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VERTICAL INDUSTRY SPECIALISATION AND TRADE

- The Case of EMU

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ABSTRACT

The rise of global supply chains has been subject to much attention in recent literature. However most work has been done within traditional trade frameworks. This leads to a narrow view of global supply chains as it implies countries specialise in vertical stages of the production process. While current literature confirms that country-level vertical specialisation is an important factor of trade, little can be said of the determinants of specialisation. We propose that an industry's position in a global supply chain determines its ability to gain from trade. We verify empirically that production integration from the EMU was more beneficial for industries in the middle of a supply chain compared to those at either extreme.

KEY WORDS: ECONOMIC INTEGRATION, TRADE, PRODUCTION FRAGMENTATION , EMU
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INTRODUCTION

The structure of trade has changed drastically over the last two decades; while intermediaries have played an important role in international trade for quite some time, their share of gross trade has risen substantially. This marks the emergence of global supply chains that have altered the nature of international trade.

While the concept of production stages is not new, its role in international trade is poorly understood. The fundamental problem with global supply chains is the inherent complexity, as international production sharing may take on any form and is highly dynamic. It is not surprising then, that current trade theory cannot account for global supply chains without imposing narrow limitation on how they form and thus affect trade.

The oldest of these traditions is the literature on "vertical specialisation" that draws heavily on classical trade theory, most commonly the Ricardian- or Heckscher-Ohlin framework. In such a setting, multi-stage production induces countries to specialise in production stages and while capturing some dynamics of global supply chains, it can only explain a fraction of the true dynamics at play.

However, spatial dispersion of global supply chains is more complex than what can be captured in these frameworks. Another approach is taken by literature that investigates the geographical dimensions of global supply chains. Empirical studies have found that integration into global supply chains vary widely across industries and countries, they also show that the integration has accelerated over the past two decades (Johnson, Noguera 2012b). This literature is built upon accounting frameworks, and so cannot in themselves explain these variation and trends; no current theory can.

In building a comprehensive framework for global supply chains, a crucial part is to unravel the trends in international trade to gain a fundamental understanding of their nature. This is where our paper makes its contribution to current research. We invert the traditional focus on country specialisation and instead propose that industries specialise in production stages. We argue that such specialisation has important implications for the diffusion of welfare effects from trade liberalisation. Industries in the middle of the supply chain has more flexibility in integrating into global supply chains, as they are less bound geographically to end-consumers or raw materials. This implies that trade liberalisation would benefit industries in the middle of the supply chain more than those that are at the extremes. We study the effects of the common currency, the euro, in the

European region and measure the productivity impact for 24 industries in 6 EMU countries over 18 years. We find evidence that industries in the middle of the value chain have gained more than industries at either extreme. Our findings highlight the need for a broader view on global supply chains in trade theory and suggest that *industry* vertical specialisation is an important determinant for the dispersion of welfare effects from trade liberalisation.

LITERATURE REVIEW

Since the work of Jones and Kierzkowski (2001, 1990) it has been known that separation of production, known as "production fragmentation", has important implications for welfare effects from trade. This line of reasoning has yielded several trade models that incorporate multi-stage production in Ricardian or Heckscher-Ohlin trade framework.[1] In such models, countries specialise in a production stage rather than a final good, commonly referred to as "vertical specialisation".[2]

The simplifying assumption that production fragmentation takes the form of vertical specialisation ignores important features of global supply chains. Nevertheless, as a first step towards better understanding, they retain the core notion of multi-stage production as an important determinant of trade.

Caliendo and Parro (2012) are among the first to employ a mutli-sector, multi-country set-up to panel data. Their estimates suggest that ignoring multi-production severely underestimates welfare effects from trade liberalisation. They analyse the effects from the NAFTA trade agreement and find that the welfare effects are 40% lower if one ignores production fragmentation. A similar perspective is that of Levchenko and Zhang (2011, 2012) who employ a multi-factor Ricardian model and estimate welfare effects from trade in the European region. Their findings suggest that gains from trade in Western Europe stems mainly from deeper trade agreements within the region.

Including a richer type of fragmentation is quite challenging as it requires a fundamental understanding of the interrelation between country- and industry specific

[1] See Dixit and Grossman (1982), Yi (2003, 2010), Grossman and Rossi-Hansberg (2008)

[2] We distinguish between vertical specialisation and production fragmentation. Vertical specialisation relates to country-level specialisation in production stages, whereas production fragmentation refers more generally to the spatial dispersion of global supply chains. Thus, vertical specialisation is a special case of production fragmentation.

forces. In attempt to gain a better understanding of supply chain integration, a body of literature draws on organizational theory to generate models of industry-level production fragmentation and trade.[3] The framework of Baldwin and Venables (2010) shed light on how the form of the supply chain impact trade. They examine supply chain integration by modelling production processes as either sequential in nature, or as assembly in no particular order. They show that integration is monotonically increasing for sequential production processes, but not necessarily for random assembly. The main point of their work is to highlight the importance of the production process as a determinant of trade. A different view is offered by Costinot, Vogel and Wang (2011) who turn the issue on its head and instead assume product differentiation *a priori* and derive the implied vertical specialisation. Such findings highlight the complexity of production fragmentation and need for richer trade models capable of capturing the dynamic nature of global supply chains. This literature underscores the need to open the black box of production fragmentation across industries and move beyond models based purely on vertical specialisation.

To avoid making *a priori* assumptions on production fragmentation, a parallel literature estimates supply chain integration by comparing value added trade to gross export.[4] Hummels, Ishii and Yi (2001) measure vertical specialisation as the domestic content of gross export and find evidence of the pervasiveness of vertical specialisation. Their estimates suggest it accounts for 21% of OECD countries' exports, having grown by 30% between 1970-1990.

Johnson and Noguera (2012a, 2012b) generalise their work to allow for "loops" (production processes need not be strictly sequential). The ratio of value-added export to gross export (VAX) measures the extent of supply chain integration, which is synonymous to production fragmentation. They find significant variation in VAX ratios over country-pairs, indicating the heterogeneous nature of production fragmentation. The VAX ratio is consistently lower for European countries indicating the high degree of integration in Europe. Also, measuring changes over time, significant structural changes in production sharing, as the VAX ratio has fallen on average 10-15% over the last four decades. The rate at which the VAX ratio falls has increased three-fold over the past two decades, indicating the importance of global supply chains. They also find that

[3] See Antras and Rossi-Hansberg (2008), Baldwin and Robert-Nicoud (2007) for a review of literature on production fragmentation

[4] This literature builds on literature on input-output linkages, see Moses (1960), Miller (1998), Chen et al. (2009), Hummels, Ishii and Yi (2001)

"deep" trade agreements, such as common currency unions, causes VAX ratios to fall by 10-15%, implying a sharp increase in production fragmentation across member states.[5]

While literature is rapidly diversifying beyond traditional trade models in search for the drivers of economic integration, most focus on country level trends. The reason for this is mainly data-driven. National Accounts do not track stages at which value is added to a product, it is currently not possible to track supply chains on an industry-level.[6]

Another body of literature that is similar to, but distinct from the trade-in-value-add framework maps the linkages between output and input of different industries. Antras et al. (2012) use input-output tables to map the usage of an industry's output through production stages.[7]

As we focus on the European Economic and Monetary Union, we relate our work to literature estimating the trade flow effects from the European common currency union. Henceforth, the common currency union will be referred to as EMU. The gravity equation is the most common tool for estimating the effect from the EMU through various specifications and there is ample evidence of pro-trade effect from the EMU, most commonly in the range of 5-20 %.[8]

However the dispersion of these flows is not clear from empirical work, nor is the welfare effects. One issue related to production fragmentation is whether the EMU has increased trade in the extensive margin, which Bergin and Lin (2012) find evidence of. Interestingly, Baldwin and Di Nino (2006) reject the prediction of trade diversion, as other countries outside the EMU saw significant positive increases in trade flows to EMU countries. And while trade volumes have increased, prices seems to have been left unaffected. Baldwin (2005) show that one can account for these anomalies if we assume all trade effects operates through the extensive margin. However such an explanation is not supported by empirical findings; while Bergin and Lin (2012) indeed find that the extensive margin responds aggressively to the common currency, the intensive margin also increased substantially following the introduction of EMU.

[5] For a full review, see Baldwin (2011), Baldwin (2012), Baldwin and Lopez-Gonzalez (2013)
[6] See Johnson and Noguera (2012a, 2012b) for a discussion
[7] See also Antras and Chor (2012)
[8] See Micco, Stein and Ordonez (2003), Bun and Klaassen (2002), de Nardis and Vicarelli (2003)

FRAMEWORK & HYPOTHESIS

Our framework builds on the core concept of Baldwin and Venables (2010), but is distinct in that we take a more general approach. The essential notion from their work is that the engineering process governs the “shape” of the production process. Consequently, the “shape” represents a comparative cost structure, which in turn determines the dynamics of trade. We show that the flexibility of input choices for a production stage is an important determinant of its ability to gain from trade. Industries bound by resources or domestic markets have less flexibility, reducing their possible gains from trade compared to intermediate production stages.

Antras et al. (2012) find that there exists a sequential link between industries, indicating that some industries are systematically closer to the end-consumers than other. They call the conceptual distance from end-consumers a measure of “upstreamness”, where an “upstream” industry is closer to raw materials and “downstream” industry is closer to end-consumers. We propose that vertical specialisation of industries is caused by the integration of supply chains, and is not a result of country specialisation. Instead, it is driven by technological requirements of the production process.

In doing so, we invert the traditional view that countries specialise in a stage of the production process. Our proposal states that industries specialise in stage in the production process, but place no restriction on country resource allocation.

