

Growth in Chains: EU Value Chain Productivity and its Slowdown*

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Abstract

We analyze Europe's post-2008 slowdown through the lens of global value chains (GVCs). We provide novel, empirical insights by using GVC total-factor productivity (TFP) measures. We show that, pre-2008, investment liberalization with China is associated—*ceteris paribus*—with higher GVC TFP and greater business-intangible investment. Business-intangible investment generates productivity spillovers, especially when combined with technology investment, while the direct TFP effect of technology intangibles is weak. A two-country macroeconomic model matches the data and liberalization dynamics. It implies persistent cross-region productivity shifts via disparities in technological adaptation and production scale effects in business capability.

Keywords: Global value chains, Intangibles, Productivity, Globalization

JEL Codes: F60, O47, L16, O14, E22

*This work is part of Business Finland's and ETLA's research project "Intangibles as drivers of change and renewal: Firm dynamics underlying the next stage of the knowledge economy" (InChange). ETLA and the authors thank Business Finland for supporting the project. We thank attendees at ASSA Annual Meeting 2026, the 8th World KLEMS, CUFE-OEP, FEBST 2025, TSER, the Finnish Economic Association's 45th Annual Meeting, and the 40th Summer Seminar of Finnish Economists for their valuable feedback. This paper used AI research tools in accordance with ethical research standards.

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1 Introduction

Despite rapid advances in digital technologies, continued diffusion of new organizational practices, and historically deep integration into global markets, total factor productivity (TFP) growth across Europe has slowed markedly after 2008. Policy discussions increasingly stress that Europe’s innovation and productivity problems are intertwined with limited scale and incomplete integration (Draghi, 2024). Moreover, research points to complementary intangible investments and organizational reconfiguration that technologies require before productivity gains appear (Brynjolfsson et al., 2021). However, the productivity impact of business innovation-related intangibles has become more complex over time and increasingly hinges on complementarities with other forms of capital and on diffusion conditions (van Ark et al., 2024). These perspectives help rationalize the European problems, but they are hard to quantify: Through which parts of GVCs do these forces operate and how they are interrelated?

In this paper, we make empirical and quantitative theoretical contributions in answering these questions. A core difficulty is measurement. While globalization fragments production across borders and industries, conventional productivity measures are not designed to track how productivity evolves within value chains or how upstream and downstream performance co-move with intangible accumulation and trade integration.¹ Thus, we develop and apply a value-chain productivity metric that is explicitly designed to track productivity dynamics at the level where globalization operates—the value chain rather than the standalone industry.

Our empirical analysis build a unified set of facts about European productivity in chains, involving impacts of globalization shocks and the total-factor productivity elasticities of technology investments. We find that Europe’s slowdown looks different when measured at the value-chain level: we document that Europe’s post-crisis productivity slowdown reflects weaker VC TFP growth both in final producer industries and in the upstream segments of their value chains.

¹The traditional measurements are based on single industries and require price deflators for intermediate inputs that are notoriously hard to measure in internationally fragmented production (e.g., due to quality change, transfer pricing, and the valuation of intangible-rich inputs) (Houseman and Mandel, 2015; Timmer, 2017; Timmer and Ye, 2020).

We then use the measurements in several analysis that provide both additional information and support the use of our VC TFP.

We first analyze evidence on the productivity impacts of globalization shocks, with the focus on the early-2000s investment liberalization between China and EU15 countries. We implement an event-study design around the entry into force of bilateral investment treaties (BITs) using treatment-timing robust methods (Callaway and Sant Anna, 2021).

The results indicate that BITs are followed by a statistically and economically significant increase in VC TFP in the market sector, with effects visible both in final producer industries and in upstream segments of the value chain. We also find that business intangibles in the final producer industry increase after the treaty comes into force. This pattern suggests a channel in which trade and investment integration raises the productivity of value chains partly through business-intangible accumulation. This pattern is not clearly visible when traditional TFP measurements are used.

Then, following van Ark et al. (2024), Corrado et al. (2022), and Corrado et al. (2017), we examine the relationship between VC TFP growth and a key factor of growth, intangible capital, using dynamic panel methods.

Our evidence points to a robust pre-2008 association between business intangibles and VC TFP growth, consistent with the view that business capabilities generate spillovers that operate across organizational and industry boundaries. In contrast, the relationship between technology-related intangibles (including R&D-type investment) and VC TFP growth is weaker in our specifications, and the estimated association for business intangibles is substantially attenuated in the post-2008 period. Importantly, we find complementarity between business and technological capability in specifications that include an interaction between business and tech intangible measures. Again, these reasonable relationships emerge visible only when the VC TFP measures are used.

Finally, to provide a theoretical underpinning and further emphasize the importance of this information, we calibrate two-country macroeconomic model. It features trade integration that changes the scale of manufacturing activity across regions and business-intangible accumulation whose effectiveness depends on scale (see, e.g., (Krugman, 1980; Melitz, 2003; Cuñat and Zymek,

2025)). The calibrated model, featuring these elements, is disciplined using moments from the empirical sections: the estimated VC TFP elasticities from the GMM analysis and the treaty-induced responses of VC TFP and intangibles from the event study.

In the model, an integration shock, *ceteris paribus*, expands Europe's value-chain opportunities and raise European productivity through business-intangible accumulation that are strengthened by positive scale economies, while simultaneously there is reallocating of manufacturing toward China. When the environment changes in the calibrated model—for example, because technology-intangible investments and diffusion disproportionately benefit China and are not effectively absorbed in Europe—there is also a shift in the locus of business capability. Europe's business-scale mechanism loses strength, while in China it becomes stronger. There is a scale-driven shift in economic advantage away from Europe.

The remainder of the paper is organized as follows. Section 2 reviews related literature. Section 3 describes the data and the construction of value-chain variables. Section 4 documents the rise and fall of EU value-chain productivity and decomposes VC TFP into final-producer versus upstream components. Section 5 studies globalization shocks through bilateral investment treaties with China using an event-study design. Section 5 uses dynamic panel estimation to assess the association between intangible investment and VC TFP growth. Section 6 presents a two-country GVC model that organizes the empirical facts through scale, diffusion frictions, and complementarity mechanisms. Section 7 concludes. Additional heterogeneity, value-added composition, and event-study robustness are reported in Appendix A.

2 Related literature

This paper is related to a large literature. The Draghi report on European competitiveness frames the European productivity slowdown as a problem of scale, diffusion, and fragmentation. It argues that Europe's productivity challenge is tightly linked to the ability to build scale in key activities and to diffuse innovations widely across a still-fragmented single market (Draghi, 2024).

This perspective is consistent with the idea that productivity growth in modern economies depends not only on invention, but on broad-based adoption, organizational upgrading, and the ability to operate at scale. Brynjolfsson et al. (2021) develop the “productivity J-curve” view: general-purpose technologies require complementary intangible investments and reorganization, which affect (measured) productivity even when underlying capabilities are improving. Guzman et al. (2024) emphasize that innovation depends on ecosystem bottlenecks and coordination among actors, suggesting that the translation of intangible capability into productivity can be sensitive to institutional constraints and to the broader environment for diffusion. In the European context, van Ark et al. (2024) argues that the productivity payoff to business innovation-related intangibles has become more nuanced and more dependent on complementarities with other assets and with diffusion conditions. These insights help interpret our evidence of a strong pre-2008 association between business intangibles and value-chain TFP (VC TFP) growth that weakens after 2008.

A related work highlights the role of scale and policy in shaping comparative advantage and the returns to capability accumulation. Juhász et al. (2024) review new empirical evidence on industrial policy mechanisms—learning, coordination, and scale-related externalities—and show how policy can shift production patterns and productivity trajectories. Complementing this, Cuñat and Zymek (2025) study how persistent global imbalances can interact with scale economies and induce durable reallocations in tradable production. These ideas map naturally to our emphasis on production scale as a mediator of intangible effectiveness and to our macro mechanism in which scale-dependent business capability is central. Clayton et al. (2025) characterize the rise of geoeconomic competition and the growing use of economic policy tools that is fueled by scale-economies, and can raise cross-border frictions and constrain technology diffusion.

This paper relates to a large literature on global value chains. In terms of measurement of productivity, our efforts are primarily driven by the challenges in accurately measuring the prices of intermediate inputs, which stem from transfer pricing practices in multinational enterprises, the complexities in valuing intangible flows, and the inadequate statistical systems for tracking intermediate prices amid quality improvements (Houseman and Mandel, 2015; Timmer, 2017;

Goldin et al., 2024). We use a decomposition of the global value-added contents of the outputs and contributions of industries and of the other sectors in the upstream value chain (Leontief, 1936; Wolff, 1994; Timmer, 2017; Timmer and Ye, 2020, Kuusi et al., 2022). The value chain approach makes visible both the substantial role of upstream industries to which industries have backward linkages as well as technology and knowledge investments as a source of productivity growth in the entire value chain (for a review, see Carvalho et al. (2021)).

Several articles have studied the motives for offshoring arising from the interaction of several complex factors (Baldwin and Robert-Nicoud, 2014). The motivation for trading tasks and offshoring typically lies in differences in the sophistication of technology and wage levels between countries. Existing empirical studies often suggest that foreign sourcing is a complement to, rather than a substitute for, domestic activity (Martinez-Galan and Fontoura, 2019; Adarov and Stehrer, 2019). Moreover, in developed countries, there tends to be a shift towards more non-routine and more interactive tasks, and the use of highly educated workers (Becker et al., 2013; Reijnders and de Vries, 2018), which benefits industries that are intangible intensive (Jona-Lasinio and Meliciani, 2019).

Our work contributes to the previous literature by showing more evidence that growing international trade and better organization of international production into global value chains led to productivity gains in the 2000s (Constantinescu et al., 2019; Goldin et al., 2024). Our work relates to evidence showing that intangible capital has contributed positively to productivity growth (Corrado et al., 2022; Corrado et al., 2017; and van Ark et al., 2024). Corresponding to our time period Deng and Liu (2024) show recently that in Europe firms reallocated from intangible assets to tangible assets during the 2011–2012, affecting adversely both output and TFP.

In terms of measurement of intangible investment and productivity accounting, we also draw on the EU KLEMS & INTANProd framework and documentation, which provide a harmonized classification of intangible assets and discuss key measurement challenges (Bontadini et al., 2023). By studying VC TFP, our work complements the research efforts of van Ark et al. (2024) that uses

the database to study the contribution of intangible capital deepening to labor productivity growth and TFP spillovers from intangible capital.

Our event study analysis relates with studies of the broader impacts of China (and other countries) on local market dynamics through international trade, see for example, Autor et al. (2013) and Autor et al. (2016). These studies have acknowledged, the identification of value chain dynamics requires a source of plausibly exogenous variation for regional exposure to value chains. This work is also related to the literature on measuring shocks in value chains (see, e.g., Baqaee and Farhi, 2019; Acemoglu and Tahbaz-Salehi, 2020; Elliott et al., 2022), and their empirical propagation (Bonadio et al., 2021; Sforza and Steininger, 2020; Boehm et al., 2019; Carvalho et al., 2021; Meier and Pinto, 2020).

Considering earlier studies related to bilateral investment treaties (BITs) with China, particularly those discussed in Zeng and Lu (2016), significant insights have been revealed. With regard to the impact of globalization on value chains, Fan et al. (2018) illustrate how China's tariff reductions facilitated quality upgrades, subsequently enhancing the efficiency with which Chinese firms utilize intermediate inputs. Furthermore, Chor et al. (2021) document a notable rise in the upstreamness of imports, a stable positioning of exports, and a rapid expansion of production stages conducted in China from 1992 to 2014—both at the aggregate level and within firms over time.

3 Data

To form our VC TFP panel, that covers the years 1995-2017 and includes 675 VC TFP series for the EU15 industries, we combine data from OECD, World KLEMS, The Conference Board and Penn world tables 10.1. Two key dataset are: OECD Inter-Country Input-Output Tables (ICIO) and World KLEMS data (KLEMs). ICIO input-output tables cover 76 individual countries (38 OECD countries and 38 non-OECD economies) and an aggregate for the rest of the world (ROW). For each country it provides input-output data for 45 industries. KLEMS provides input factor data (labor

and capital inputs and shares) for 30 countries and basically the same industries.² Additionally, we gather input factor data for 7 other countries from OECD STAN database, which has the same industry classification as ICIO. For those countries for which we do not have industry level factor inputs data we use country-level data from Penn world tables 10.1 (PWT10.1).³ Finally, we calculate aggregate input factor and weighted average input share series for ROW using PWT10.1 that provides input factor data in levels.

