0.11***	0.10***	0.05*	0.05**	-0.01	-0.01
	(0.018)	(0.018)	(0.017)	(0.017)	(0.025)	(0.025)	(0.024)	(0.025)	(0.013)	(0.013)
EU Accession									-0.05***	-0.05***
									(0.015)	(0.010)
Eurozone			-0.01***	-0.01***			-0.00	0.00	0.01	0.01**
			(0.003)	(0.003)			(0.005)	(0.005)	(0.006)	(0.005)
Output gap			0.58***	0.56***			0.62***	0.73***	0.54***	0.53***
			(0.050)	(0.055)			(0.058)	(0.066)	(0.032)	(0.031)
FX			0.75***	0.74***			0.45***	0.56***	0.78***	0.78***
			(0.036)	(0.039)			(0.062)	(0.069)	(0.030)	(0.029)
Commodities			0.02***	0.03***			0.03***	0.03***	0.03***	0.03***
			(0.004)	(0.005)			(0.006)	(0.006)	(0.004)	(0.004)
FOREIGN	-0.09*	-0.09	-0.08	-0.07	0.02	0.02	0.01	0.01	-0.08**	-0.07**
	(0.052)	(0.053)	(0.051)	(0.051)	(0.085)	(0.086)	(0.085)	(0.085)	(0.032)	(0.032)
Time Effects	N	Y	N	Y	N	Y	N	Y	N	N
Constant	0.03***	0.03***	0.03***	0.03***	-0.00	0.00	-0.01	-0.01	0.06***	0.06***
	(0.001)	(0.003)	(0.003)	(0.004)	(0.002)	(0.006)	(0.004)	(0.008)	(0.009)	(0.006)
Observations	5,437	5,437	5,199	5,199	5,168	5,168	4,947	4,947	6,088	6,088
R-squared	0.005	0.040	0.157	0.159	0.006	0.008	0.061	0.067	0.152	0.150

Note: This table reports the regression estimates of the effect of backward and forward integration into EU value chains on producer price inflation. The results show a price decreasing effect of backward linkages and a price increasing effect of forward integration. Joining the Eurozone has a small and negative effect on producer price inflation. The other control variables behave as expected. All independent variables are estimated in first differences to strengthen the causal interpretation. Robust standard errors in all specifications; *** p<0.01, ** p<0.05, * p<0.1.