Note that the traditional view in trade models of vertically specialised countries is a special case of our proposition. Tautologically, a country is not an economic agent as it does not act on its own. When a country vertically “specialise”, this refers to resources being allocated to a vertically differentiated industry. Nevertheless, our proposition is more general in that a country need not systematically allocate resources to a certain industry; indeed a pareto-optimal equilibrium may occur when countries allocate resources to all production stages. What drives trade is how stages are linked together through global supply chains. To illustrate our proposal, we reiterate an example of Baldwin and Venables (2010, p.1):

“*Numerous examples serve to illustrate the pervasiveness of unbundling. The ‘Swedish’ Volvo S40 has an air-conditioner made in France, the headrest and seat warmer made in Norway, the fuel and brake lines in England, the hood latch cable in Germany, and so on.*”

An important fact underlining our framework is that global supply chains are not really global, but a regional process of integration (Baldwin 2011). This means that European countries are highly integrated, but relatively separated from economies outside Europe, such as US or Asian economies.[9]

Thus, we can think of production in Europe as interlinked. While our reasoning does not place any restriction on these linkages, our hypothesis is more easily expounded if we exemplify it with a sequential production process. In a closed economy, a production process starts with the refinement of a raw material R. This material is then used to produce an intermediary product I, which then goes through an arbitrary number of production stages before it is made into a final good and distributed, denoted by D. The production process can schematically be represented as:

$$R \rightarrow I_1 \rightarrow \cdots \rightarrow I_n \rightarrow D$$

where the last stage I_n denotes the final good F so that $I_n = F$. We now introduce another country that may have the same, different or overlapping production stages. If we open up the economies to trade, production stages in the two processes may import inputs from each other. The pattern of trade depends on how we model the economic conditions. Schematically we have:

$$\begin{tikzcd}
R^a \arrow[r] \arrow[dr, dashed] & {I_1}^a \arrow[r] \arrow[dr, dashed] & \cdots \arrow[r] \arrow[dr, dashed] & {I_n}^a \arrow[r] \arrow[dr, dashed] & D^a \arrow[d, dashed, <->] \\
R^b \arrow[r] \arrow[ur, dashed] & {I_1}^b \arrow[r] \arrow[ur, dashed] & \cdots \arrow[r] \arrow[ur, dashed] & {I_n}^b \arrow[r] \arrow[ur, dashed] & D^b
\end{tikzcd}$$

where upper case a and b denote two separate countries. We let dashed arrows denote trade possibilities. In standard trade models, the core mechanism for trade is based on cost minimization at each production stage and trade stems from comparative cost differences. In a modern economy, the assumption of homogenous products is not very likely to be accurate.[10] We take product differentiation into account so that each production stage will purchase the intermediate that best meets the desired trade-off

[9] For empirical evidence, se Johnson and Noguera (2012b), Baldwin and Lopez-Gonzalez (2013)

[10] For an argument on the importance of taking product differentiation into account, see Hallak (2004), Khandelwal (2009)

between quality and costs. Thus moving from autarky to trade can only optimise the production process and we would expect a productivity gain.[11]

The key insight is *where* we would expect the trade to generate productivity gains. Note that refinements of raw materials are bound geographically and so trade would only increase their potential market, but not lead to a technological improvement. The same logic applies for the distribution of final goods; trade would only increase their potential revenue, but not the efficiency of the distribution.[12] Productivity gains would befall intermediate production stages, as this is where optimization of inputs take place. While the example above is a simplification of production processes, it highlights our core point: upstream industries are bound to sources of material, and downstream industries are bound to markets. Note that this is a schematic representation and not a model in itself, we cannot always establish this result if we generalise the production process; added complexity renders the outcome conditional on the specifics of the process.

Nevertheless, we argue that allowing for a more general production process, including "loops" and random assembly order still validates the result above. For example, a random assembly order may take a circular route so that technological backwards diffusion becomes probable. In this scenario, refinement of raw materials may experience a productivity gain. However intermediate stages would benefit even more than they did under sequential production sharing as they have an even greater set of possible inputs. [13]

The essential notion is that production fragmentation requires geographical flexibility, which is possible to a greater extent for industries in the middle of a supply chain, as opposed to those at the end.

A completely random or a strictly sequential production process is not likely to approximate real supply chains. A hybrid between the two implies that the relative effectiveness of substitutes decrease as the "distance" between stages increases. The set of effective substitutes for a given production stage may lie both upstream and downstream of that stage, but within relative proximity. In this setting, industries in the middle of the production stage have the greatest flexibility in input choice and thus have

[11] At worst there will be no trade, preserving *status quo*
[12] However for this to hold, we must assume that technological diffusion cannot go backwards in a sequential production process, nor spread from production to services.
[13] We can also relax the implicit assumption of technological diffusion between production and services, the reasoning will be equivalent

the greatest potential to benefit from trade. For example, “downstream” industries such as retail trade in Netherlands or “upstream” industries such as wood production in Finland are bound to the location of end-consumers and wood, respectively. Their flexibility is not as great as that of intermediate industries, for instance the optics industry in Germany, which may alter inputs on either the supply- or demand side. Our hypothesis is therefore:

The common currency union in the European Union has had a greater productivity impact on industries in the middle of supply chains, compared to upstream or downstream industries.

Our second hypothesis is implied in our framework:

T*he EMU had a positive average effect on productivity*

We have already mentioned that in terms of production processes, trade can only improve productivity; this is in accordance with virtually all trade models as they imply real welfare gains from trade. Adding to this, there is ample evidence of pro-trade flows from the EMU in the region of 5-20%.

EUROPEAN ECONOMIC AND MONETARY UNION

The European Economic and Monetary Union springs from an ambition of closer economic and monetary co-operation within the European Union (EU) (European Commission 2013). While the process of economic integration has run parallel to EU, the European Economic Monetary Union takes the development towards a single market one step further. In the three-stage process, the third and final platform includes a common currency, the euro.

Risse (1999) claims that variation in attitudes towards the common currency cannot solely be explained by economic interests. Attitudes towards EMU are to a large extent influenced by decision maker’s vision of the European political order.

Advocates of EMU have stressed that not only does the EMU lower trade barriers; it is also a step towards economic stability. As such, acceding countries must adhere to certain standards. In mid-1998 the European Commission concluded that 11 member states (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain) had achieved the level of sustainable convergence required to join the EMU (European Commission 2013). Of the remaining EU-15 countries, Denmark and UK opted out while Sweden and Greece did not meet the necessary conditions. In time, Greece joined the EMU and Sweden is contractually bound to follow at some point in time.

An important aspect investigating the effects of the EMU is whether or not the producers had any influence over potential membership. Polling-data at the time of introduction suggests that public support was 66% in countries adopting the common currency while slightly lower at 48% in the remaining EU-15 countries (The Economist 1999). Figures show that only about 25% felt well-informed about the actual implications of the currency union, indicating that the decision to join the EMU cannot be attributed exclusively to economic interests.

METHOD

Our research design consisted of three stages; 1) we employed industry upstreamness values (UV) of Antras et al. (2012) which are based on the STAN database, and mapped these to industry UV for our industry classification, which is that of the EUKLEMS database. 2) We employed the EUKLEMS database to estimate productivity levels. 3) The two prior steps were linked together to estimate the how the EMU affected productivity levels conditional on upstreamness.

Mapping of Upstreamness Values

We mapped the estimates of Antras et al. (2012), which are based on the OECD STAN database, to industries in the EUKLEMS database. These two databases use almost identical industry classification, which allowed us to map UV directly. When the STAN database was more disaggregated, the industries in our dataset were assigned the average of the sub-industries.

Antras et al. (2012) estimates UV for a certain year (2005). This is somewhat unfortunate as an industry's UV may change with time. Thus, one must contemplate at what rate these changes may take place. A change in UV is analogous to a repositioning of an industry. Such industry-specific repositioning imply there is an exogenous shock that carries such force it causes a disequilibrium in that industry, prompting a complete reshape. Such shocks are few and fare apart and while industries may have been hit by such shocks during our time sample, we argue that the rarity of such events imply that provided there has been some industry-specific shock, it would only distort a small portion of the sample. While not strictly true, assuming constant UV over time is a fair approximation over shorter time-spans such as ours.

Estimation of Total Factor Productivity

Theory of productivity has over the years branched out into several theoretical framework and empirical models. By far the most common framework in empirical work is to specify a constant elasticity of scale (CES) production function, often in the Cobb-Douglas form.[14]

The Cobb-Douglas production function defines output (Y) as a function of Capital (K), Labour (L), and Intermediary (M) inputs. The function makes the implicit

[14] When first introduced by Cobb and Douglas (1928), they imposed the assumption of constant returns to scale. Later, Arrow et al. (1961) extended the function to constant output elasticities that need not equal one.

assumption of constant marginal rate of substitution and strong separability in inputs. Assuming constant output elasticities, technological efficiency is captured as a Hicks-neutral technological change. This is commonly referred to as Total Factor Productivity (TFP). In our notation, familiar function is identified as:

$$Y = AK^{\rho_K}L^{\rho_L}M^{\rho_M}$$

where ρ_i is the output elasticity of input i and A is the Hicks-neutral TFP measure. We impose no restriction on (global) elasticity of scale, defined as $\epsilon = \sum_i \rho_i$. By employing industry-level data, it is assumed that each industry can be represented by an aggregate production function.

We followed Van Beveren (2012) who provides an account of the general procedure in estimating TFP values. The starting point is the logarithmic version of the Cobb-Douglas production function:

$$lnY_{i,t} = lnA_{i,t} + \rho_M lnM_{i,t} + \rho_K lnK_{i,t} + \rho_L lnL_{i,t}$$

The empirical Cobb-Douglas is measured in real values, our data was reported in nominal terms. The EUKLEMS dataset include inflations series for output and total intermediaries and we deflated gross output and total intermediaries with the corresponding price series. As no wage inflation data was compatible with our data, we approximated wage inflation with the price series for intermediaries. Data on capital stock was reported in real terms and we converted all real values into USD.