For some countries we impute missing input factor and input share values for the years 1995-2008.⁴ Furthermore, following Kuusi et al. (2022), if we lack data for certain industries in a certain country we use the "next" aggregate level data as a proxy of this industry.⁵ This is reasonable because we deal with growth rates and input shares. Undeniably, this adds some inaccuracy to our measures, but the next-level data can be considered a good proxy because the growth rates of a certain industry are likely highly correlated with the next aggregate-level data.

Out of 76 countries we have meaningful input data at industry-level for 37 countries.⁶ For those countries which for no industry-level data is available we use country-level input data. The 37 countries for which we have input data at industry-level include the most developed and largest economies of the world (also new KLEMS data for China industries). Therefore, arguably, for the

²We use the ICIO industry classification in our dataset and adjust the industry division in the KLEMS data accordingly. Note that for China the industry classification is somewhat different from EU KLEMS data. In this case the most closest industry (or the nearest higher level aggregate) is used as a proxy for the ICIO industry.

³PWT10.1 lacks labor and capital share data for BGD, KHM, MMR, PAK and VNM. For these countries this data is from The Conference Board (TCB). Additionally, both PWT10.1 and TCB lack data for BRN, for this country we use the input factors and shares calculated for ROW.

⁴For BEL (years 1995-1998) and BGR, HRV, CYP, EST, GRC, HUN, IRL, LVA, LTU, LUX, MLT, POL, PRT, ROU, SVN (years 1995-2007) the KLEMS labour services volume indices are continued using the growth rates of persons employed. For USA the missing values for year 1995 of KLEMS capital service volume index are set to be the same as in 1996. For CAN capital and labor shares are set to be the same as in year 2007 (years 1995-2006) and for the years 1995-1996 in some industries the missing data for total employment are replaced by the value in year 1998. For CHL the missing values for year 1995 of OECD Stan net capital stock are set to be the same as in 1996 and capital and labor shares are set to be the same as in year 2007 (years 1995-2006). Note also that in some rare cases, for some specific industry and year, there are negative value added values in the data. In these cases, we replace the negative value with a near-zero positive value to enable the use of logarithms.

⁵For example, if data for petroleum and coal products (19) is missing for certain country, we use data for chemical, rubber, plastics, fuel products and other non-metallic mineral products (19-23) and if this data is also missing we then use data for whole manufacturing (c). Ultimately, we use data for total value added if no other closely related aggregate data is available.

⁶Note that while for most countries the data covers the different industries rather comprehensively there are some exception. For example, for CHL we only have industrial data on a high level of aggregation.

EU15 countries we study, the input factor and share data is available at industry level for most parts of their global value chains. Therefore, regardless of the data shortages, for the EU15 the measure of global value chain TFP can be considered an (good) approximation of the "true" global value chain TFP.

Other variables, such as traditional TFP and output are from KLEMS. The intangible variables are also from KLEMS and the division of total intangibles to technology related and business innovation related intangibles is calculated following van Ark et al. (2024) and Corrado et al. (2022).⁷ Data on Bilateral Investment Treaties (BIT) are from UNCTAD.

4 European VC productivity growth

In this section we calculate industry-level TFP that accounts for all input factors used in the industry's value chain (VC TFP). The calculation of VC TFP relies on two key methodological achievements in the literature. Firstly, we calculate value added contributions of the global value chain using the hypothetical extraction method by Los et al. (2016). Accordingly, the difference between the actual global value added distribution and a hypothetical distribution, where the production of a certain industry is set to zero, gives the total value added in the value chain of this industry. Secondly, following Timmer (2017) and Kuusi et al. (2022), using these industry's value added contribution to the global value chain and country-industry specific input factors we calculate input factor requirements of a certain industry. Finally, the input factor requirements and country-industry specific input shares allow us to derive VC TFP for a certain industry from a traditional production function.

We next describe the derivation of VC TFP in more detail, for more see Los et al. (2016), Timmer (2017) and Kuusi et al. (2022). The hypothetical extraction method is as follows.

⁷Technology related intangibles are formed by summing the real values of computer software and databases, R&D, entertainment, artistic and literary originals and mineral exploration from KLEMS intangibles data. Accordingly, business innovation related intangibles include new product development costs in the financial industry, industrial design, brand, organizational capital and training.

$$VA = v(I - A)^{-1}Y * i \quad (1)$$

where VA is a value chain matrix that contains industry- and country specific value added contributions, v is a row vector of the ratios of value added to gross output, i is a column vector of ones implying that it sums all elements of the final demand matrix Y . $(I - A)^{-1}$ is the Leontief inverse where I is a identity matrix and A is a matrix that contains the use of intermediate products.

The hypothetical world where certain country-industry's production is excluded can be derived by extracting this industry' production of final goods and intermediate products to other industries in own and other countries and calculate VA again. The hypothetical world is denoted VA^* . Then,

$$\Delta VA = VA - VA^* \quad (2)$$

ΔVA contains the value added contributions of different industries of different countries to the specific industry in question. Further on we denote these value added contributions $VAVC$ and each contributions share as VAs . Value chain TFP of country-industry J can be obtained as follows (for brevity time index t is dropped):

$$\Delta \log(Q_J) = \sum_{j=1}^{3465} \overline{VAs_{Jj}} (\bar{\alpha}_L^j * \Delta \log(\tilde{L}_j) + \bar{\alpha}_K^j * \Delta \log(\tilde{K}_j)) + \Delta \log(TFP_J) \quad (3)$$

where

$$\tilde{L}_j = \frac{L_j VAVC_{Jj}}{VA_j}, \quad \tilde{K}_j = \frac{K_j VAVC_{Jj}}{VA_j}. \quad (4)$$

In equation (3) Q is output in real terms, \tilde{L} is labor and \tilde{K} is capital requirements and TFP is total factor productivity. $\overline{VAs_{Jj}}$ is the Törnqvist share of value added contribution's yearly share of country-industry j from the country-industry's J value chain. In equations (4) L_j is labor input and K_j is capital input in real terms of country-industry j . VA_j is total value added of country-industry j and $VAVC_{Jj}$ is the value added contribution of country-industry j from the country-industry's J

value chain. $\bar{\alpha}_{L,K}$ are the Törnqvist shares of the yearly labor and capital shares of country-industry j . We can solve TFP from equation (3) because we have data on everything else.

4.1 Value chain growth dynamics

We begin by documenting value chain productivity dynamics in EU15 industries over 1995–2017 and how these dynamics changed after the 2008 crisis.⁸ Table 1 reports output growth and its decomposition into input contributions and VC TFP growth for broad sectors. Two aggregate facts motivate the rest of the paper. First, before 2008, EU15 value chains exhibited positive VC TFP growth, with manufacturing in particular showing sizeable VC TFP contribution. Second, after 2008, output growth stagnated and VC TFP growth weakened broadly, consistent with a Europe-wide slowdown in productivity growth within global value chains.

Table 1: Output growth and its decomposition into TFP and input growth contribution within value chains for different sectors (rows)

	1995-2007			2008-2017		
	Output growth	Input contr.	VC TFP	Output growth	Input contr.	VC TFP
Manufacturing	2.5	1.3	1.2	-0.7	-0.8	0.1
Market serv	4.6	3.8	0.8	1.1	1.6	-0.5
Other serv	1.8	2.2	-0.4	0.9	1.5	-0.6
Utilities + cons	2.8	2.5	0.3	0.0	0.8	-0.8
Average	3.2	2.4	0.8	0.1	0.4	-0.2

Notes: Entries are average annual growth rates (percentage points). Output growth is decomposed into the contribution of aggregate primary inputs used across the full value chain and value-chain TFP (VC TFP). EU15; industries grouped into broad sectors.

Final producer vs. upstream contributions VC TFP aggregates productivity across the entire chain, so it is useful to ask whether the slowdown originates primarily in final producer industries

⁸The Appendix compares annual VC TFP growth to conventional EU KLEMS TFP growth at the same country–industry–year level by examining the wedge $\varepsilon = g^{VC} - g^{KLEMS}$ and its square, ε^2 (Appendix Tables 8 and 9). Three patterns stand out. First, the wedge is systematically larger in value chains with a larger market-services component, which is consistent with the idea that conventional industry-based TFP measures are particularly restrictive in service-intensive and networked production structures. Second, neither the level nor the volatility of the wedge rises systematically with the foreign share of the value chain. This suggests that the use of foreign upstream information in our VC TFP measure does not mechanically create extra volatility or systematic bias; rather, the difference between VC TFP and conventional TFP appears to reflect the economic content of value chains, especially the role of market services. Third, the results are consistent with previous exercises using VC TFP measurements.

or in the upstream part of the chain. Following Timmer (2017), we use EU KLEMS TFP growth estimates to decompose VC TFP into the final producer industry’s TFP growth and the TFP growth originating in the rest of the value chain. Table 2 shows that the post-2008 slowdown is visible in both components. In manufacturing and market services, the upstream part of the chain contributes little to TFP growth pre-2008 and turns negative after 2008, while final producer TFP growth also weakens.

Table 2: TFP decomposition to final industry TFP and the rest of the value chain TFP by sector (rows)

	1995-2007		2008-2017	
	Final TFP	Other VC TFP	Final TFP	Other VC TFP
Manufacturing	1.0	0.2	0.3	-0.1
Market serv	0.8	0.1	0.0	-0.5
Other serv	-0.6	0.2	-0.4	-0.2
Utilities + cons	0.0	0.3	-0.6	-0.2
Average	0.7	0.2	0.0	-0.3

Notes: Value-chain TFP is decomposed into the TFP of the final-producer industry and the residual TFP from the upstream part of the value chain supplying intermediate inputs. Entries are average annual growth rates (percentage points). EU15.

All in all, the slowdown in Europe after 2008 is visible in VC TFP and reflects weakened productivity both in final producer industries and in the upstream part of value chains. This motivates the next step: studying whether a major globalization shock—integration with China through investment treaties—is associated with temporary increases in VC TFP and intangible investment.

5 Empirical findings on value-chain productivity

This section brings together the paper’s main empirical analysis of value-chain productivity. We first study whether a major globalization shock—the entry into force of bilateral investment treaties (BITs) with China—is associated with changes in productivity within European value chains. We then estimate reduced-form elasticities linking value-chain TFP growth to intangible investment and other inputs. The two exercises are complementary. The event-study analysis provides sharply

timed evidence on how improved access to global value chains is associated with productivity and intangible responses, while the elasticity analysis summarizes more systematically how business and technology-related capabilities relate to value-chain productivity growth over time. Across both exercises, the value-chain TFP measure provides a clearer picture of productivity dynamics than conventional industry-level TFP.

5.1 Empirical strategy

Our first empirical strategy uses policy-driven liberalization events that can shift the organization and scale of cross-border production. We focus on China’s bilateral investment treaties with EU countries signed in the period 2000–2014 and treat the years when the treaties enter into force as the event years.⁹ These treaties expanded the legal security of bilateral investment relationships and included broader two-way provisions, allowing investor-to-state dispute settlement.

Treatment is assigned at the country level and the outcomes are measured at the country–industry level. Given staggered timing and likely treatment-effect heterogeneity, we use the event-study estimator of Callaway and Sant Anna (2021). As a baseline, the control group consists of countries where only first-generation BITs with China are in force. The treated countries are the Netherlands (2004), Sweden (2004), Germany (2005), Finland (2006), Portugal (2008), Spain (2008), Belgium (2009), Luxembourg (2009), and France (2010), while the baseline control group includes Austria, Denmark, Greece, Ireland, Italy, and the United Kingdom. We focus on an event window from seven years before to seven years after the event so that all treated countries contribute to each coefficient estimate. Standard errors are clustered at the country–industry level. Additional robustness exercises, including treated-only countries, alternative windows, and alternative estimators, are reported in the Appendix.

Our second empirical strategy studies the relationship between intangible accumulation and VC TFP growth. Following van Ark et al. (2024), Corrado et al. (2022), and Corrado et al.

⁹Another possibility would be to use the signing year as the event year. Our pre-trend analysis, however, suggests that entry into force is the more suitable timing, and Zeng and Lu (2016) also find that BITs tend to affect foreign direct investment more strongly once they become legally effective.

(2017), we estimate dynamic panel models that relate productivity growth to the current and lagged log stocks of business and technology-related intangibles, tangible input growth, and the foreign market-services share. We also include an interaction between business and technology intangibles.