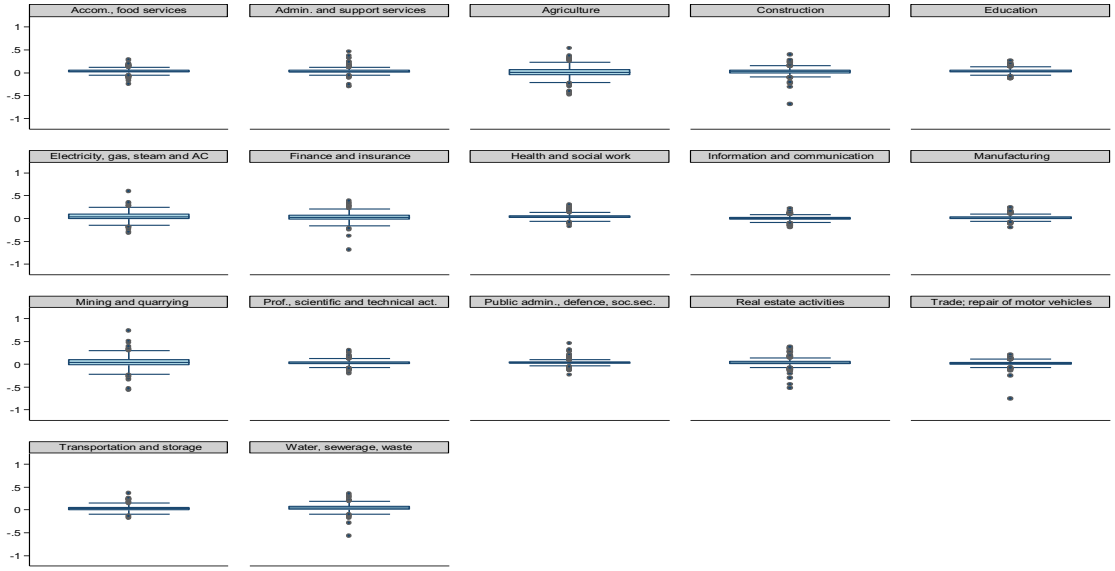
Annex

Table A1: Tradable and nontradable sectors

Section	Title	Division	Tradable (1) or Nontradable (0)
A	Agriculture, forestry and fishing	01 - 03	1
B	Mining and quarrying	05 - 09	1
C	Manufacturing	10 - 33	1
D	Electricity, gas, steam and air conditioning supply	35	1
E	Water supply; sewerage, waste management and remediation activities	36 - 39	1
F	Construction	41 - 43	0
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	45 - 47	1
H	Transportation and storage	49 - 53	1
I	Accommodation and food service activities	55 - 56	0
J	Information and communication	58 - 63	1
K	Financial and insurance activities	64 - 66	1
L	Real estate activities	68	0
M	Professional, scientific and technical activities	69 - 75	1
N	Administrative and support service activities	77 - 82	1
O	Public administration and defence; compulsory social security	84	0
P	Education	85	0
Q	Human health and social work activities	86 - 88	0
R	Arts, entertainment and recreation	90 - 93	0
S	Other service activities	94 - 96	0

Note: Following 1, this table provides the split of the economy into a tradable and a nontradable sector.

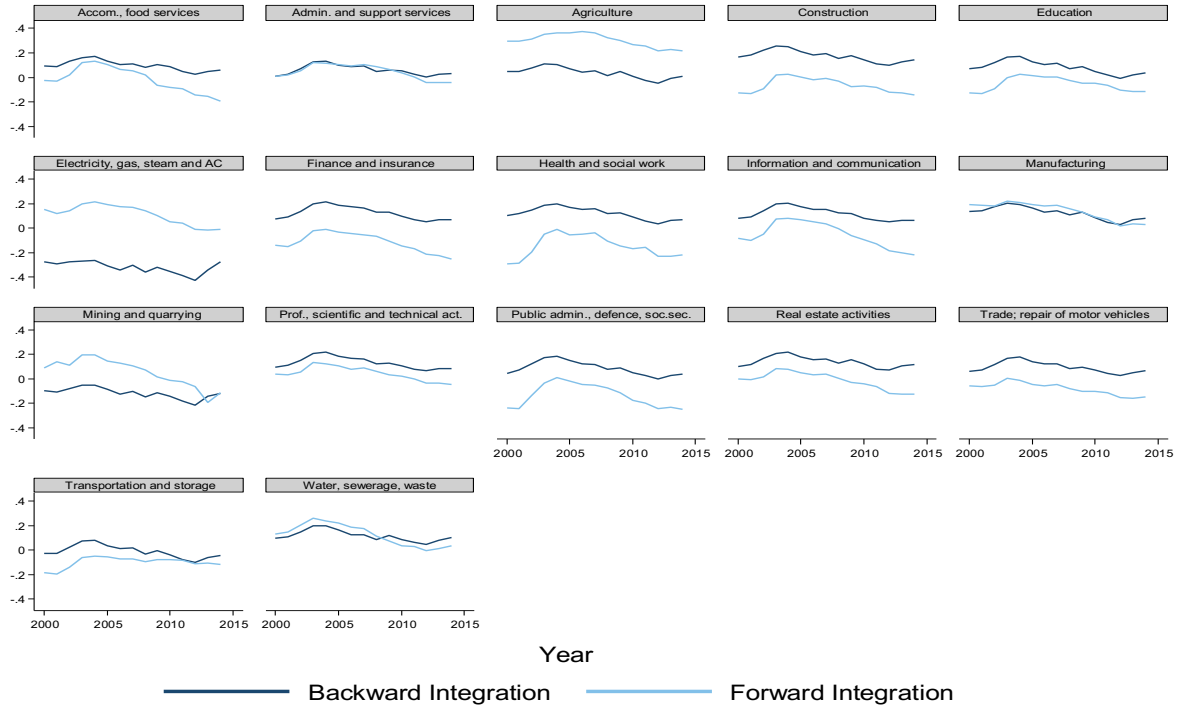
Figure A1: Histogram of price changes in natural logs across sectors



Source: WIOD Release 2016, own calculations.

Note: This graph shows the different variance patterns across sectors if the indicator is pooled across countries. There is large variance in ‚Agriculture, forestry and fishing', 'Financial and insurance activities' and ‚Electricity, gas, steam and air conditioning supply'. "Nontradable sectors" such as 'Human health and social work activities', ‚Education', ‚Real estate activities' or ‚Public administration and defence; compulsory social security' exhibit rather small levels of variance. This suggests different factors determining price developments across sectors.

Figure A2: Backward and Forward Integration Indicators across Sectors (country mean) and time



Source: WIOD Release 2016, own calculations.
Note: This graph shows the value added weighted backward and forward integration across sectors (mean over all countries) over time. The forward indicator is defined as the surplus of final use of value added in other EU Member States over extra-EU countries. Backward integration is measured as the surplus of sourcing from industries in other EU Member States over extra-EU countries.