EU represents a fairly homogenous economic environment and we argue that the producer specific factors will not differ significantly between countries; thus we assume that production technology (*i.e.* output elasticities) differ between industries, but not across countries. This has another intuition as the Hicks-neutral TFP factor measures technological differences exogenous to the production function, such as country-specific differences. We arrived at the following econometric production equation:

$$y_{i,j,t} = \beta_{0,i} + \beta_{m,i}m_{i,j,t} + \beta_{k,i}k_{i,j,t} + \beta_{l,i}l_{i,j,t} + \epsilon_{i,j,t}$$

Where t denotes time, i denotes industry, j country, lower-case letters denote natural logarithms. $\epsilon_{i,j,t}$ is an unobserved productivity shock term that includes two types of effects; producer specific efficiency shocks $(e_{i,j,t})$ and idiosyncratic errors $(u_{i,j,t})$. $(u_{i,j,t})$ is an i.i.d. component that includes misspecification- and measurement errors. Consequently we have that $\epsilon_{i,j,t} = u_{i,j,t} + e_{i,j,t} = e_{i,j,t}$. Comparing the logarithmic Cobb-Douglas with the production model, we note that:

$$lnA_{i,j,t} = a_{i,j,t} = \beta_{0,i} + \epsilon_{i,j,t} = \beta_{0,i} + e_{i,j,t}$$

To obtain TFP estimates, we first estimated the output elasticities by running the following regression using OLS:

$$y_{i,j,t} = \beta_{0,i} + \beta_{m,i}m_{i,j,t} + \beta_{k,i}k_{i,j,t} + \beta_{l,i}l_{i,j,t} + e_{i,j,t}$$

Using estimated output elasticities, we rearranged the estimated production model and solved for TFP according to the equation:

$$\hat{a}_{i,j,t} = \hat{\beta}_{0,i} + \hat{e}_{i,j,t} = \hat{y}_{i,j,t} - \hat{\beta}_{m,i}m_{i,j,t} - \hat{\beta}_{k,i}k_{i,j,t} - \hat{\beta}_{l,i}l_{i,j,t}$$

To find the TFP estimates, we solved $\widehat{\Omega}_{i,j,t} = e^{\hat{a}_{i,j,t}}$.

Theory shows that the obtained TFP estimates suffer from simultaneity bias, generally resulting in a positive correlation between labour and capital (Van Beveren 2012). This can be seen in the standard set-up of diminishing MRTS; if an unobserved productivity shock induces a producer to increase production, the optimal choice will be to increase both inputs. As capital is quasi-fixed and labour is variable, labour will correlate more with the productivity shock. Levinsohn and Petrin (2003) demonstrate that coefficient for labour will be positively biased and the capital coefficient will be negatively biased. Most theoretical issues with productivity are at the firm-level, so corrections require firm-level data. We argue that the direction of the bias in output elasticities remain unchanged throughout our time period as it relates to fundaments of production; estimated coefficients are consistent and will not affect final results. [15]

[15] Mendershausen (1938) argues that the function can at best be seen as an ex post measure of trend in technological change. Following his critique, Simon and Levy (1963) question whether it can be interpreted as a

EMU Productivity Impact and Upstreamness

We combined the assigned UV for each industry with their estimated total factor productivity in a difference-in-difference (DID) regression. Wooldridge (2008) lay out the fundamentals of the DID method and its applicability; this is especially pertinent when data reflects a natural experiment. In our case, the policy change is an exogenous event where governments are changing their monetary policy, and consequently altering the conditions in which producers operate. Two key criteria need to be met for the DID method to estimate the true effect of the policy change; first the treatment group and control group must be similar so that any changes pre- and post-event are indeed due to the event. Second, the policy change must be exogenous; otherwise there is risk of self-selection bias.

The treatment group consisted of countries joining the EMU at the time of introduction. The control group comprised EU member states that did not adopt the common currency in 1999. The countries included are presented in Table 1 (Appendix). The Czech Republic and Slovenia were included in the control group to allow for a more sizeable control group, although not EU member states until 2004. We argue that the strict accession process into EU ensures potential members assimilate institutional structures and economic factors in advance of actual acceptance (European Union 2013). The control- and treatment group are similar due to the relatively homogenous culture and economic environment within the EU. Henceforth, the treatment group is referred to as 'EMU countries' and our control group as 'non-EMU countries'.

The choice of joining the EMU was either decided by parliament or by public voting, both are procedures beyond the control of any producer. Adding to that, there were no apparent preferences. At the time of introduction, the approval rate was 66% in EMU countries compared to 48% in non-EMU countries. In public opinion, the EMU was poorly understood, just above 20% stated they felt well-informed (The Economist 1999). We conclude that the decision to join or not to join the common currency was ambiguous and the outcome beyond the control of producers. As such, the introduction of the EMU was an exogenous event.

production function. Marschak and Andrews (1944) noted that inputs are not independently chosen, but relate to unobservable economic conditions of the firm, resulting in the simultaneity problem. Griliches and Mairesse (1997) provide an overview of theoretical issues with productivity estimation while Van Beveren (2012) and Van Biesebroeck (2004) provide accounts of predominant responses in econometric research.

Along with the treatment- and control group, we defined two periods; pre- and post-EMU introduction. Our sample could then be broken down into four groups. The group of interest is the one including EMU countries post-EMU introduction. We defined a dummy variable that took on the value 1 if an observation was from an EMU-country after the break year. Otherwise, the dummy variable took on the value 0.

While defining the country-groups was fairly straightforward, the break-year is not an obvious choice. We followed Micco, Stein and Ordonez (2003), who detect a structural break the year post-EMU introduction, 1999. We specified our DID regression as:

$$\hat{a}_{i,j,t} = \beta_0 + CTRY_j + IND_i + YEAR_t + \beta_{V1} v_{i,j} + \beta_{V2} {v^2}_{i,j} + \beta_E EMU_i + \beta_{EV1}(v_{i,j} \times EMU_i) + \beta_{EV2}({v^2}_{i,j} \times EMU_i)$$

where EMU_i is the dummy variable separating out observations from an EMU member state after the break year. $v_{i,j}$ represent the natural logarithm of UV from industry i and country j. $CTRY_j$, IND_i and $YEAR_t$ are the country-, industry- and year dummies that controlling for additional institutional and/or technological trends over time. Adding these dummies will however prohibit the use of R-squared in a deterministic manner because the dummy variables on all dimensions will capture much of the variation.

Once the estimated coefficients had been obtained, we tested our hypothesis by evaluating the average treatment effect:

$$D = Treatment\ group - Control\ group = \beta_E + \beta_{EV1} \times v_m + \beta_{EV2} \times {v_m}^2$$

where v_m denotes any UV drawn from the EMU sample.

DATA

Upstreamness

The underlying data used by Antras et al. (2012) is drawn from the Input-Output tables in the OECD STAN database. Input-Output tables describe the relationship between sales and purchases among producers and consumers within an economy. In the OECD STAN Input-Output database, flows are illustrated for both final and intermediary sales and purchases using industry outputs (Nadim, Yamano 2006).

Antras et al. (2012) measure an industry's conceptual distance from the end consumer. The method assumes that the value of output in any industry Y_i is the sum of its use as final good F_i and the sum of its use as an intermediate good Z_i. Intermediate goods are measured in terms of how much is used in the production in another industry:

$$Y_i = F_i + Z_i = F_i + \sum_j d_{i,j} Y_j$$

where d_{ij} is the dollar amount of industry *i*'s output needed to produce one dollar's worth of output in industry *j*. The authors assume $d_{ij} \leq 1$, which imply a ratio relating the value of industry *i* inputs in the production of industry *j* outputs. By iterating this identity with respect to industries *j*, the index express how industry *i*'s output is used as intermediate at different positions in the value chain:

$$Y_i = F_i + \sum_j d_{i,j} F_j + \sum_j \sum_k d_{i,k} d_{k,j} F_j + \cdots$$

Antras and Chor (2012) suggest constructing an UV measurement by weighing each stage with an integer value and dividing with the industry total output. The UV measures how the total output is used as intermediates, as well as how much of that is in turn used as intermediates:

$$U_i = 1 \times \frac{F_i}{Y_i} + 2 \times \frac{\sum_j d_{i,j} F_j}{Y_i} + 3 \times \frac{\sum_j \sum_k d_{i,k} d_{k,j} F_j}{Y_i} + \cdots$$

Note that each term is conceptually a different production stage, and that the more of an industry's output that is required in the production of another industry's output, the higher the UV.

Productivity

EUKLEMS is part of a research project estimating productivity in the EU and financed by the European Commission.[16] The database has primarily been constructed by pooling data from national statistical offices. Where needed, the data has been harmonised to ensure comparability. Main areas of harmonisation have been industry classification and price indexing for output and intermediaries. We make use of time series data on 24 industries, in 11 countries, over 18 years, leaving us with a balanced dataset containing approx. 4400 observations.[17] The selection of countries was constrained by data. For the Czech Republic, Germany, Slovenia, and Sweden some years are missing in the beginning and/or the end of our time period.

We employed the EUKLEMS dataset on 32 industries, as it most closely followed the STAN industry classification used by Antras et al. (2012). From this industry set, we excluded industries in the non-competing sectors, such as government-owned services. The reason is two-fold; first, O'Mahony and Timmer (2009) warn that the lack of a competitive market threatens the integrity of estimations on quantity and price deflators. We also excluded real estate as the authors stress that these measures include non-competitive estates and may bias any estimates for the same reason.