Let g_{ict}^{VC} denote annual VC TFP growth in country–industry–year cell (i, c, t) , then our model is

$$g_{ict}^{VC} = \rho g_{ic,t-1}^{VC} + \beta_B b_{ict} + \beta_{B,-1} b_{ic,t-1} + \beta_Z z_{ict} + \beta_{Z,-1} z_{ic,t-1} \quad (5)$$

$$+ \beta_{BZ}(b_{ict}z_{ict}) + \beta_{BZ,-1}(b_{ic,t-1}z_{ic,t-1}) + \beta_Q q_{ict} + \beta_{Q,-1} q_{ic,t-1} + \mu_{ic} + \tau_t + u_{ict}, \quad (6)$$

where b and z denote business and technology-related intangibles, q collects the other controls, μ_{ic} is a country–industry effect, and τ_t is a year effect.

We estimate this specification by two-step system GMM in the spirit of Arellano and Bond (1991) and Blundell and Bond (1998). The main econometric challenge is to balance dynamic identification against instrument proliferation. We therefore evaluated unrestricted, lag-restricted, collapsed, and leaner instrument sets. The pooled 1995–2017 interaction models remain too fragile to serve as preferred estimates, whereas the pre-2008 interaction model provides the most satisfactory combination of economic content and diagnostics. The post-2008 interaction model is reported as supporting evidence.¹⁰

To complement the GMM analysis, we also estimate fixed-effects regressions with the same contemporaneous and lagged right-hand-side variables but without internal instrumentation. These estimates do not rely on a large instrument matrix and therefore provide a transparent robustness benchmark. Their interpretation is aided by the fact that the lagged dependent variable is close to zero in the preferred pre-2008 GMM specification, so omitting it in the fixed-effects robustness regressions does not appear to remove a quantitatively important source of persistence. Taken together, the GMM and fixed-effects estimates allow us to assess whether the complementarity

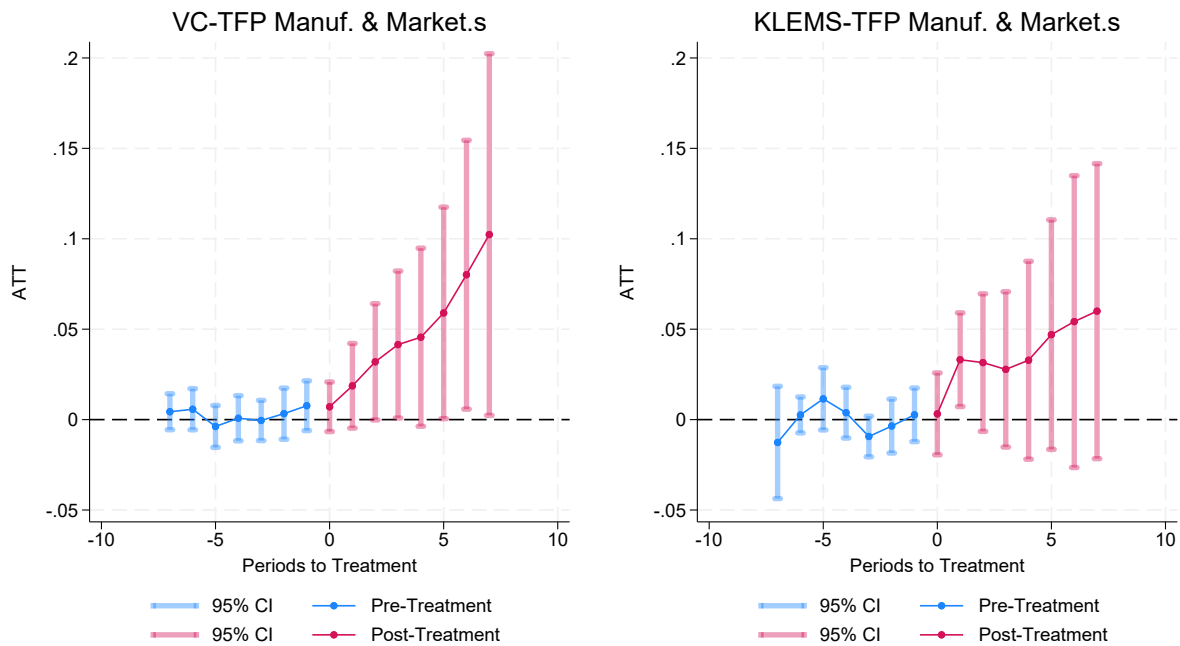
¹⁰In the preferred pre-2008 interaction model, the Hansen and AR(2) tests are both non-rejecting, whereas unrestricted full-sample specifications generate very large instrument sets and uninformative Hansen tests, and aggressively collapsed variants either reject the overidentifying restrictions or leave them undefined.

patterns are specific to the instrumented dynamic specification or also visible in a more direct within-panel approach.

5.2 Results

Globalization shocks and value-chain productivity. We first consider the response of productivity to BIT-induced integration with China. We concentrate on the market sector (manufacturing and market services), which is the part of the economy most likely to respond through changes in value-chain organization. Figure 1 reports dynamic effects on traditional TFP and VC TFP. Both measures increase after the treaties enter into force, but the increase is more pronounced and more clearly sustained for VC TFP. The pre-treatment coefficients fluctuate close to zero, which supports the identifying assumption. The comparison between the two productivity measures is informative in its own right: the same globalization shock is more clearly visible when productivity is measured at the value-chain level rather than industry by industry.

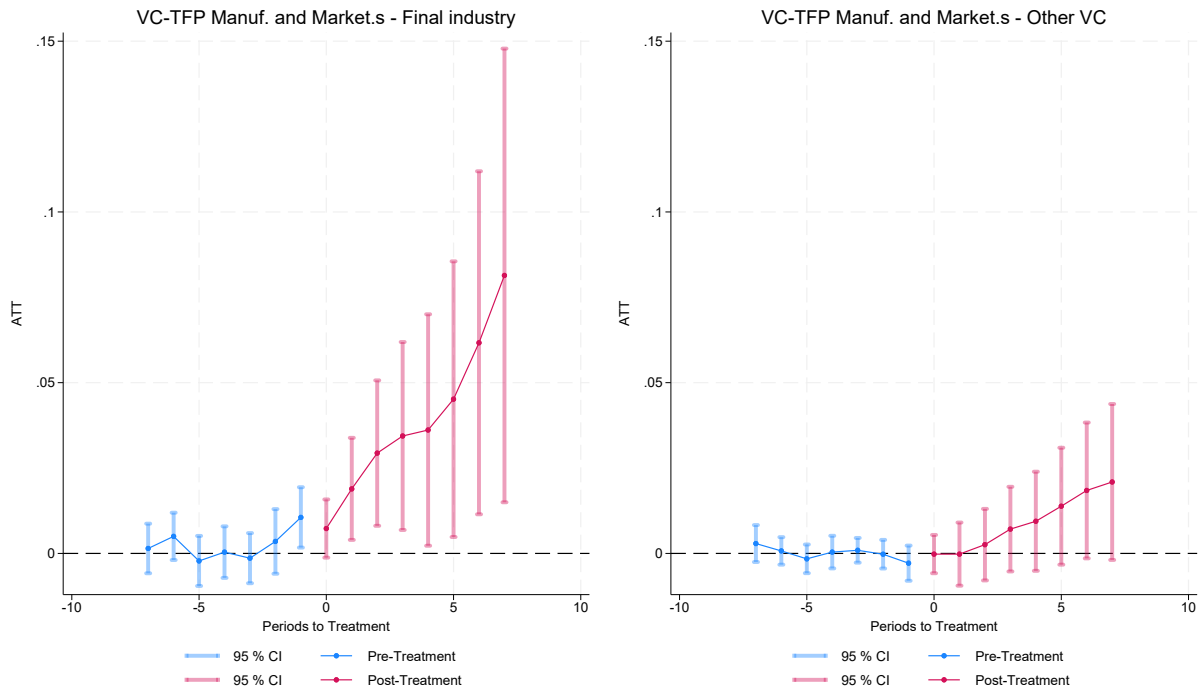
Figure 1: Development of TFP after BITs agreement enters into force



Note: The dots are event coefficients and the bars their bootstrapped 95 % confidence intervals clustered at unit level. The pre-treatment coefficients are blue and the post-treatment coefficients red.

Figure 2 then decomposes VC TFP into productivity growth in the final producer industry and in the rest of the value chain. The positive post-treaty response is visible in both components, although it is more pronounced in the final producer industry. This suggests that the benefits of integration do not operate solely through the final industry itself, but also through reorganization and productivity changes in upstream segments of the chain.

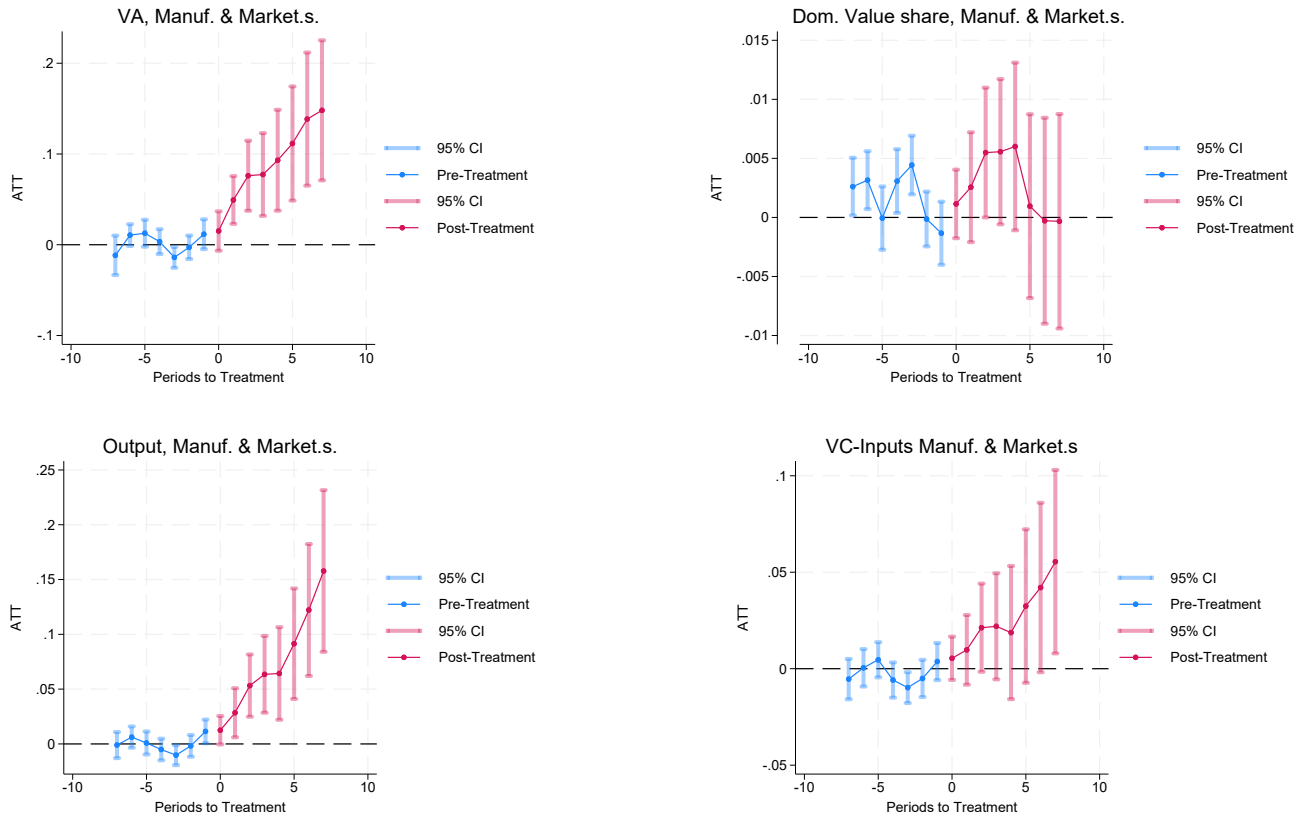
Figure 2: Development of TFP after BITs agreement enters into force



Note: The dots are event coefficients and the bars their bootstrapped 95 % confidence intervals clustered at unit level. The pre-treatment coefficients are blue and the post-treatment coefficients red.

The mechanism is further clarified in Figure 3. Output and value added rise after the treaty enters into force, while the increase in total factor requirements along the value chain is smaller. This is consistent with the idea that BITs improved the organization and scale of cross-border production, allowing output to expand faster than value-chain inputs. The same figure also shows only limited movement in the domestic value-added share, suggesting that the main effect operates through productivity-enhancing reorganization rather than a simple substitution between domestic and foreign stages.