In EUKLEMS, industry total gross output, total intermediaries, and corresponding volume and price series are taken from National Accounts series of each individual country. Total labour cost in some industry j at any time t, is defined as

$$L_{j,t} = P_{j,t}^{L} \times Q_{j,t}^{L} \;=\; T_{j,t}^{L} + LC_{j,t}^{e} + \; LC_{j,t}^{s}$$

where $T_{j,t}^{L}$ is labour tax, $LC_{j,t}^{e}$ is compensation of employees, $LC_{j,t}^{s}$ compensation of self-employed. Labour compensation is derived from National Accounts data on work force, hours worked and labours unit cost.

[16] The version employed is the November 2009 release of the 32-industry datasets, available at www.euklems.net. For a full review of EUKLEMS, see O'Mahony and Timmer (2009), Timmer et al. (2007a, 2007b)

[17] For a comprehensive list of Countries, see Table 1 in Appendix

The capital stock in EUKLEMS is constructed starting with a base value from National Accounts and complemented with depreciation rates and rates of return from US Bureau of Economic Analysis as these are more detailed. This captures the well documented concept that different types of assets vary in efficiency and deteriorate with time, the so called vintage effect. Timmer et al. (2007b) base the construction of the capital stock on the widely known perpetual inventory method. This method value the "effective" asset stock A at time t as a weighted sum of past investments, where weights relate to the vintage effect. In specifying the vintage effect, θ_t, the authors assume a geometric depreciation pattern based on a constant depreciation rate δ_k. The vintage term for an asset type *k* at time *t* is defined as $\theta_t = (1-\delta_k)^t$. Any $A_{k,t}$ is then defined as:

$$A_{k,t} = \sum_{\tau=0}^{\infty} \theta_{k,\tau} I_{k,t-\tau} = \sum_{\tau=0}^{\infty} (1-\delta_k)^{\tau} I_{k,t-\tau} = (1-\delta_k) A_{k,t-1} + I_{k,t}$$

where $I_{k,t}$ denotes net investments in asset type k at time *t*. Two important implicit assumptions are made in this formulation; first, different services from different types of vintages are perfect substitutes (Timmer et al. 2007b). Second, the rate of technological diffusion remains fairly stable. The resulting function for the capital stock for an industry *i* at a time *t* is then the sum of the sub-types of assets:

$$K_t^i = \sum_k A_{k,t}^i$$

RESULTS

Upstreamness Values

The UV estimates of Antras et al. (2012) are presented in Table 2 (Appendix). The sample mean is 2.5 with 50% of estimates within the range of 2.0-3.0. In terms of production stages, this implies that the middle of a supply chain is approximately 2-3 production stages away from the end-consumer. Industry estimates deviate considerable from the average industry UV, as presented in table 3 (Appendix). Industry estimates for Germany, Austria and UK are systematically lower than industry averages, while industry estimates for Finland the Czech Republic are systematically higher than industry averages. This suggests these economies are geared towards one extreme of the supply chain, indicating country-level vertical specialisation. However, all industry deviations are not consistent, some industries deviates in the opposite direction. This points to the complexity of production fragmentation; while a country may be vertically specialised, industries within that country are not always necessarily specialised in a similarly.

Adding to that, in remaining countries, industries deviate strongly in either direction or not at all. There seems to be no clear determinant of what industry deviate and in which direction. This heterogeneity supports our proposition that vertical specialisation of industries is not necessarily a result of country specialisation.

Note that there is a central tendency of the distribution of UV estimates, presented in Figure 1 (Appendix). Some of this central tendency can be expected from economic intuition; while we do not know what determines the number of production stages, it is quite intuitive that too many would be ineffective as the coordination cost would outweigh the benefit of division of labour. However much of this central tendency may be caused by the use of aggregated data. Aggregating sub-industries will hide inherent heterogeneity and if such variation is present throughout industries, the estimated UV will crowd towards the mean, underestimating the true vertical distance in production processes. A pointer that there is an issue with aggregated data, are some peculiar results, implying that suppliers are more downstream than their main market. Take for instance the transport equipment industry, whose main market is arguably the more upstream transport market.

Total Factor Productivity

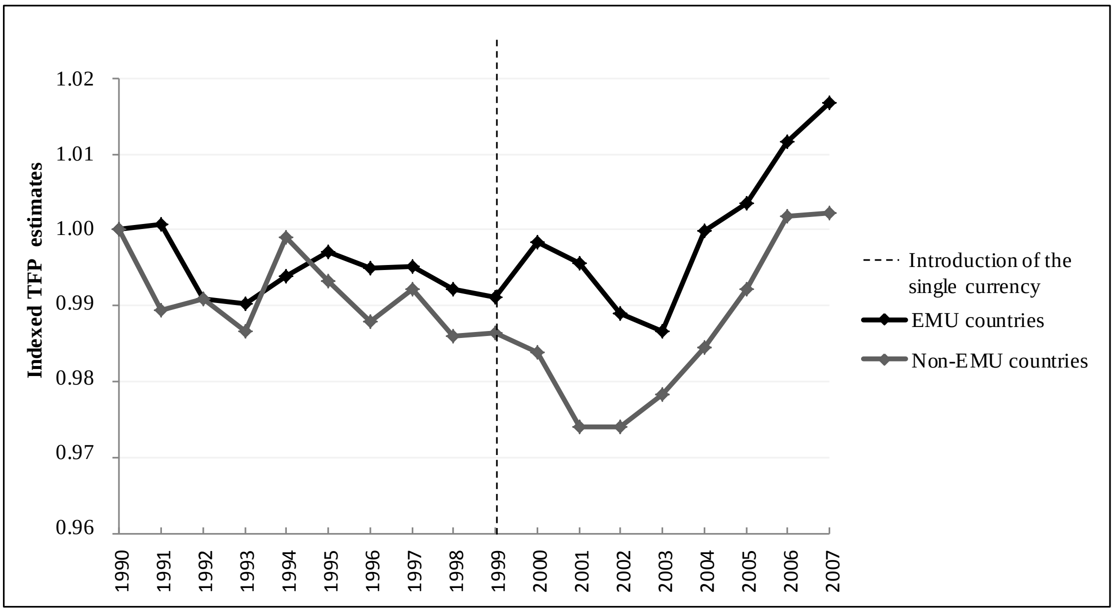
Running the regression on gross real output yields coefficients for capital, labour and intermediaries presented in Table 4 (Appendix). We note that the estimates imply constant returns to scale in all industries. While intermediates and labour show reasonable estimates, the capital coefficients are rather low in several cases which is to be expected from the simultaneity bias (most of these low estimates are also insignificant).

Comparing the correlation between the coefficients and upstreamness reveal an interesting link to economic fundamentals; the correlation between the labour coefficient and upstreamness is -0.40, implying that the incremental effect on output from additional labour declines slightly with upstreamness. Conversely, the correlation between the intermediary coefficient and upstreamness is 0.28, implying that the incremental effect on output from additional intermediary inputs increase marginally with upstreamness. Intuitively, upstream industries are generally more capital intensive and with capital being fixed in the short run, output is primarily determined by the amount of intermediates to be processed. A visual inspection of the coefficients suggest upstream industries, are highly dependent on input materials with estimated coefficients approximately 15% higher than the average.

Logarithmic TFP estimates are fairly normally distributed around 0.66, as illustrated in Figure 2 (Appendix). Average industry TFP shows no apparent trend, industries display non-monotonic time trends and there is an even split between industries accumulating a modest gain or loss in the region of 10%.

Comparing indexed average TFP for EMU countries and non-EMU countries, presented in Figure 3, we detect signs of a structural break. Before the introduction of the common currency, there are no systematic differences between average TFP between the two groups. After the introduction of the common currency however, EMU countries experience an increase of approximately 1 percentage point, while non-EMU countries decline marginally. EMU-countries sustain higher TFP level throughout our sample.

FIGURE 3: TFP MOVEMENTS



Effects from EMU

The results from the DID regressions is presented in Table 5. We compare a specification where the relations between logarithmic TFP (lnTFP) and logarithmic UV (lnUV) is linear with a specification that is non-linear. An F-test on the interaction terms indicate the both specification are significant, but that the non-linear specification is a better fit. Comparing an lnUV specification with a UV in level form show a remarkable resemblance. In both cases, the EMU dummy variables and linear interaction terms are significant at the 1% level, while the squared interaction terms are significant at the 5% level. An F-test for joint significance for interaction terms yields an F-statistic of 12.83 and 10.85 respectively, implying joint significance.

Interestingly, the use of lnUV or UV as regressor yields identical results in evaluating the estimated effect from EMU. As our starting point was the logarithmic version, we will discuss the results from this specification, although any results presented also hold if UV is in level form.

TABLE 5: REGRESSION RESULTS - EMU EFFECT ON TFP WITH REGARDS TO UPSTREAMNESS

VARIABLES	LINEAR LN UPSTREAM lnTFP	NON-LINEAR LN UPSTREAM lnTFP	NON-LINEAR LEVEL UPSTREAM lnTFP
EMU-dummy	-0.0138	-0.0827***	-0.119***
	(0.0105)	(0.0262)	(0.0398)
ln UV	-0.0299***	-0.110***	
	(0.0113)	(0.0402)	
UV			-0.0442*
			(0.0235)
$(\ln UV)^2$		0.0463*	
		(0.0238)	
UV^2			0.00638
			(0.00441)
EMU * ln UV	0.0281**	0.206***	
	(0.0119)	(0.0705)	
EMU * UV			0.0955***
			(0.0337)
EMU * $(\ln UV)^2$		-0.104**	
		(0.0446)	
EMU * UV^2			-0.0163**
			(0.00694)
Constant	0.718***	0.748***	0.227***
	(0.0116)	(0.0166)	(0.0336)
Industry Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	4,392	4,392	4,392
R-squared	0.914	0.914	0.914

UV denotes upstreamness values
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The estimated average treatment effect is obtained as:

$$\hat{D} = \hat{\beta}_E + \hat{\beta}_{EV1} \times \hat{v}_m + \hat{\beta}_{EV2} \times \hat{v}_m{}^2 = -0.0827 + 0.206 \times \hat{v}_m - 0.104 \times \hat{v}_m{}^2$$

Note that he treatment effect relates to the difference between two logarithms, which can be approximated by (Wooldridge 2008):

$$\ln(y_j) - \ln(y_k) \approx \frac{y_j - y_k}{y_k} = \frac{\Delta y}{y_k} \quad s.t. \quad \left|\frac{\Delta y}{y_k}\right| \ll 1$$

This approximation lends the treatment effect an intuitive appeal, as it measures the relative difference in productivity between EMU countries and non-EMU countries conditional on upstreamness. To find the percentage effect from EMU, the treatment effect is multiplied with 100 so that $\%\widehat{\Delta} \approx 100 \times \widehat{D}$.