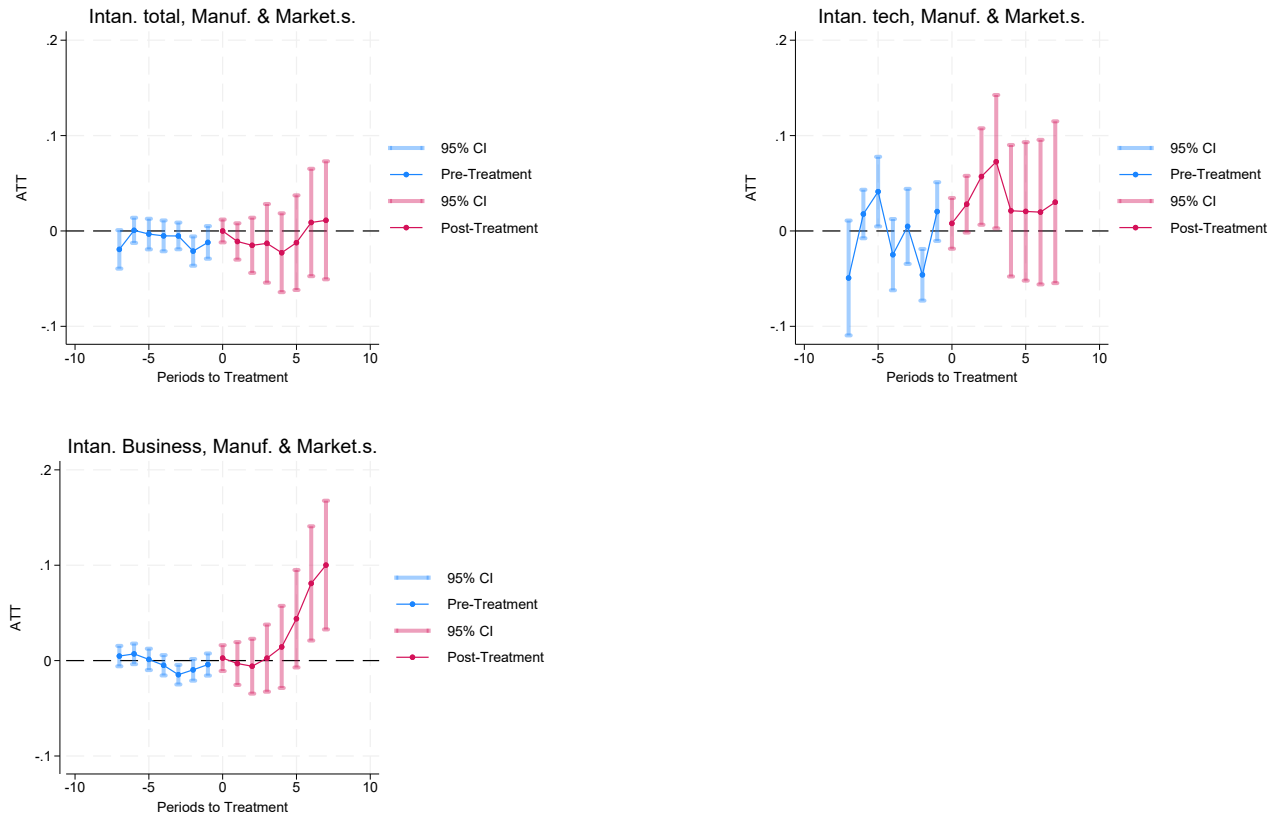
Figure 3: Development of Value added, output, inputs and domestic value share after BITs agreement enters into force



Note: The dots are event coefficients and the bars their bootstrapped 95% confidence intervals clustered at unit level. The pre-treatment coefficients are blue and the post-treatment coefficients red.

A natural candidate mechanism is intangible accumulation in the final producer industry. Figure 4 shows that business-related intangibles increase after BITs enter into force, while the corresponding response of technology-related intangibles is visibly weaker and noisier in the available sample. This difference is important for the rest of the paper. It indicates that the strongest reduced-form response to globalization is not a pure technology-adoption effect, but rather an increase in business-oriented capability that is plausibly linked to reorganization, coordination, and the scaling up of activity in the chain. Again, this pattern is more tightly connected to VC TFP than to conventional TFP.

Figure 4: Development of Final industry intangibles after BITs agreement enters into force



Note: The dots are event coefficients and the bars their bootstrapped 95 % confidence intervals clustered at unit level. The pre-treatment coefficients are blue and the post-treatment coefficients red. Note that the sample size differs between the different specifications. It is 5803 for “Intangibles total”, 5831 for “Intangibles tech” and 8818 for “Intangibles business”.

As an additional robustness check, we also restrict the sample to countries that eventually signed a BIT with China. The resulting estimates remain positive and of similar magnitude, which suggests that the baseline findings are not driven simply by persistent differences between BIT-signing and non-signing countries. At the same time, as discussed in the Appendix, this treated-only exercise should not be interpreted as eliminating all endogeneity concerns in treaty timing.

Elasticity estimations. Table 3 reports the elasticity estimates. Column (1) is the preferred pre-2008 cross-elasticity system-GMM specification for VC TFP growth, column (2) reports the

corresponding post-2008 specification, and column (3) replaces VC TFP with conventional KLEMS TFP. Columns (4)–(6) provide fixed-effects robustness estimates for the same interaction specification.

The main result is in column (1). In the pre-2008 VC TFP specification, the contemporaneous interaction between business and technology intangibles is positive and precisely estimated, while the lagged interaction is negative and of similar magnitude. The same sign pattern also appears in the own business-intangible coefficients.¹¹ The offsetting current and lagged coefficients hints towards a temporary acceleration in growth during the adjustment phase. Read together, these estimates indicate that higher technology-related capability raises the marginal short-run payoff of business-intangible accumulation, and vice versa. This complementarity is the clearest and most robust elasticity result in the paper, and it emerges most clearly when productivity is measured at the value-chain level.

The post-2008 results are much weaker. In column (2), the interaction terms become small and imprecisely estimated and the own-intangible coefficients also attenuate substantially. This does not imply that intangibles cease to matter altogether, but it does indicate that the strong pre-2008 complementarity between business and technological capability is no longer visible in the later sample. The post-2008 interaction model remains informative as a comparison point because its AR(2) and Hansen diagnostics remain in a non-rejecting range, but it is clearly less sharp than the pre-2008 specification.

The comparison with conventional TFP is also revealing. In column (3), where the dependent variable is KLEMS TFP growth rather than VC TFP growth, the coefficients retain broadly similar signs but are much less precise. The fixed-effects robustness results point in the same direction. In column (4), the pre-2008 VC TFP fixed-effects specification still shows a positive impact effect for business intangibles, a negative lagged business term, and a negative lagged interaction term, while the corresponding pre-2008 KLEMS fixed-effects estimates in column (6) are economically

¹¹Consider the simplified law of motion $g_t = \rho g_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + e_t$. If x rises permanently by Δx in period t , then the impact effect on growth is $\beta_0 \Delta x$. From period $t+1$ onward, the incremental effect is approximately $(\beta_0 + \beta_1) \Delta x$, up to propagation through ρ . Hence, when β_0 and β_1 have opposite signs and similar magnitudes, a permanent increase in x produces a burst of growth on impact but does not permanently raise the growth rate thereafter.

much noisier. Column (5) shows that the post-2008 VC TFP fixed-effects estimates also weaken substantially. These robustness results are useful precisely because they do not rely on internal instruments. Their message is consistent with the GMM analysis: the complementarity and short-run business-capability effects are easier to detect with VC TFP than with conventional TFP, and they are strongest before 2008.

We have also estimated the interaction model separately for market services and manufacturing in the pre-2008 sample. The sectoral decomposition points in broadly similar directions as the pooled specification, especially in market services, but the estimates become less precise once the sample is split. We therefore view the pooled pre-2008 interaction specification as the most informative empirical summary.

6 A quantitative-theory framework

As our last approach, we provide a unifying, theoretical framework that jointly addresses the previous findings. The empirical sections point to three regularities that a parsimonious mechanism model should organize jointly, and have not been clear before the use of our VC productivity metric.

First, in the pre-2008 period, European value-chain productivity (VC TFP) rises and globalization shocks—proxied by bilateral investment treaties (BITs) with China—are followed by higher VC TFP and greater business-intangible investment. Second, the dynamic-panel analysis indicates that business and technology intangibles are most effective when they enter jointly: the preferred pre-2008 cross-elasticity specification points to complementarity between business capability and technological capability. Third, after 2008 the productivity association weakens and the data are consistent with a reallocation of scale and innovation effectiveness away from Europe.

To connect these facts, we use a deliberately workhorse two-country steady-state framework. The model has two ingredients that are standard—Armington-CES trade in manufactured goods with iceberg costs and cross-border sourcing of intangible services—and one ingredient that is central for our interpretation of the data and recent policy discussions: scale-dependent business

Table 3: Intangibles and productivity growth: cross-elasticity specifications and fixed-effects robustness

	Two-step system GMM			Fixed effects robustness		
	(1)	(2)	(3)	(4)	(5)	(6)
	1995–2007 VC TFP	2008–2017 VC TFP	1995–2007 KLEMS TFP	1995–2007 VC TFP	2008–2017 VC TFP	1995–2007 KLEMS TFP
Dependent _{<i>t</i>-1}	-0.00 (0.06)	-0.13 (0.08)	-0.03 (0.06)			
Bus. intangibles	0.18** (0.07)	0.01 (0.05)	0.32 (0.25)	0.26*** (0.05)	0.04 (0.04)	0.27 (0.21)
Bus. intangibles _{<i>t</i>-1}	-0.20** (0.07)	-0.02 (0.05)	-0.32 (0.25)	-0.24*** (0.05)	-0.04 (0.05)	-0.25 (0.18)
Tech. intangibles	-0.07** (0.02)	-0.01 (0.05)	-0.13 (0.13)	-0.03 (0.03)	-0.02 (0.03)	0.01 (0.13)
Tech. intangibles _{<i>t</i>-1}	0.09** (0.03)	0.03 (0.05)	0.16 (0.14)	0.04 (0.03)	0.03 (0.04)	-0.03 (0.13)
Bus. × Tech. intangibles	0.02*** (0.00)	0.00 (0.01)	0.03 (0.02)	0.01 (0.00)	0.00 (0.00)	0.00 (0.02)
Bus. _{<i>t</i>-1} × Tech. _{<i>t</i>-1}	-0.02** (0.01)	-0.00 (0.01)	-0.03 (0.02)	-0.01** (0.00)	-0.00 (0.01)	-0.00 (0.02)
Tangibles	-0.60*** (0.07)	-0.28*** (0.07)	-0.80* (0.33)	-0.57*** (0.06)	-0.39*** (0.04)	-0.30 (0.19)
Tangibles _{<i>t</i>-1}	0.62*** (0.08)	0.27*** (0.07)	0.81* (0.35)	0.54*** (0.06)	0.36*** (0.04)	0.28 (0.22)
Share of foreign market serv.	0.05 (0.37)	-0.67 (0.36)	0.46 (1.53)	-0.44* (0.25)	-0.40* (0.23)	-2.14** (0.98)
Share of foreign market serv. _{<i>t</i>-1}	0.01 (0.36)	0.71 (0.37)	-0.34 (1.55)	0.57** (0.24)	0.33 (0.22)	2.19*** (0.77)
Observations	2748	3004	2591	2798	3004	2595
Number of groups	277	318	241	277	318	241
Instruments	275	311	275			
Hansen (<i>p</i>)	0.178	0.100	0.759			
AR(1) (<i>p</i>)	0.010	0.022	0.002			
AR(2) (<i>p</i>)	0.474	0.619	0.473			
Within <i>R</i> ²				0.239	0.216	0.073

Notes: Columns (1)–(3) report two-step system-GMM estimates with year effects. Columns (4)–(6) report fixed-effects estimates with year effects and robust standard errors clustered at the value-chain panel identifier (*id*). The dependent variable is annual VC TFP growth in columns (1), (2), (4), and (5), and annual EU KLEMS TFP growth in columns (3) and (6). Intangibles are the log stocks of business- and technology-related intangible capital. Tangibles are constructed from the growth of aggregate primary-factor inputs used in the value chain and expressed in logs. The pooled 1995–2017 interaction models are not reported because unrestricted versions display instrument proliferation, while collapsed and aggressively trimmed variants either reject the overidentifying restrictions or leave them undefined. Significance: **p* < 0.10, ***p* < 0.05, ****p* < 0.01.

capability. In the model, the productivity effect of business-intangible effort is increasing in the scale of tradable production. This provides a compact way to capture the idea that globalization can raise productivity not only through static specialization, but also by making organizational and managerial investments more effective in larger and more integrated production systems (Krugman, 1980; Melitz, 2003; Cuñat and Zymek, 2025).