The functional form of $\widehat{D}$ suggest that the effect of EMU is concave in lnUV. The concave relationship can easily be seen by taking the derivative with respect to any value of v_m:

$$\frac{d(D)}{d(v_m)} = 0.206 - 0.208 \times v_m$$

While the derivative is positive for small values of v_m, it is monotonically decreasing in v_m. The derivate is equal to zero at v_m= 0.99 where the function reaches it maximum % effect from EMU (1.95). The corresponding level UV is 2.69, which very close to the estimated mean UV of 2.50. Although the relationship is indeed concave, visual inspection shows that the relationship is very sensitive to changes in the most upstream industry, Mining and quarrying, as this industry 'pulls' the slope downwards.

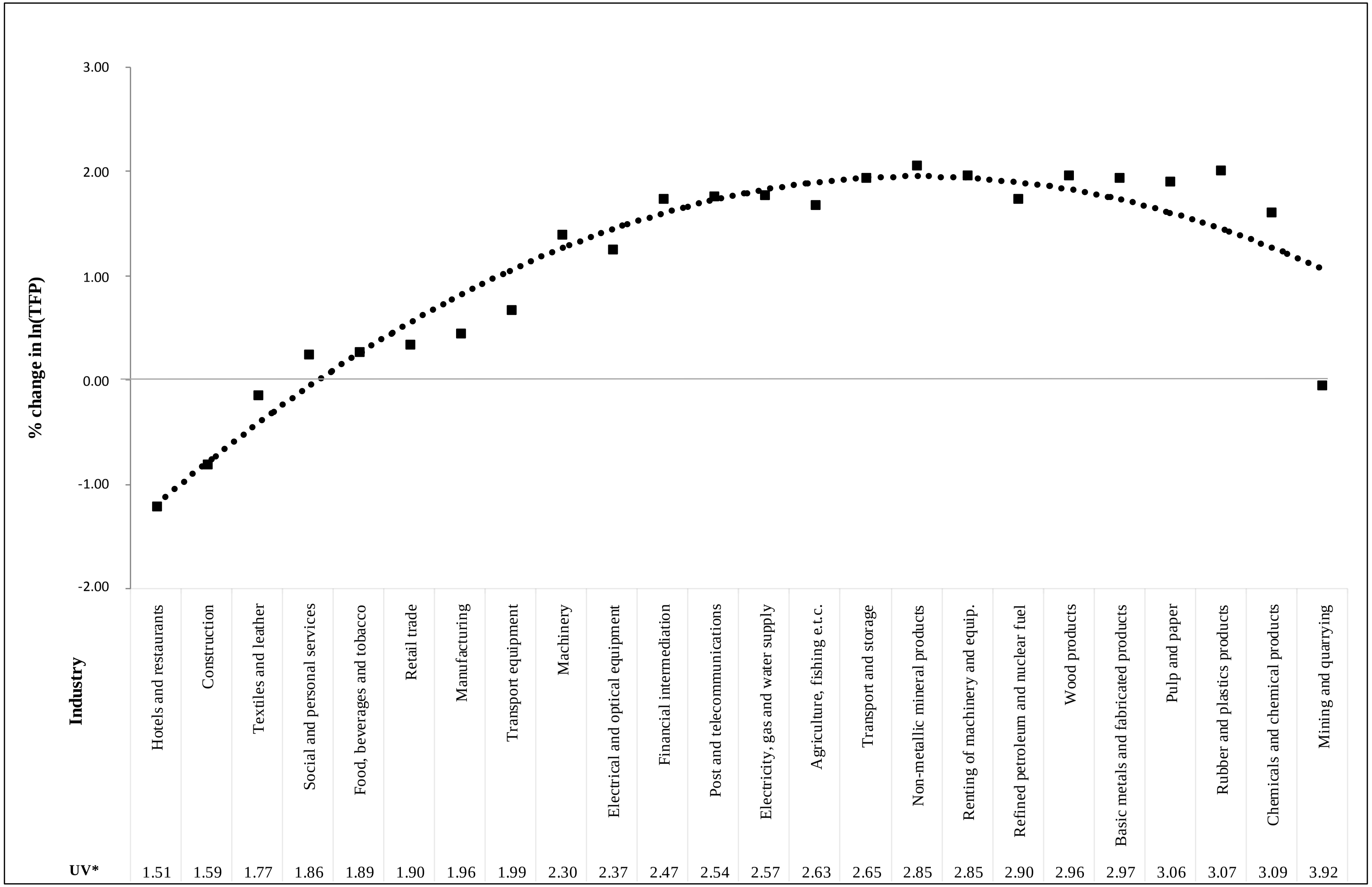
Turning to the estimated effects, Figure 4 presents the average estimated industry effect.[18] Two features stand out; first, the three most downstream industries exhibit negative productivity impacts from EMU, which is mainly due to the very downstream estimates for German Industries and to some extent Austrian industries (Table 6, Appendix). Second, the downstream side of supply chains seem to have gained less than the upstream side of the supply chain, which display considerable resilience. The country-specific estimates are presented in figures 6A-6F (Appendix), which show a general tendency for asymmetric productivity gain for upstream and downstream industries. This suggest downstream industries are less flexible than upstream industries. In our framework, the only plausible explanation is that there is very limited technological diffusion between services and production, so that the determinants of trade impact on productivity for downstream industries are separate from that of more upstream industries. To investigate this more formally, more disaggregated data and formal trade theory incorporating production processes is needed.

Lastly, we note that the average country effect and effect for EMU as a whole is positive at 1.11%, confirming that the EMU has yielded a productivity gain.

We conclude that industries in the middle of supply chain gains more from "deep" trade agreements compared to industries further upstream or downstream, thus confirming our hypothesis.

[18] Figure 5 (Appendix) plots all country effects simultaneously and Figures 6A-6F (Appendix) illustrates the effect of our EMU countries separately.

FIGURE 4: AVERAGE % EFFECT OF EMU ON TFP



*UV denotes average Upstreamness Value per industry

Robustness

To control for data issues, we first perform a Breusch-Pagan test determining the presence of heteroskedasticity in both the TFP regressions and the DID regression. We correct for this by estimating robust standard errors.

We are concerned with the likely bias in our productivity coefficients. We worry that the labour coefficient is positively biased and that the capital coefficient is negatively biased. We exclude negative capital coefficients in the DID which generates a slightly greater average effect of the EMU and a more symmetric function. Excluding insignificant capital coefficients instead lowers the average EMU effect from 1.11% to 0.89% as can be seen in Table 5 in Appendix.

In addition, we also tested the effect of including the Czech Republic and Slovenia in our control group. The rationale behind the inclusion was the strict accession process proceeding EU membership, indicating that economies would have been aligned prior to their admittance in 2004. Excluding the Czech Republic and Slovenia from our sample, significance is preserved and the estimated coefficients are essentially unaffected.

Furthermore, we have previously assumed 1999 as break-year because this is when the common currency was first introduced. To hedge against potential noise in the transition period, we exclude the years surrounding the introduction, 1998-2000. Significance is preserved but the coefficients increase in absolute terms. In effect, the difference function becomes more pronounced (and symmetric). As in the case of the negative capital coefficients, the maximum value increased and the curve shifted slightly towards downstream industries. We see a greater average effect, but not materially different from the original estimate. We also test the average EMU effect using different break-years, leaving the significance levels essentially unaffected. The general productivity effect is persistently positive, as can be seen in Figure 7. In conclusion, while the discussed changes do affect our results, the impact is minor.

CONCLUSION

We propose an alternate view on how production fragmentation and trade is interrelated. In our framework trade is governed by the technical requirements of the production process; we show that industries that vertically specialise in the middle of the supply chain will be command the greatest flexibility in input choice from production fragmentation. This in turn yields greater possibilities for productivity increases from trade. We test this hypothesis against the introduction of the EMU and find that there is a statistical significant relationship between productivity gains and industry-level vertical specialisation, where industries in the middle of the supply chain reaped the greatest rewards.

Interestingly, our findings also sit well with estimates of trade flow effects from “deep” trade agreements such as EMU. Since a productivity shock increases value add, our estimates suggest value added trade increased with 1.11%. Comparing this to an increase in gross trade with 5-20%, the value added content of trade would fall by 7-16%, which is in accordance with what Johnson and Noguera (2012b) find by an alternate route. This highlights the persistence of production sharing and the real welfare gains from integrated supply chains.

Our findings underscores the complexity and pervasiveness of global supply chains. We show that apart from country-level specialisation, industry-level specialisation is an important determinant of the impacts from trade. However our findings are not general and a more thorough framework for production fragmentation, industry vertical specialisation and trade would be topic for future research.