The model is not intended to deliver a fully identified account of Europe’s slowdown. Rather, its role is more limited and, we believe, more useful. First, it clarifies why business and technology intangibles may matter more through interaction than through their own separate direct effects. Second, it provides a disciplined framework for comparing the pre-2008 liberalization evidence to the post-2008 slowdown through a small number of transparent counterfactual margins. For this reason, the preferred pre-2008 cross-elasticity estimates from Section 5 serve as the main empirical bridge from the reduced-form analysis to the model, while the additive elasticity estimates are treated as a secondary benchmark.

6.1 Environment

There are two countries $i \in \{E, C\}$, Europe and China. Each country produces a manufactured variety that is traded subject to iceberg trade costs $\tau_M \geq 1$.¹² Labor supply is inelastic, L_E and L_C , and manufacturing uses a one-period tangible capital stock K_i that depreciates at rate δ_K . Preferences are standard and imply a steady-state real return on capital,

$$\frac{r_i}{P_i} = \bar{R} \equiv \frac{1}{\beta} - (1 - \delta_K), \quad (7)$$

where r_i is the nominal rental rate and P_i is the country price index.

¹²The model is deliberately targeted to the tradable manufacturing segment of the value chain and the intangible-capability services that organize and upgrade that segment. It abstracts from non-tradable sectors and from within-country reallocations outside the tradable GVC block. This focus is useful here because the empirical sections emphasize value-chain productivity, trade integration, and the role of business capability in traded production.

Final-good aggregation. In each country, a competitive final-good sector aggregates the home and imported varieties into a final good Y_i with Armington-CES elasticity $\sigma_M > 1$. Let p_E be the European and p_C the Chinese factory-gate price. The price indices are

$$P_E = \left(p_E^{1-\sigma_M} + (\tau_M p_C)^{1-\sigma_M} \right)^{\frac{1}{1-\sigma_M}}, \quad P_C = \left(p_C^{1-\sigma_M} + (\tau_M p_E)^{1-\sigma_M} \right)^{\frac{1}{1-\sigma_M}}. \quad (8)$$

Demands satisfy the usual CES spending rules, and variety market clearing for Europe is

$$q_E = y_{EE} + \tau_M y_{CE}, \quad (9)$$

with the analogous condition for China holding by Walras' law.

Manufacturing production and TFP. Manufacturing output is Cobb–Douglas,

$$q_i = T_i K_i^\alpha L_i^{1-\alpha}. \quad (10)$$

Manufacturing TFP is augmented by effective bundles of business and technological intangibles,

$$T_i = \bar{T}_i A_i^{\theta_{A,i}} Z_i^{\theta_{Z,i}}, \quad (11)$$

where \bar{T}_i is a country-specific level shifter and $(\theta_{A,i}, \theta_{Z,i})$ govern the productivity elasticities of business and technological intangibles.

Cross-border sourcing of intangible services. Each country uses a CES bundle of domestic and foreign business-intangible services,

$$A_E = \left(a_E^{\frac{\sigma_A-1}{\sigma_A}} + \left(\frac{a_C}{\tau_A} \right)^{\frac{\sigma_A-1}{\sigma_A}} \right)^{\frac{\sigma_A}{\sigma_A-1}}, \quad A_C = \left(a_C^{\frac{\sigma_A-1}{\sigma_A}} + \left(\frac{a_E}{\tau_A} \right)^{\frac{\sigma_A-1}{\sigma_A}} \right)^{\frac{\sigma_A}{\sigma_A-1}}, \quad (12)$$

where $\tau_A \geq 1$ is an iceberg-type friction in sourcing business-intangible services. Similarly, countries form a CES bundle of technological services,

$$Z_E = \left(z_E^{\frac{\sigma_Z-1}{\sigma_Z}} + \left(\frac{z_C}{\tau_Z} \right)^{\frac{\sigma_Z-1}{\sigma_Z}} \right)^{\frac{\sigma_Z}{\sigma_Z-1}}, \quad Z_C = \left(z_C^{\frac{\sigma_Z-1}{\sigma_Z}} + \left(\frac{z_E}{\tau_Z} \right)^{\frac{\sigma_Z-1}{\sigma_Z}} \right)^{\frac{\sigma_Z}{\sigma_Z-1}}, \quad (13)$$

where z_i are country-specific technology shifters and τ_Z captures frictions in cross-border technology services.

Business-capability formation. Business-intangible spending is a fixed share of final production,

$$I_i^A = s_i^A Y_i, \quad (14)$$

and domestic business capability is determined by a reduced-form translog relation,

$$\ln a_i = \ln \bar{a}_i + \eta_A \ln I_i^A + \mu_A (\ln I_i^A)(\ln S_i). \quad (15)$$

The interaction term $(\ln I_i^A)(\ln S_i)$ is the scale channel of the model. Given investment effort, the marginal effectiveness of business-intangible spending is higher when the scale of tradable production is larger. We define delivered manufacturing scale as total delivered sales of the country- i variety,

$$S_E \equiv y_{EE} + y_{CE}, \quad S_C \equiv y_{CC} + y_{EC}. \quad (16)$$

This makes the scale mechanism transparent: trade integration affects business capability by changing the scale at which production networks operate. In the present context, this is useful because the empirical evidence points more strongly to business capability than to the direct effect of technology alone.

Equilibrium. Under perfect competition and constant returns, factor prices satisfy the usual marginal-product conditions. In particular, the nominal rental rate is

$$r_i = p_i \alpha T_i K_i^{\alpha-1} L_i^{1-\alpha}, \quad (17)$$

and (7) pins down K_i given (p_i, P_i, T_i) . Nominal income equals the value of manufacturing output, $p_i q_i$, and in the balanced-trade benchmark nominal absorption equals income so that $Y_i = (p_i q_i) / P_i$.

6.2 Experiments and calibration

We use steady-state comparisons to represent the two empirical phases. **Step 0** is the high-trade-cost benchmark. **Step 1** lowers goods trade costs and represents the liberalization phase associated with deeper GVC integration. In **Step 2**, starting from Step 1, we evaluate local changes in productivity shifters, sourcing frictions, and selected elasticities in order to summarize the kinds of disturbances that can account for a weaker European trajectory after 2008. These Step 2 exercises are therefore best read as structured comparative statics rather than as a unique identification of the post-2008 shocks.

Predetermined and estimated parameters. Table 4 reports the baseline parameterization. Standard macro and trade parameters are set to conventional values. We set $\sigma_A = \sigma_Z = 6$ to allow meaningful but imperfect substitution in cross-border intangible sourcing, and normalize the investment elasticity in (15) to $\eta_A = 1$. The remaining parameters are estimated by minimum distance.

Matched moments from the empirical sections. We discipline the model with moments drawn directly from the empirical analysis. The first set of moments summarizes the pre-2008 BIT episode: the increase in European VC TFP, the increase in upstream VC TFP (proxied by China in the model), and the increase in business intangibles in the final producer. The second set of moments comes from the preferred pre-2008 cross-elasticity specification in Section 5: the local

elasticity of VC TFP with respect to business intangibles, the corresponding elasticity with respect to technology intangibles, and the interaction elasticity. Finally, we target the initial relative macro size using the nominal GDP ratio between Europe and China.

Estimation by minimum distance. Let $m(\Theta)$ denote the vector of model moments implied by a candidate parameter vector Θ . We estimate Θ by minimizing a weighted quadratic loss in relative deviations,

$$\min_{\Theta} \sum_k \omega_k \left(\frac{m_k(\Theta) - \widehat{m}_k}{0.5|m_k(\Theta)| + 0.5|\widehat{m}_k| + \epsilon} \right)^2, \quad (18)$$

where \widehat{m}_k are empirical targets, ω_k are weights, and ϵ is a small constant used only to avoid division by zero. The baseline fit reported below yields an objective value of 1.937 in this scaled-distance metric.

Table 4: Macroeconomic model calibration: parameters

	<i>Europe</i>	<i>China</i>
Panel A. Estimated parameters		
Elasticity in business intangibles (θ_i^A)	0.6863	0.3270
Elasticity in tech intangibles (θ_i^Z)	0.0098	0.8010
Scale–business interaction (μ_A)		0.4004
Size shifter (\bar{T}_i)	4.5141	0.1349
China Step-1 tech shifter (z_1^C)		3.4078
China Step-1 business shifter (\bar{a}_1^C)		0.6500
Panel B. Predetermined parameters		
Discount factor (β)		0.96
Depreciation rate (δ_K)		0.06
Armington elasticity (σ_M)		4.0
Sourcing elasticities ((σ_A, σ_Z))	6.0	6.0
Capital share (α)		0.35
Labor endowments (L_E, L_C)	1.0	4.0
Business investment shares ((s_E^A, s_C^A))	0.06	0.03
EU business shifter (\bar{a}_E)		1.0
EU technology shifter (z_E)		1.0
Investment elasticity in (15) (η_A)		1.0
Trade costs, Step 0 ($\tau_M^H, \tau_A^1, \tau_Z^1$)	1.60, 1.20, 1.10	
Trade costs, Step 1 ($\tau_M^L, \tau_A^1, \tau_Z^1$)	1.10, 1.20, 1.10	

Notes: Panel A reports the estimated parameters. Panel B lists predetermined parameters taken from standard quantitative trade-macro calibrations or directly from the empirical setting. The objective value of the minimum-distance criterion is 1.937.

Table 5: Matched empirical moments and model counterparts

Moment	Target	Model	Gap
Pre-liberalization EU/CN GDP ratio	3.000	2.067	-0.933
EU VC TFP response in Step 0→1	0.100	0.080	-0.020
Upstream/China TFP response in Step 0→1	0.030	0.035	+0.005
EU business-capability response in Step 0→1	0.100	0.119	+0.019
Pre-2008 business elasticity (β_A)	0.180	0.662	+0.482
Pre-2008 technology elasticity (β_Z)	-0.070	-0.039	+0.031
Pre-2008 interaction elasticity (β_{AZ})	0.020	0.016	-0.004

Notes: The targeted elasticity moments are taken from the preferred pre-2008 cross-elasticity specification in Table 3. The business-capability target is based on the change in the effective business-capability bundle A_E , which is the object that enters productivity in the model. The same liberalization step also raises the domestic component a_E by more, as reported below.

6.3 Results and interpretation

Pre-2008 liberalization gains

Table 6 reports the model steady states before and after the decline in goods trade costs. The only structural change between Step 0 and Step 1 is the reduction in τ_M . Despite its simplicity, the model generates a joint increase in productivity, output, and capability in both regions. The direct match to the empirical liberalization episode is visible in the targeted objects: European manufacturing TFP rises by 8.0%, upstream/Chinese manufacturing TFP rises by 3.5%, and Europe’s effective business-capability bundle A_E rises by 11.9%.

The same liberalization step also generates informative non-targeted moments. Europe’s domestic business-capability component a_E rises by 15.6%, European final output Y_E by 24.8%, and European manufacturing output q_E by 16.7%, while the effective technology bundle Z_E is unchanged by construction. These patterns line up well with the reduced-form evidence in Section 5. The BIT event-study results show a clear increase in VC TFP, an increase in output and value added, and a positive response in business-related intangibles, whereas technology-related intangibles display much weaker movement (Figures 1, 3, and 4). In the model, A_E is the closest analogue to the capability bundle that enters productivity directly, while a_E is the closer analogue to a purely domestic business-capability component. The fact that both increase, and that a_E rises

somewhat more strongly than A_E , helps bracket the empirical business-intangible response rather than tie it to a single model object.¹³

Table 6: Steady states around the integration shock (Step 0 vs. Step 1)

	Step 0	Step 1	% change (0→1)
Goods trade cost (τ_M)	1.60	1.10	–
EU manufacturing TFP (T_E)	0.9978	1.0776	8.00
China manufacturing TFP (T_C)	0.2243	0.2321	3.47
EU effective business bundle (A_E)	0.1085	0.1214	11.86
EU domestic business capability (a_E)	0.0738	0.0853	15.57
EU effective tech bundle (Z_E)	4.5983	4.5983	0.00
EU final output (Y_E)	2.0880	2.6056	24.79
China final output (Y_C)	0.9225	1.2806	38.82
EU manufacturing output (q_E)	1.9900	2.3223	16.70
China manufacturing output (q_C)	0.8284	0.9607	16.06
EU delivered scale (S_E)	1.8898	2.2607	19.63
China delivered scale (S_C)	0.7416	0.9102	22.74

Notes: Step 0 is the pre-liberalization steady state with high goods trade costs and Step 1 is the post-liberalization steady state after the fall in goods trade costs. Values are in model units. The percentage changes are the main objects used in the comparison to the BIT evidence.