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APPENDIX

TABLES

TABLE 1: DATA OVERVIEW

Country	Abbrev.	Years	No. of Industries	No. of Observations	EMU	Mean Upstreamness
Austria	AUT	1990-2007	24	432	YES	2.37
Finland	FIN	1990-2007	24	432	YES	2.82
Germany	GER	1991-2007	24	408	YES	2.25
Italy	ITA	1990-2007	24	432	YES	2.45
Netherlands	NLD	1990-2007	24	432	YES	2.60
Spain	ESP	1990-2007	24	432	YES	2.49
Czech Republic	CZE	1995-2007	24	312	NO	3.06
Denmark	DNK	1990-2007	24	432	NO	2.48
Slovenia	SVN	1995-2006	24	288	NO	2.53
Sweden	SWE	1993-2007	24	360	NO	2.61
United Kingdom	UK	1990-2007	24	432	NO	2.07
Total	11	1990-2007	24	4392	6 YES / 5 NO	2.51

TABLE 2: UPSTREAMNESS VALUES BY COUNTRY AND INDUSTRY

	AUT	FIN	GER	ITA	NLD	ESP	CZE	DNK	SVN	SWE	UK	Mean	SD	SD / Mean
Hotels and restaurants	1.49	1.78	1.30	1.51	1.89	1.18	2.05	1.74	1.70	1.80	1.22	1.59	0.27	0.17
Construction	1.57	1.45	1.40	1.55	1.81	1.82	2.01	1.50	1.77	1.81	1.70	1.66	0.17	0.11
Textiles and leather	1.61	1.74	1.47	2.20	1.67	1.98	3.40	1.71	2.94	1.71	1.31	1.91	0.56	0.29
Social and personal services	1.85	1.71	1.93	1.97	2.05	1.70	1.94	2.04	1.58	1.78	1.71	1.85	0.14	0.08
Food, beverages and tobacco	1.68	2.20	1.49	1.96	2.26	1.84	1.96	2.28	1.81	1.75	1.58	1.90	0.26	0.14
Retail trade	1.84	2.16	1.69	1.99	1.96	1.77	2.87	1.78	2.04	2.02	1.75	1.96	0.28	0.15
Manufacturing	1.74	2.50	1.62	2.03	1.61	2.48	2.78	1.74	2.39	2.20	1.51	2.02	0.41	0.20
Transport equipment*	2.12	1.93	1.98	2.12	1.86	1.95	2.44	1.67	2.04	2.59	1.51	2.00	0.28	0.14
Machinery	2.23	2.75	2.15	2.03	2.43	2.29	2.23	2.24	1.90	2.35	1.88	2.23	0.23	0.11
Electrical and optical equipment*	2.10	3.49	2.24	2.15	2.43	2.06	3.48	2.36	2.27	2.14	2.01	2.41	0.50	0.21
Financial intermediation	2.50	2.47	2.41	2.64	2.50	2.31	3.04	2.22	2.34	2.41	1.98	2.43	0.24	0.10
Post and telecommunications	2.52	3.07	2.35	2.51	2.34	2.51	2.99	2.80	2.31	2.58	2.38	2.58	0.24	0.10
Electricity, gas and water supply*	3.07	2.76	2.27	2.34	2.50	2.54	2.49	1.93	2.38	2.64	2.11	2.46	0.30	0.12
Agriculture, fishing e.t.c.	2.52	3.35	2.03	2.60	3.01	2.41	2.77	3.02	2.15	2.92	1.80	2.61	0.45	0.18
Transport and storage*	2.55	2.91	2.76	2.45	2.55	2.73	3.21	3.41	3.20	3.27	2.30	2.82	0.35	0.13
Non-metallic mineral products	2.68	2.97	2.69	2.94	2.88	2.95	3.54	2.68	2.91	3.02	2.45	2.86	0.25	0.09
Renting of machinery and equip.*	2.74	3.40	2.67	2.83	2.97	2.56	3.13	2.70	2.72	2.78	2.64	2.83	0.23	0.08
Refined petroleum and nuclear fuel	2.49	3.35	2.49	2.54	3.67	3.04	3.49	3.47	2.44	3.09	2.02	2.92	0.52	0.18
Wood products	2.83	3.13	2.65	2.98	2.74	3.47	4.22	2.65	3.62	3.37	2.54	3.06	0.46	0.15
Basic metals and fabricated products	2.57	3.49	2.77	2.91	3.17	3.00	4.04	3.13	3.21	3.04	2.40	3.04	0.40	0.13
Pulp and paper	3.22	3.59	2.60	2.88	2.96	3.14	3.87	3.07	3.26	3.24	2.47	3.10	0.37	0.12
Rubber and plastics products	2.91	3.19	2.86	3.07	3.09	3.31	3.95	2.97	3.36	3.15	2.50	3.09	0.32	0.11
Chemicals and chemical products	2.70	3.64	2.71	2.98	3.98	2.74	3.52	3.15	2.90	2.91	2.64	3.08	0.43	0.14
Mining and quarrying*	3.41	4.88	3.48	3.67	4.33	3.93	4.28	3.54	3.56	4.21	3.24	3.86	0.48	0.13

*unweighted average from sub-industries

Source: Upstreamness Values were extracted using the works of Antras et al. (2012)

TABLE 3: UPSTREAMNESS VALUES - DEVIATION FROM MEAN - BY COUNTRY AND INDUSTRY

	AUT	FIN	GER	ITA	NLD	ESP	CZE	DNK	SVN	SWE	UK
Hotels and restaurants	-0.06	0.12	-0.18	-0.05	0.19	-0.26	0.29	0.09	0.07	0.13	-0.23
Construction	-0.05	-0.13	-0.16	-0.07	0.09	0.10	0.21	-0.10	0.07	0.09	0.02
Textiles and leather	-0.16	-0.09	-0.23	0.15	-0.13	0.04	0.78	-0.10	0.54	-0.10	-0.31
Social and personal services	0.00	-0.08	0.04	0.06	0.11	-0.08	0.05	0.10	-0.15	-0.04	-0.08
Food, beverages and tobacco	-0.12	0.16	-0.22	0.03	0.19	-0.03	0.03	0.20	-0.05	-0.08	-0.17
Retail trade	-0.06	0.10	-0.14	0.02	0.00	-0.10	0.46	-0.09	0.04	0.03	-0.11
Manufacturing	-0.14	0.24	-0.20	0.00	-0.20	0.23	0.38	-0.14	0.18	0.09	-0.25
Transport equipment*	0.06	-0.04	-0.01	0.06	-0.07	-0.03	0.22	-0.17	0.02	0.30	-0.25
Machinery	0,00	0.23	-0.04	-0.09	0.09	0.03	0,00	0,00	-0.15	0.05	-0.16
Electrical and optical equipment*	-0.13	0.45	-0.07	-0.11	0.01	-0.15	0.44	-0.02	-0.06	-0.11	-0.17
Financial intermediation	0.03	0.02	-0.01	0.09	0.03	-0.05	0.25	-0.09	-0.04	-0.01	-0.19
Post and telecommunications	-0.02	0.19	-0.09	-0.03	-0.09	-0.03	0.16	0.09	-0.10	0.00	-0.08
Electricity, gas and water supply*	0.25	0.12	-0.08	-0.05	0.02	0.03	0.01	-0.22	-0.03	0.07	-0.14
Agriculture, fishing e.t.c.	-0.03	0.28	-0.22	0.00	0.15	-0.08	0.06	0.16	-0.18	0.12	-0.31
Transport and storage*	-0.10	0.03	-0.02	-0.13	-0.10	-0.03	0.14	0.21	0.13	0.16	-0.18
Non-metallic mineral products	-0.06	0.04	-0.06	0.03	0.01	0.03	0.24	-0.06	0.02	0.06	-0.14
Renting of machinery and equip.*	-0.03	0.20	-0.06	0.00	0.05	-0.10	0.11	-0.05	-0.04	-0.02	-0.07
Refined petroleum and nuclear fuel	-0.15	0.15	-0.15	-0.13	0.26	0.04	0.20	0.19	-0.16	0.06	-0.31
Wood products	-0.08	0.02	-0.13	-0.03	-0.10	0.13	0.38	-0.13	0.18	0.10	-0.17
Basic metals and fabricated products	-0.15	0.15	-0.09	-0.04	0.04	-0.01	0.33	0.03	0.06	0.00	-0.21
Pulp and paper	0.04	0.16	-0.16	-0.07	-0.05	0.01	0.25	-0.01	0.05	0.05	-0.20
Rubber and plastics products	-0.06	0.03	-0.07	-0.01	0.00	0.07	0.28	-0.04	0.09	0.02	-0.19
Chemicals and chemical products	-0.12	0.18	-0.12	-0.03	0.29	-0.11	0.14	0.02	-0.06	-0.06	-0.14
Mining and quarrying*	-0.12	0.26	-0.10	-0.05	0.12	0.02	0.11	-0.08	-0.08	0.09	-0.16

*unweighted average from sub-industries

Source: Upstreamness Values were extracted using the works of Antras et al. (2012)