Quality of fit and interpretation. The calibration matches the liberalization moments and the interaction elasticity reasonably well. In Table 5, the model comes close to the European and upstream TFP responses and to the increase in European business capability, while also matching the interaction elasticity β_{AZ} closely. The main tension is the own business-elasticity moment β_A . The model implies a larger elasticity of productivity with respect to business capability than the reduced-form estimate. We view this as informative rather than fatal. The empirical business-intangible index is likely to combine spending, implementation, and gradual organizational adoption, whereas the model maps investment more directly into effective capability. In other words, the model appears to capture complementarity and scale dependence more successfully than the precise level

¹³The event-study evidence identifies the direction and broad magnitude of the liberalization response more cleanly than the exact mapping from empirical business-intangible measures to a single model object. For that reason, we use A_E as the calibration target because it enters the productivity block directly, while also reporting a_E as a non-targeted comparison.

of the own elasticity. This is one reason why the cross-elasticity result is the more useful empirical moment for disciplining the theory.

The estimated structural parameters support this reading. Europe has the stronger business-capability elasticity (θ_E^A), while the direct European technology elasticity is close to zero. China, by contrast, has a much larger direct technology elasticity ($\theta_C^Z \approx 0.80$). This asymmetry is useful for organizing the post-2008 evidence: technology-oriented shifts need not stabilize Europe's relative position once production is fragmented internationally, whereas business-capability losses can be especially costly for the downstream region.

The scale channel itself is economically meaningful. Our estimate $\mu_A = 0.4004$ implies that a 10% expansion in tradable scale raises domestic business capability by about 4% before general-equilibrium feedback through prices, trade shares, and input linkages. This is not meant to be interpreted as an economy-wide externality. Rather, it is a traded-GVC-sector scale elasticity concentrated in manufacturing and closely related business services, which is precisely the margin the empirical sections emphasize.

Comparative-advantage shifts post-2008

To interpret the post-2008 slowdown, we report local comparative statics around the Step 1 equilibrium. Table 7 focuses on four transparent shifts: a 1% increase in Europe's business-capability shifter, a 1% increase in Europe's technology shifter, a 1% increase in China's business-capability shifter, and a 1% increase in China's technology shifter. These are not meant to be a unique decomposition of the post-2008 period. Rather, they summarize the directions in which the model is most sensitive once it has been disciplined by the pre-2008 evidence.

Several patterns are clear. First, shocks to business capability have broad and economically meaningful spillovers. A 1% increase in Europe's business-capability shifter raises EU TFP by 0.84% and EU output by 1.23%, while also increasing China's TFP and output. This is the model analogue of business-capability spillovers in a fragmented value chain: organizational improvements are not fully local once production is cross-border. Second, technology shocks

Table 7: Core post-2008 comparative statics (1% shocks around Step 1)

	$\bar{a}_{E,2} + 1\%$	$z_{E,2} + 1\%$	$\bar{a}_{C,2} + 1\%$	$z_{C,2} + 1\%$
EU TFP (T_E)	0.844	-0.007	0.284	-0.023
China TFP (T_C)	0.365	0.192	0.150	0.576
EU output (Y_E)	1.233	0.017	0.419	0.049
China output (Y_C)	0.697	0.239	0.268	0.718
EU business capability (A_E)	1.232	-0.015	0.415	-0.044
China business capability (A_C)	1.121	-0.025	0.459	-0.074

Notes: Each column reports the percentage change in endogenous variables relative to the Step 1 steady state when the indicated Step 2 shifter increases by 1%. Additional Step 2 results for trade frictions, sourcing frictions, and elasticity changes are reported in Appendix A.3.

are more asymmetric. A 1% increase in Europe’s technology shifter leaves EU TFP essentially unchanged in the local approximation, while China benefits more clearly. By contrast, a 1% increase in China’s technology shifter raises China’s TFP and output strongly, with only limited spillovers to Europe. In the model, this reflects the fact that technology shocks change the relative efficiency of tasks inside the chain and therefore tend to reallocate scale toward the region that is better placed to expand. Third, the Appendix shows that adverse shocks to trade or sourcing frictions can also lower Europe’s performance, but the strongest quantitative effects continue to run through business capability and its interaction with scale.

This interpretation is also consistent with the reduced-form results. The pre-2008 empirical evidence points to gains tied to business intangibles and their complementarity with technology, while post-2008 the same complementarity becomes much weaker in the data. The model captures this shift naturally when Europe’s business-capability environment deteriorates, when the scale channel weakens, or when China receives technology-oriented gains that translate more strongly into upstream expansion. The main role of the model is therefore not to resolve the entire post-2008 episode into a single primitive shock, but to show how the pre-2008 liberalization facts, the pre-2008 cross elasticity, and the post-2008 weakening of the business-capability channel can be understood within one compact mechanism.

7 Concluding remarks

European productivity growth has slowed markedly since the Global Financial Crisis, despite rapid advances in digital technologies and substantial investment in intangible assets. This paper revisits the slowdown through the lens of global value chains by constructing a panel of value-chain TFP (VC TFP) for EU15 industries over 1995–2017. The value-chain perspective matters because productivity and input growth increasingly reflect inter-industry linkages and cross-border production networks rather than isolated sectoral performance.

Our first contribution is measurement and decomposition. We aggregate primary inputs across the full chain to obtain VC TFP indexed by the final producer, and we decompose VC productivity into components originating in final industries and in upstream segments. The post-2008 slowdown is broad-based in this decomposition: VC TFP weakens both in final producer industries and in the upstream part of the chain. This shifts attention from a purely “within-industry” productivity story toward mechanisms that operate through value-chain organization, intermediate input use, and the productivity of upstream suppliers.

Our second contribution is to connect VC productivity dynamics to globalization shocks and intangible investment. In an event-study design, bilateral investment treaties with China are followed by increases in VC TFP and business-related intangible investment in final industries. In dynamic panels estimated by system GMM, business-related intangibles are strongly associated with VC TFP growth prior to 2008, whereas this relationship is much weaker after 2008, while technology-related intangibles are weaker in baseline specifications. Taken together, the evidence points to business-oriented intangible capabilities—organizational capital, management practices, branding, and related assets—as an important channel through which integration and scale can translate into value-chain productivity improvements, and to a post-2008 regime in which these channels deliver smaller measured gains.

Finally, we propose a tractable two-country GVC model that organizes the empirical patterns through market-access shocks, scale reallocation across countries, and complementarity between business capability and technology investment. The model is not intended as a complete account

of Europe's slowdown, but it clarifies which wedges are needed to replicate the shift from pre-2008 expansion to post-2008 stagnation in value-chain productivity. A natural direction for future work is to integrate richer sources of heterogeneity (for example, firm-level organization and multinational network structure) and to quantify how changes in trade, technology, and geopolitically motivated frictions alter the productivity returns to intangible investment.

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A Appendix

A.1 VC TFP measurement: additional analysis

Measurement error relative to conventional TFP. To further assess the robustness of the VC TFP measure, we compare annual VC TFP growth with conventional EU KLEMS TFP growth at the same country–industry–year level. We define the measurement wedge as

$$\varepsilon_{it} = g_{it}^{VC} - g_{it}^{KLEMS}, \quad (19)$$

and its squared value as

$$\varepsilon_{it}^2 = \left(g_{it}^{VC} - g_{it}^{KLEMS} \right)^2. \quad (20)$$

The purpose of this exercise is not to treat KLEMS TFP as a “true” benchmark. Rather, it is a validation exercise that asks two questions. First, is the wedge between the two measures systematically larger in value chains with a larger role for market services, where standard industry-based TFP measures are more likely to miss reorganization and upstream service contributions? Second, does the wedge—or its volatility—increase mechanically with the foreign share of the value chain, which would be a concern given that the VC TFP measure uses foreign input data for the upstream part of the chain?

Table 8 reports fixed-effects regressions for the signed wedge ε_{it} . The results point to three broad findings. First, the wedge is smaller when the final producer accounts for a larger share of value added: the coefficient on the final producer share is negative in the full sample. This means that the difference between VC TFP and conventional TFP is largest in chains where a greater share of value added originates outside the final producer industry. Second, the wedge is systematically larger in value chains with a larger market-services component. The coefficient on the domestic market-services share is positive and statistically significant in the full sample, in 1995–2007, and in 2008–2017. By contrast, manufacturing shares are small and imprecisely estimated. This pattern is consistent with the broader interpretation of the paper: conventional industry-level TFP measures are particularly restrictive in service-intensive and networked value chains, where productivity improvements operate through logistics, organization, finance, marketing, and other market services that are not confined to the final producer industry. This interpretation is also in line with the value-added composition results reported above, which show a large and increasing role for market services in European value chains (Tables 16 and 18).

Table 9 turns to the squared wedge ε_{it}^2 , which captures volatility in the difference between VC TFP and conventional TFP. Here the picture is notably different. The market-services effect that is visible in the signed wedge is not statistically discernible in the squared wedge, implying that service intensity is associated primarily with a *systematic level difference* between VC TFP

and conventional TFP, not with unstable measurement. Most importantly for the use of foreign upstream information, there is no systematic evidence that a larger foreign component of the value chain produces either excess volatility or mechanical bias in the new measure. In the ε_{it} regressions, the coefficients on foreign manufacturing, foreign market services, and foreign other services are statistically insignificant throughout. In the ε_{it}^2 regressions, neither the overall foreign shares nor the foreign service share are statistically significant. Thus, while the level difference between VC TFP and conventional TFP is larger in service-intensive chains, the additional reliance on foreign upstream data does not appear to create a mechanically more volatile or systematically biased measure. If anything, the results suggest that the main difference between the two productivity concepts reflects the economic content of value chains rather than noise coming from the foreign part of the data.

Direct comparison with earlier VC TFP exercises. The regression evidence above is complemented by direct comparisons to earlier applications of value-chain productivity accounting. We revisit the German automotive industry discussed by Timmer (2017) and the construction example in Kuusi et al. (2022). These examples are useful because they provide transparent benchmarks where a value-chain perspective should matter most: automotive production relies heavily on internationally sourced components and business services, while construction productivity increasingly depends on upstream factory-based production and prefabrication rather than on-site activity.

Overall, the comparisons increase confidence that the VC TFP series capture economically meaningful patterns rather than idiosyncratic noise. In the German automotive industry in 1995–2007, we confirm the main message in Timmer (2017): a substantial part of productivity growth originates outside the final industry. In our data, output grew by 6.0% annually, input contributions account for 3.7 percentage points, and VC TFP growth amounts to 2.4 percentage points. Of this, only 0.8 percentage points come from the final producer industry itself, while 1.5 percentage points originate from the rest of the value chain. Relative to Timmer (2017), the input contribution is

Table 8: VC TFP measurement wedge relative to conventional TFP and value-added composition

	Dependent variable: $\varepsilon = g^{VC} - g^{KLEMS}$			
	Own share 1995–2017	Composition 1995–2017	Composition 1995–2007	Composition 2008–2017
Final producer share	-0.15** (0.05)			
Domestic manufacturing share		-0.02 (0.13)	-0.40 (0.29)	0.60 (0.38)
Foreign manufacturing share		0.00 (0.19)	0.45 (0.35)	-0.18 (0.62)
Domestic market services share		0.24* (0.10)	0.56* (0.26)	0.41** (0.15)
Foreign market services share		0.12 (0.27)	0.36 (0.60)	0.15 (0.59)
Domestic other services share		0.39 (0.28)	0.67 (0.69)	0.19 (0.53)
Foreign other services share		0.24 (8.09)	-16.35 (16.69)	6.28 (15.18)
Year fixed effects	Yes	Yes	Yes	Yes
Value-chain fixed effects	Yes	Yes	Yes	Yes
Observations	7,393	7,393	3,581	3,812
Groups	392	392	336	392
Within R^2	0.010	0.010	0.019	0.013

Notes: Fixed-effects estimates with robust standard errors clustered at the value-chain panel identifier (id). The dependent variable ε is the annual difference between VC TFP growth and EU KLEMS TFP growth. “Final producer share” is the value-added share of the final producer industry in the chain. The composition variables are domestic and foreign value-added shares of upstream manufacturing, market services, and other services. Significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 9: Volatility of the VC TFP measurement wedge and value-added composition

	Dependent variable: $\varepsilon^2 = (g^{VC} - g^{KLEMS})^2$	
	Own share 1995–2017	Composition 1995–2017
Final producer share	-0.14 (0.09)	
Domestic manufacturing share		0.17 (0.10)
Foreign manufacturing share		0.06 (0.13)
Domestic market services share		0.06 (0.10)
Foreign market services share		0.16 (0.20)
Domestic other services share		0.43 (0.31)
Foreign other services share		-1.20 (4.94)
Year fixed effects	Yes	Yes
Value-chain fixed effects	Yes	Yes
Observations	7,393	7,393
Groups	392	392
Within R^2	0.006	0.005

Notes: Fixed-effects estimates with robust standard errors clustered at the value-chain panel identifier (id). The dependent variable ε^2 is the square of the annual difference between VC TFP growth and EU KLEMS TFP growth. “Final producer share” is the value-added share of the final producer industry in the chain. The composition variables are domestic and foreign value-added shares of upstream manufacturing, market services, and other services. Significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

very similar, but the share of final-industry TFP is smaller in our data, suggesting a larger role for foreign upstream contributions.

The same exercise also shows how the value-chain perspective helps interpret the post-2008 slowdown. In German automotive manufacturing, output growth slows to 2.3% in 2008–2017, input growth falls markedly, and upstream VC TFP weakens from 1.5 to 0.3 percentage points. At the European level, automotive output is essentially stagnant in 2008–2017, but VC TFP remains positive because of productivity gains in the broader chain. Finally, in construction, our findings line up with Kuusi et al. (2022): VC TFP provides a less pessimistic picture than conventional industry-based productivity measures because upstream productivity contributions are positive even when the final industry’s own TFP contribution is negative. This is exactly the type of environment where value-chain accounting is informative, since technological progress often shifts activity from the final producer to upstream suppliers and prefabricated production stages.

Table 10: Corollaries with earlier VC TFP studies and extensions

	Output growth	Input contr.	VC TFP	Final TFP	Other VC TFP
German automot., 1995–2007	6.0%	3.7	2.4	0.8	1.5
German automot., 2008–2017	2.3%	1.0	1.3	0.9	0.3
European automot., 2008–2017	-0.1%	-1.3	1.2	0.4	0.8
European construction, 1995–2017	0.5%	0.6	-0.1	-0.3	0.2

Notes: Entries report average annual growth rates (percentage points). “Final TFP” denotes EU KLEMS TFP growth in the final producer industry and “Other VC TFP” the contribution of the remaining value chain. The automotive example revisits Timmer (2017); the construction example revisits Kuusi et al. (2022) using the present dataset.

Heterogeneity in VC productivity dynamics across countries. The aggregate slowdown masks substantial cross-country heterogeneity. Some countries maintained positive VC TFP growth after 2008 by reducing inputs while preserving productivity, while others experienced weak VC TFP performance alongside weak growth. The tables below provide country-level decompositions for market services and manufacturing. The discussion emphasizes broad patterns rather than country-by-country narratives.

Two broad patterns stand out. First, post-2008 VC TFP performance is often associated with input contraction, consistent with restructuring and reallocation. Second, a subset of countries

Table 11: Output growth and its decomposition for market services by country (rows).

	1995-2007			2008-2017		
	Output growth	Input contr.	VC TFP	Output growth	Input contr.	VC TFP
AUT	5.3 %	3.9	1.5	0.6 %	1.0	-0.4
BEL	2.6 %	2.9	-0.3	1.6 %	2.6	-0.9
DEU	4.3 %	3.3	1.1	2.1 %	1.6	0.5
DNK	5.3 %	4.7	0.6	1.3 %	0.7	0.6
ESP	5.2 %	5.5	-0.3	1.0 %	1.2	-0.1
FIN	4.8 %	2.8	2.0	1.0 %	1.1	0.0
FRA	4.4 %	3.7	0.7	1.7 %	2.2	-0.5
GBR	4.0 %	2.3	1.7	1.5 %	1.9	-0.4
GRC				-1.9 %	1.4	-3.3
ITA	3.4 %	3.8	-0.4	-0.3 %	0.3	-0.6
LUX				3.7 %	3.8	-0.1
NLD	5.1 %	4.0	1.1	1.9 %	2.7	-0.8
SWE	4.5 %	4.0	0.5	2.1 %	1.7	0.4
Total	2.8 %	2.6	0.2	1.1 %	1.6	-0.5

Notes: Country codes are ISO-3. Entries are average annual growth rates (percentage points). Output growth is decomposed into the contribution of aggregate primary inputs used across the full value chain and VC TFP. A tilde (~) denotes unavailable data for the country-sector in the sample window.

Table 12: Output growth and its decomposition for manufacturing by country.

	1995-2007			2008-2017		
	Output growth	Input contr.	VC TFP	Output growth	Input contr.	VC TFP
AUT	4.0 %	2.3	1.8	1.2 %	1.1	0.1
BEL	1.2 %	0.5	0.7	-0.9 %	-0.1	-0.8
DEU	2.7 %	1.1	1.7	0.4 %	0.0	0.3
DNK	1.2 %	0.8	0.3	-0.8 %	-1.3	0.5
ESP	3.1 %	2.5	0.5	-0.3 %	-2.3	2.0
FIN	4.0 %	2.2	1.8	-0.8 %	-1.2	0.4
FRA	2.2 %	1.3	0.9	-0.8 %	-0.5	-0.2
GBR	1.4 %	-1.5	2.9	-0.8 %	-0.8	0.0
GRC				-4.0 %	-3.8	-0.2
ITA	2.5 %	2.5	0.0	-1.4 %	-1.3	-0.1
LUX				-1.9 %	-1.4	-0.5
NLD	2.4 %	1.1	1.3	0.8 %	0.9	-0.1
Average	2.5 %	1.3	1.2	-0.7 %	-0.8	0.1

Notes: Country codes are ISO-3. Entries are average annual growth rates (percentage points). Output growth is decomposed into the contribution of aggregate primary inputs used across the full value chain and VC TFP. A tilde (~) denotes unavailable data for the country-sector in the sample window.

maintains positive VC TFP growth in both market services and manufacturing, while others exhibit persistently weak VC TFP growth across sectors. This motivates examining the composition of inputs and the distribution of productivity across value chain segments.

Final producer vs. upstream heterogeneity after 2008. Country-level heterogeneity is also visible in the decomposition of VC TFP into final producer vs upstream components in 2008–2017. Table 13 summarizes these patterns. In some countries, final producer TFP remains positive while upstream TFP is negative, consistent with weak diffusion of productivity improvements along the chain. In others, both components are negative, consistent with a broader productivity malaise.

Table 13: TFP decomposition to final industry TFP and the rest of the value chain TFP by country (rows) in 2008-2017.

	Market services 08- Final TFP	Other VC TFP	Manufacturing 08- Final TFP	Other VC TFP
AUT	0.1	-0.5	0.0	0.1
BEL	-0.2	-0.7	0.3	-1.1
DEU	0.4	0.1	0.3	0.0
DNK	0.5	0.1	0.8	-0.3
ESP	-0.3	0.2	0.3	1.7
FIN	0.2	-0.3	0.3	0.1
FRA	0.0	-0.5	0.3	-0.5
GBR	1.3	-1.8	0.8	-0.8
GRC	-1.6	-1.7	-0.6	0.3
ITA	-0.3	-0.3	0.0	0.0
LUX	0.1	-0.2	2.9	-3.4
NLD	0.0	-0.8	0.3	-0.4
SWE	0.2	0.1		

Notes: Country codes are ISO-3. Entries decompose VC TFP into final-producer TFP and upstream VC TFP (percentage points per year) for 2008–2017.

Input composition: domestic vs. foreign labor and capital. To interpret why input growth and VC TFP changed differently across sectors, we decompose input contributions into domestic and foreign labor and capital components. Table 14 shows a broad decline in input growth after 2008, especially in manufacturing. In market services, domestic capital contributions remain comparatively stable, which is consistent with the view that much of post-2008 growth effort was capital deepening in services, even as value chain TFP weakened.

Table 14: Decomposition of input contributions to output growth by sector and period (rows), percentage points

	Total	Labor		Capital	
		Domestic	Foreign	Domestic	Foreign
Manufacturing					
95-07	1.3	-0.1	0.2	0.7	0.6
08-17	-0.8	-0.6	-0.3	0.1	0.1
Market services					
95-07	3.8	1.2	0.3	1.9	0.4
08-17	1.6	0.3	0.1	0.9	0.3
Other services					
95-07	2.2	1.2	0.1	0.7	0.2
08-17	1.5	0.8	0.0	0.5	0.1
Utilities + cons					
95-07	2.5	0.5	0.3	1.2	0.5
08-17	0.8	0.0	-0.2	0.9	0.1

Notes: Entries report average annual changes (percentage points) in the contributions of labor and capital inputs used across the value chain. “Change” refers to the difference between 2008–2017 and 1995–2007 averages.

Table 15 summarizes domestic vs foreign input contributions by country. The foreign component varies substantially across countries, consistent with differences in exposure to GVCs and the role of international services. These patterns provide context for why the BIT shock and the intangible spillovers matter differently across countries.

Value-added composition in the value-chain data. We also examine the value-added composition in our value-chain data. The results can be found in Table 16. This analysis focuses on manufacturing, market services, other services, and the construction and utilities sector. The value-added breakdown includes the contributions from the final producer (the final producer) and other industries.¹⁴

¹⁴Manufacturing includes all manufacturing activities (ISIC class C). Utilities and Construction encompasses utilities (such as electricity, gas, steam, and air conditioning supply), water supply, sewerage, waste management, and remediation activities, as well as construction (ISIC class D-F). Market Services include wholesale and retail trade, transportation and storage, accommodation and food service activities, information and communication, financial and insurance activities, real estate activities, professional, scientific and technical activities, and administrative and support service activities (ISIC class G-N). Other Services cover public administration and defense, education, human health and social work activities, arts, entertainment and recreation, other service activities, activities of households as employers, and activities of extraterritorial organizations and bodies (ISIC class O-U). We also include agriculture, forestry, fishing, and mining activities (ISIC class A, B) as provider of inputs

Table 15: Domestic and foreign input contribution to output growth by country (row), percentage points

	Manufacturing		Market services	
	Domestic	Foreign	Domestic	Foreign
AUT	0.3	0.8	0.5	0.5
BEL	-0.2	0.1	1.6	0.9
DEU	0.0	0.0	1.1	0.5
DNK	-0.8	-0.5	0.6	0.1
ESP	-1.5	-0.8	1.4	-0.2
FIN	-0.5	-0.8	0.8	0.3
FRA	-0.4	-0.2	1.9	0.3
GBR	-0.4	-0.5	1.8	0.1
GRC	-2.5	-1.2	1.6	-0.2
ITA	-0.7	-0.6	0.5	-0.2
LUX	-0.1	-1.4	1.3	2.5
NLD	0.1	0.7	1.7	0.9
SWE			1.6	0.1

Notes: Entries report average annual contributions (percentage points) of domestic vs. foreign labor and capital inputs to output growth by country. Country codes are ISO-3.

Between 1995 and 2017, the final producer industry accounted for about 56.5% of the value-added in the value chain, with the majority originating from the domestic part of the chain. Market services contributed 25.7% of the value-added, manufacturing 8.4%, and final production 4.5%. The data reveals consistent organization across sectors, with the final producer industry's share being the largest, varying between 40% and 76%. The highest shares were found in other services, while the lowest were in manufacturing. The role of market services in value added also remains consistently high, with the highest share (outside the final producer industry) in the manufacturing sector.

From 1995 to 2017, the most significant change has been the increase in the private service sector's value-added share, which rose by 4.2 percentage points. Meanwhile, the shares of the final industry, manufacturing, and the final sector decreased by roughly the same amount. This change predominantly occurred in the foreign part of the value chain, as shown in Table 19. Professional, scientific, technical, administrative, support service activities, financial, insurance, and trade activities contributed significantly to the increase in the services sector.