TABLE 4: INDUSTRY DATA - ESTIMATED COEFFICIENTS

Industry	Mean Upstreamness [a]	$\beta_{k,i}$ [b]	$\beta_{l,i}$ [b]	$\beta_{m,i}$ [b]	Implied EOS
Hotels and restaurants	1.59	0.09***	0.45***	0.46***	1.00
	(0.273)	(0.022)	(0.045)	(0.031)	
Construction	1.66	0.10***	0.33***	0.57***	1.00
	(0.178)	(0.010)	(0.017)	(0.019)	
Textiles and leather	1.92	0.00	0.22***	0.78***	1.00
	(0.562)	(0.016)	(0.013)	(0.018)	
Social and personal services	1.85	0.10***	0.42***	0.48***	1.00
	(0.147)	(0.012)	(0.031)	(0.026)	
Food, beverages and tobacco	1.90	0.04**	0.18***	0.78***	1.00
	(0.264)	(0.015)	(0.011)	(0.018)	
Retail trade	1.97	0.20***	0.38***	0.42***	1.00
	(0.289)	(0.021)	(0.021)	(0.025)	
Manufacturing	2.03	0.09***	0.27***	0.63***	0.99
	(0.411)	(0.024)	(0.015)	(0.016)	
Transport equipment	2.00	0.03**	0.15***	0.82***	1.00
	(0.289)	(0.013)	(0.010)	(0.008)	
Machinery	2.24	-0.03***	0.29***	0.74***	1.00
	(0.239)	(0.009)	(0.011)	(0.015)	
Electrical and optical equipment	2.42	-0.20***	0.31***	0.88***	0.99
	(0.503)	(0.023)	(0.019)	(0.019)	
Financial intermediation	2.43	0.15***	0.32***	0.47***	0.93
	(0.243)	(0.024)	(0.021)	(0.022)	
Post and telecommunications	2.58	0.08**	0.44***	0.49***	1.01
	(0.247)	(0.032)	(0.029)	(0.026)	
Electricity, gas and water supply	2.46	0.16***	0.21***	0.64***	1.00
	(0.308)	(0.022)	(0.018)	(0.016)	
Agriculture, fishing e.t.c.	2.61	0.14***	0.20***	0.70***	1.04
	(0.458)	(0.014)	(0.019)	(0.020)	
Transport and storage	2.83	0.18***	0.26***	0.56***	0.99
	(0.358)	(0.011)	(0.014)	(0.017)	
Non-metallic mineral products	2.87	-0.00	0.27***	0.73***	1.00
	(0.253)	(0.011)	(0.010)	(0.017)	
Renting of machinery and equip.	2.83	0.03***	0.66***	0.34***	1.03
	(0.238)	(0.005)	(0.033)	(0.035)	
Refined petroleum and nuclear fuel	2.92	0.01	0.07***	0.93***	1.02
	(0.525)	(0.013)	(0.010)	(0.013)	
Wood products	3.07	0.02***	0.14***	0.85***	1.00
	(0.466)	(0.008)	(0.014)	(0.012)	
Basic metals and fabricated products	3.04	-0.02*	0.20***	0.81***	0.99
	(0.408)	(0.010)	(0.011)	(0.017)	
Pulp and paper	3.10	-0.05*	0.15***	0.88***	0.99
	(0.375)	(0.026)	(0.011)	(0.029)	
Rubber and plastics products	3.10	-0.02*	0.22***	0.80***	0.99
	(0.330)	(0.014)	(0.012)	(0.018)	
Chemicals and chemical products	3.08	-0.15***	0.19***	0.94***	0.97
	(0.436)	(0.033)	(0.014)	(0.029)	
Mining and quarrying	3.87	0.46***	-0.08***	0.62***	0.99
	(0.489)	(0.022)	(0.027)	(0.033)	

[a] Standard deviations in parentheses

[b] Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

TABLE 6: % EFFECT OF EMU PER INDUSTRY AND COUNTRY

Industry	Austria	Finland	Germany	Italy	Netherlands	Spain	Average
Hotels and restaurants	-1.68	0.19	-3.53	-1.49	0.65	-5.08	-1.82
Construction	-1.04	-2.01	-2.47	-1.21	0.33	0.38	-1,00
Textiles and leather	-0.78	0,00	-1.84	1.54	-0.39	0.97	-0.08
Social and personal services	0.49	-0.15	0.81	0.95	1.19	-0.25	0.51
Food, beverages and tobacco	-0.34	1.53	-1.64	0.90	1.64	0.43	0.42
Retail trade	0.45	1.45	-0.30	1,00	0.90	0.12	0.60
Manufacturing	-0.04	1.90	-0.73	1.12	-0.80	1.88	0.56
Transport equipment	1.37	0.81	0.97	1.37	0.55	0.88	0.99
Machinery	1.59	1.95	1.42	1.12	1.85	1.68	1.60
Electrical and optical equipment	1.30	1.26	1.61	1.42	1.84	1.20	1.44
Financial intermediation	1.90	1.88	1.82	1.95	1.90	1.71	1.86
Post and telecommunications	1.91	1.78	1.76	1.91	1.74	1.90	1.83
Electricity, gas and water supply	1.78	1.95	1.65	1.75	1.89	1.92	1.82
Agriculture, fishing e.t.c.	1.91	1.47	1.14	1.94	1.83	1.83	1.69
Transport and storage	1.92	1.89	1.95	1.86	1.92	1.95	1.92
Non-metallic mineral products	1.95	1.86	1.95	1.87	1.91	1.87	1.90
Renting of machinery and equip.	1.95	1.40	1.95	1.93	1.86	1.93	1.84
Refined petroleum and nuclear fuel	1.89	1.46	1.89	1.92	0.96	1.80	1.65
Wood products	1.93	1.72	1.95	1.85	1.95	1.29	1.78
Basic metals and fabricated products	1.93	1.27	1.95	1.90	1.68	1.84	1.76
Pulp and paper	1.63	1.10	1.94	1.91	1.86	1.71	1.69
Rubber and plastics products	1.90	1.66	1.92	1.78	1.77	1.51	1.76
Chemicals and chemical products	1.95	1.02	1.95	1.85	0.37	1.95	1.52
Mining and quarrying	1.38	-1.69	1.28	0.97	-0.38	0.49	0.34
Country average	1.14	1.07	0.81	1.34	1.21	1.08	1.11

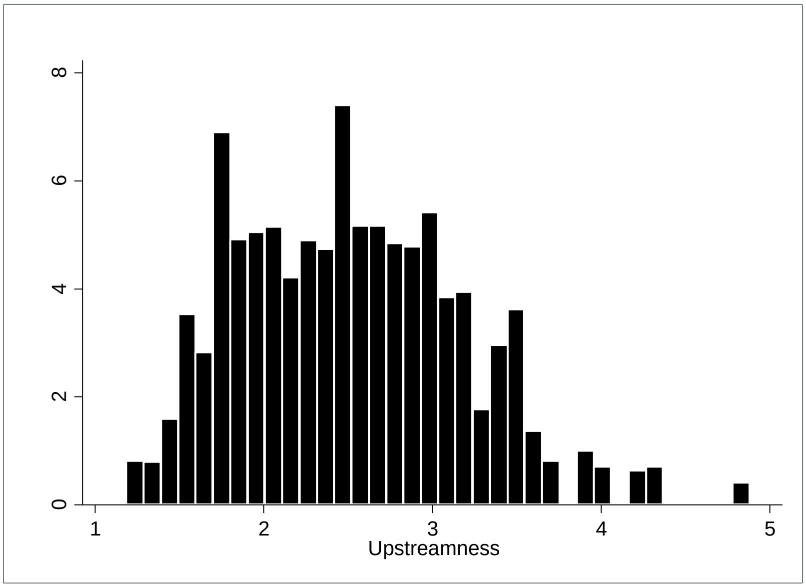
TABLE 7: REGRESSION RESULTS - ROBUSTNESS

VARIABLES	**BASE REGRESSION** lnTFP	**EXCL. SVN & CZE** lnTFP	**EXCL. YEARS 1998-2000** lnTFP	**EXCL. NEG β's FROM STAGE 1** lnTFP	**EXCL. INSIGN β's FROM STAGE 1** lnTFP
EMU-dummy	-0.0827***	-0.0890***	-0.0979***	-0.103***	-0.0963***
	(0.0262)	(0.0257)	(0.0300)	(0.0250)	(0.0280)
ln UV	-0.110***	-0.131***	-0.137***	-0.0796**	-0.128***
	(0.0402)	(0.0469)	(0.0459)	(0.0389)	(0.0454)
$(\ln UV)^2$	0.0463*	0.0434	0.0603**	0.0331	0.0635**
	(0.0238)	(0.0292)	(0.0275)	(0.0233)	(0.0265)
EMU * ln UV	0.206***	0.204***	0.244***	0.298***	0.231***
	(0.0705)	(0.0704)	(0.0804)	(0.0680)	(0.0745)
EMU * $(\ln UV)^2$	-0.104**	-0.100**	-0.123**	-0.163***	-0.116**
	(0.0446)	(0.0452)	(0.0509)	(0.0438)	(0.0471)
Constant	0.748***	0.0666**	0.259***	0.729***	0.209***
	(0.0166)	(0.0261)	(0.0266)	(0.0161)	(0.0264)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Average EMU Effect %	1.11	0.61	1.30	2.15	0.89
Observations	4,392	3,792	3,600	2,928	3,843
R-squared	0.914	0.938	0.909	0.926	0.908

UV denotes upstreamness values
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

FIGURES

FIGURE 1: DESCRIPTIVE STATISTICS - DISTRIBUTION OF UPSTREAMNESS VALUES



Source: Upstreamness Values were extracted using the works of Antras et al. (2012)

FIGURE 2: DESCRIPTIVE STATISTICS - DISTRIBUTION OF LN(TFP)

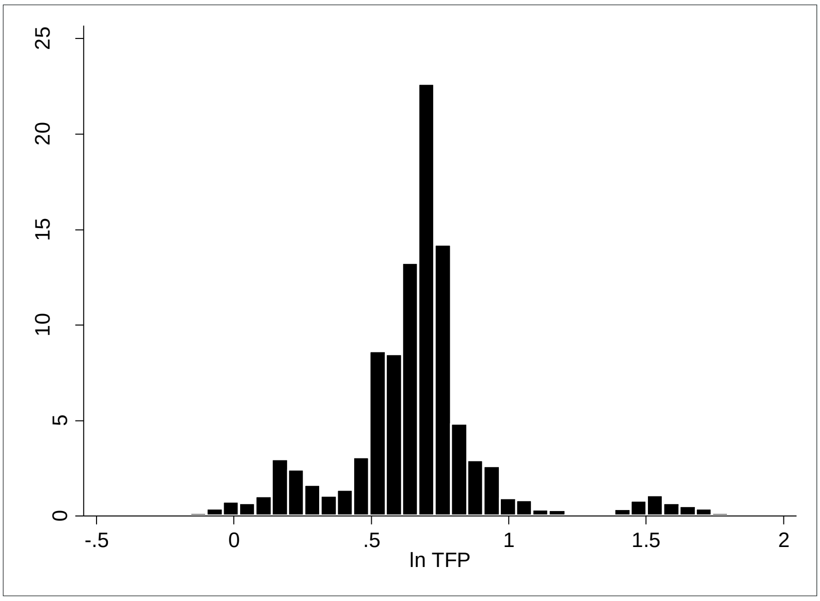
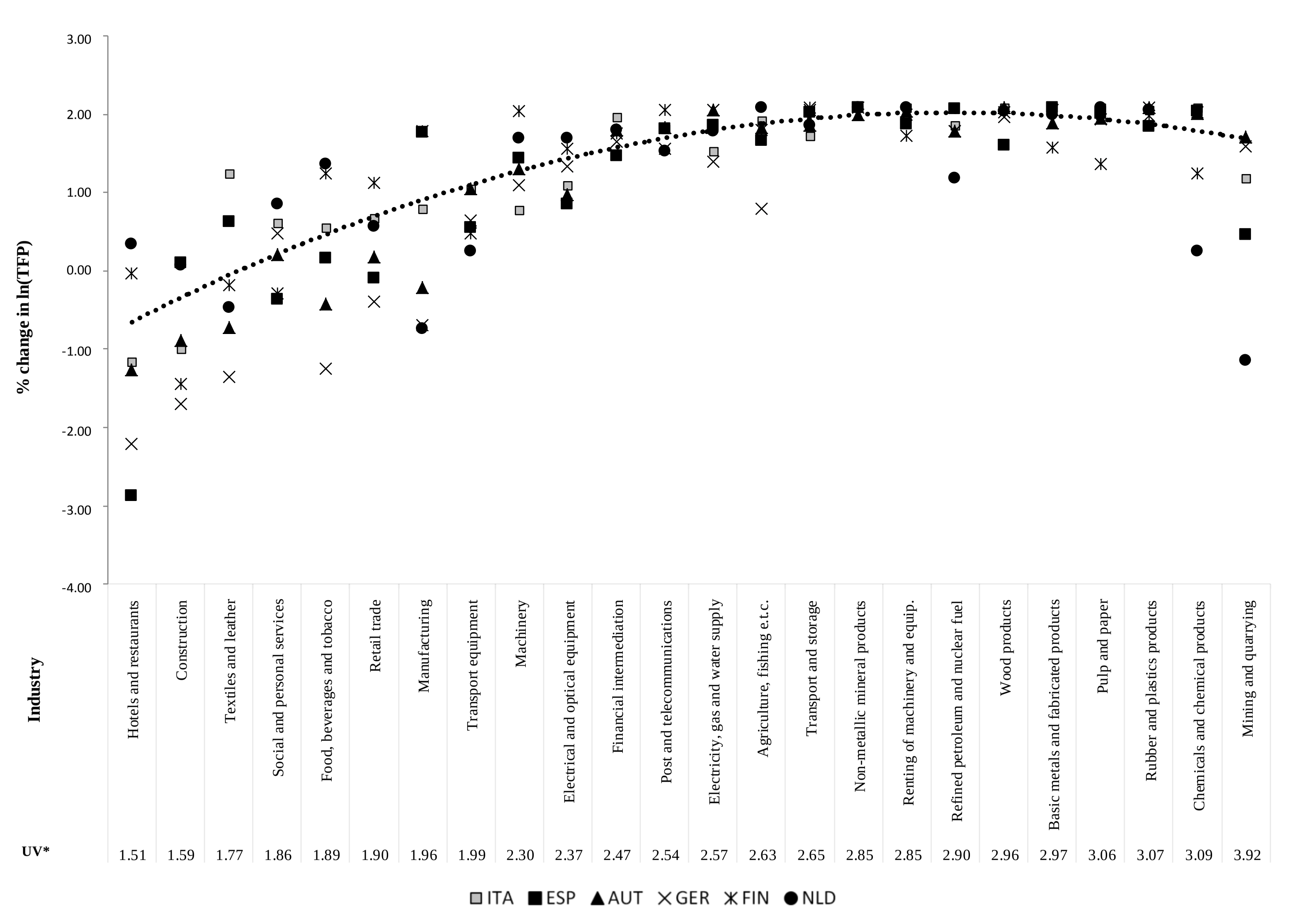


FIGURE 5: % EFFECT OF EMU ON TFP - ALL 'EMU COUNTRIES'



*UV denotes average Upstreamness Value per industry

FIGURE 6A: % EFFECT OF EMU ON TFP - AUSTRIA

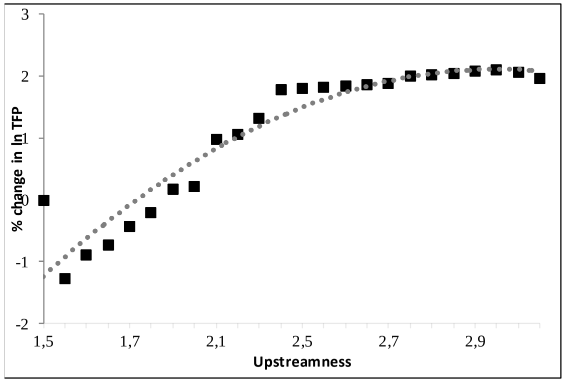


FIGURE 6B: % EFFECT OF EMU ON TFP - FINLAND

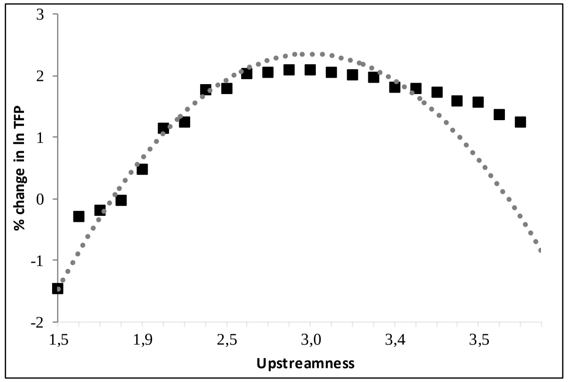


FIGURE 6C: % EFFECT OF EMU ON TFP - GERMANY

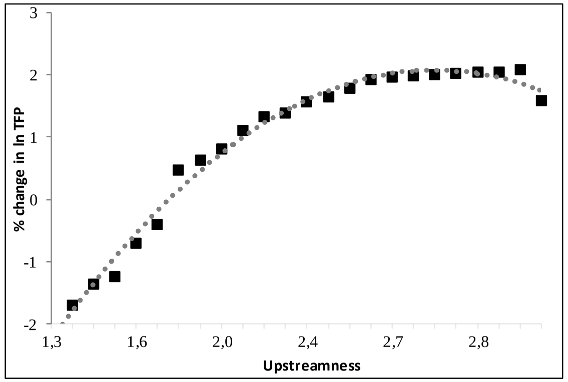


FIGURE 6D: % EFFECT OF EMU ON TFP - ITALY

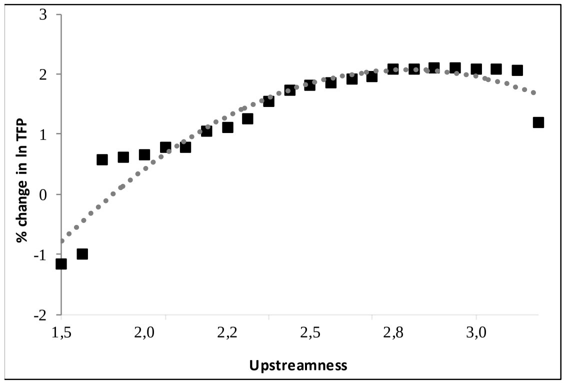


FIGURE 6E: % EFFECT OF EMU ON TFP - NETHERLANDS

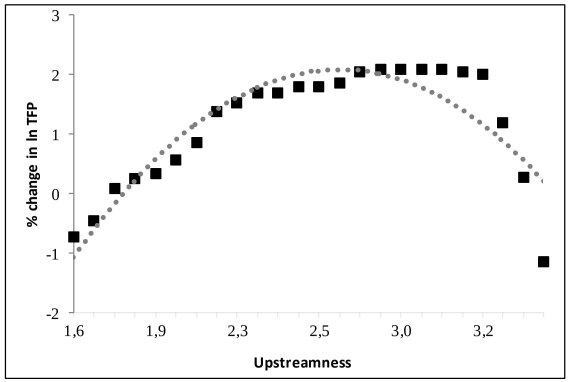


FIGURE 6F: % EFFECT OF EMU ON TFP - SPAIN

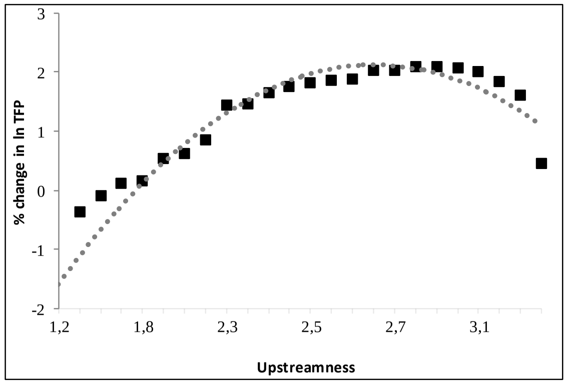


FIGURE 7: DIFFERENCE IN AVG % EFFECT ON TFP USING DIFFERENT BREAK YEARS