Table 16: Value-added composition for manufacturing, market services, other services, and construction and utilities sector (columns), as well as unweighted averages

	Average	Manufacturing	Market services	Other services	Util. & construction
Final industry	56.5 %	40.4 %	57.7 %	76.1 %	52.1 %
Manufacturing	8.4 %	12.7 %	6.4 %	4.2 %	10.4 %
Market services	25.7 %	32.7 %	28.6 %	15.1 %	26.5 %
Other services	1.8 %	1.7 %	2.0 %	1.3 %	2.1 %
Final	4.5 %	8.1 %	2.5 %	1.2 %	6.2 %
Util. & construct.	3.0 %	4.1 %	2.7 %	2.2 %	2.8 %

Notes: Value-added (VA) shares are computed from OECD ICIO and reported as percentages of gross output. “Final producer” denotes VA generated in the final-producer industry; “Other industries” aggregates VA generated upstream.

Table 17: Value-added composition changes 1995-2017 for manufacturing, market services, other services, and construction and utilities sector (columns), as well as unweighted averages, percentage points

	Average	Manufacturing	Market services	Other services	Util. & construction
Final industry	-1.6	-3.7	-1.2	-1.4	-0.2
Manufacturing	-1.1	-0.1	-1.4	-0.6	-2.4
Market services	4.2	4.7	3.7	2.5	6.0
Other services	0.5	0.7	0.4	0.6	0.4
Final	-2.1	-2.1	-0.9	-0.7	-4.6
Util. & construct.	0.0	0.5	-0.7	-0.4	0.8

Notes: Entries report changes (percentage points) in value-added shares between 1995 and 2017. “Final producer” denotes VA generated in the final-producer industry; “Other industries” aggregates VA generated upstream.

Table 18: Foreign and domestic value-added decomposition for manufacturing, market services, other services, and construction and utilities sector (columns)

		Average	Manufacturing	Market services	Other services	Util. & construction
Final industry	dom	55.3 %	37.5 %	55.8 %	76.0 %	51.7 %
	for	1.3 %	2.9 %	1.9 %	0.0 %	0.4 %
Manufacturing	dom	4.3 %	5.8 %	3.4 %	2.2 %	5.8 %
	for	4.1 %	6.8 %	3.0 %	2.0 %	4.6 %
Market services	dom	15.8 %	17.6 %	18.8 %	10.4 %	16.5 %
	for	9.9 %	15.0 %	9.8 %	4.7 %	10.0 %
Other services	dom	1.4 %	1.1 %	1.6 %	1.1 %	1.7 %
	for	0.4 %	0.6 %	0.4 %	0.1 %	0.4 %
Final	dom	1.1 %	2.3 %	0.5 %	0.3 %	1.3 %
	for	3.4 %	5.9 %	2.0 %	0.8 %	4.9 %
Util. & construct.	dom	2.3 %	2.8 %	2.2 %	2.0 %	2.3 %
	for	0.6 %	1.3 %	0.5 %	0.3 %	0.5 %
Total	dom	80.2 %	67.2 %	82.3 %	92.0 %	79.3 %
	for	19.7 %	32.4 %	17.7 %	8.0 %	20.7 %

Notes: Decomposes value-added into domestic vs. foreign components (shares of gross output, percent) using OECD ICIO. “Final producer” denotes the final-producer industry; “Other industries” aggregates upstream sectors.

Table 19: Foreign and domestic value-added composition changes 1995-2017 for manufacturing, market services, other services, and construction and utilities sector (columns), percentage points

		Average	Manufacturing	Market services	Other services	Util. & construction
Final industry	dom	-2.0	-3.6	-2.7	-1.4	-0.1
	for	0.4	0.0	1.6	0.0	-0.1
Manufacturing	dom	-1.0	-0.6	-1.1	-0.4	-2.0
	for	-0.1	0.4	-0.2	-0.2	-0.4
Market services	dom	-0.5	-1.3	-1.4	0.0	0.8
	for	4.7	6.0	5.1	2.6	5.2
Other services	dom	0.3	0.5	0.1	0.5	0.3
	for	0.2	0.3	0.3	0.1	0.2
Final	dom	-0.4	-0.3	-0.2	-0.2	-0.8
	for	-1.7	-1.9	-0.7	-0.5	-3.8
Util. & construct.	dom	0.0	0.4	-0.7	-0.4	0.7
	for	0.1	0.1	0.1	0.0	0.0
Total	dom	-3.5	-4.9	-6.1	-2.0	-1.0

Notes: Entries report changes (percentage points) in domestic and foreign value-added shares between 1995 and 2017 using OECD ICIO. “Final producer” denotes the final-producer industry; “Other industries” aggregates upstream sectors.

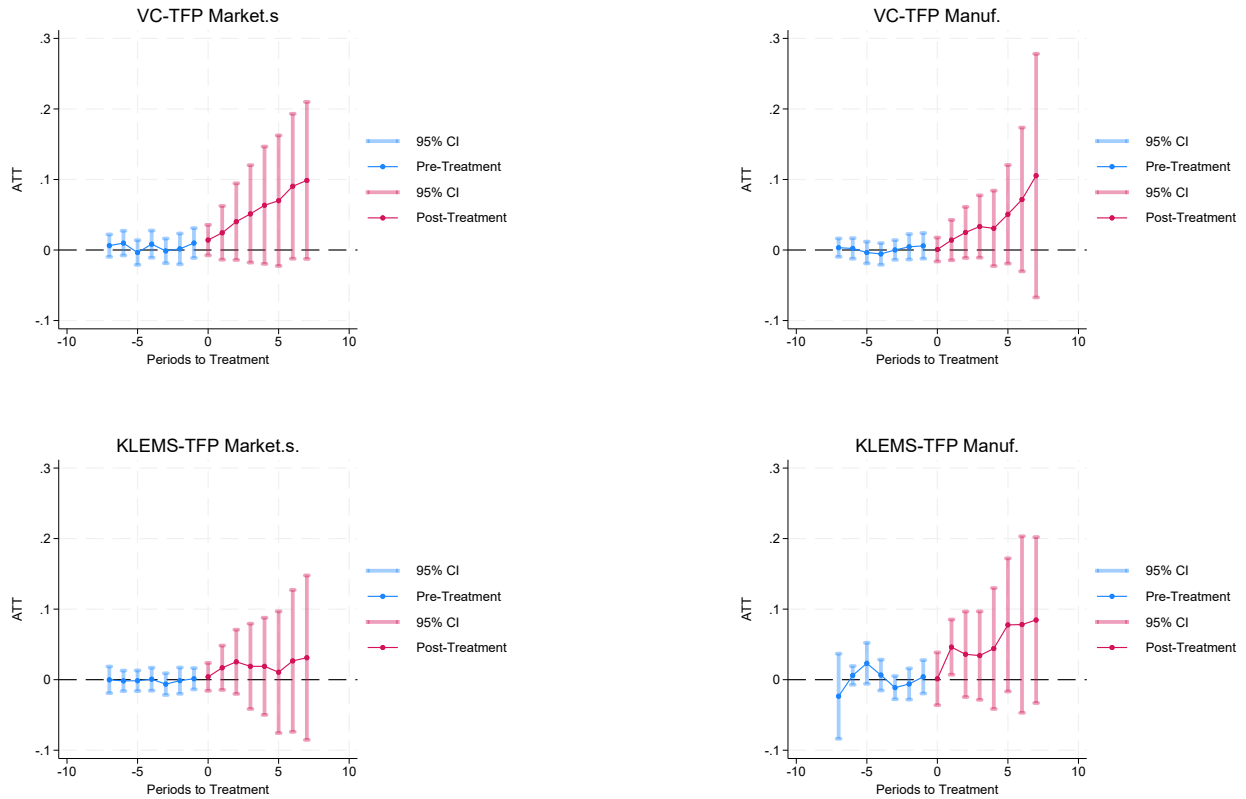
A.2 Event study: robustness, interpretation, and heterogeneity

Additional BIT interpretation and heterogeneity. The BIT evidence in Section 5 shows a positive VC TFP response and a clear increase in business-related intangibles, but the magnitude and location of effects vary across sectors and value chain segments. Two interpretive points are useful for the broader narrative.

First, the VC TFP response is more pronounced in market services than in manufacturing when comparing VC TFP to traditional TFP (Figures 1–5). This is consistent with the idea that service-intensive value chains rely heavily on reorganizing tasks and relationships (logistics, finance, management, and other market services), which may be poorly captured in traditional productivity measures and more sensitive to intangible capability. Second, the decomposition into final producer vs upstream TFP indicates that market services exhibit clearer upstream improvements after BITs than manufacturing (Figure 2), which is consistent with services being intermediated through broader network linkages.

Figure 5 shows that the difference between VC TFP and traditional TFP is more pronounced in market services, consistent with the idea that value chain linkages and input mismeasurement are more salient in service-intensive chains.

Figure 5: Development of TFP after BITs agreement enters into force



Note: The dots are event coefficients and the bars their bootstrapped 95 % confidence intervals clustered at unit level. The pre-treatment coefficients are blue and the post-treatment coefficients red.

Robustness of the event study analysis. It seems that the effect on VC TFP is not very heterogeneous. When each group is examined separately, the results are rather similar, even for the sample of only manufacturing industries or market services. Except for a few exceptions, the pre-event coefficients are insignificant. Moreover, while there are some differences in magnitude, the coefficient in all groups reflects a similar upward pattern after the event as the aggregated coefficients. However, when examined separately the post-event coefficients are not statistically significant, while a clearly larger share of the mass of the confidence intervals is positive.

Recall that Callaway and Sant Anna (2021)'s approach requires a large number of clusters for the inference to be valid. We only have 15 clusters in our baseline specification. However, it would be

more adequate to cluster the standard errors at the policy-level (country-level) instead of country-industry level. If we do cluster at the policy-level the post-event coefficients are insignificant at the 0.05 level. However, the confidence bands are located clearly more on the positive side. Furthermore, if we utilize the method by Borusyak et al. (2024) or the traditional "two-way fixed effects" the results are very similar to our baseline results.

If we alter the event window to its maximum, 13 years before and after the event, we notice that the post-event coefficients after year 7 are on average 0.13. Also, the pre-event coefficients before year 7 are seemingly close to zero. It also seems as if the last post-event coefficients (years 9 to 13) would start to stabilize somewhere around 0.13, compared to the upward-trend present in the first post-event coefficients (years 1 to 8).

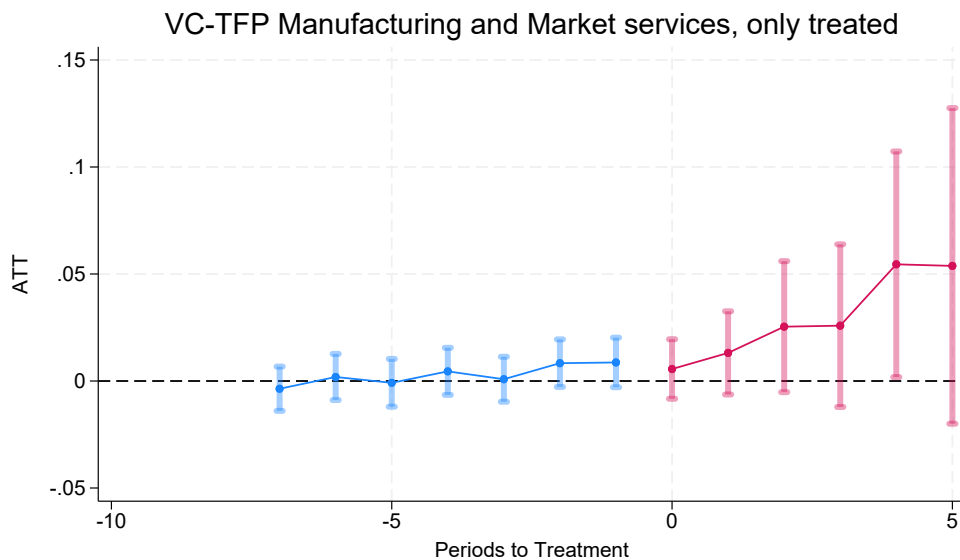
Given that we have rather few control and treated countries, it is possible that the observations from one influential country would be responsible for the results. It would then be quite doubtful whether the BITs agreements caused these results or something else that happened within this country at the same time that the BITs agreements entered into force. Considering VC TFP, we test for influential countries by leaving one country at a time out of the sample. We find that each time the results stay roughly the same, and while the significances and magnitudes somewhat change, the coefficients draw a rather similar pattern in each case.

As an additional robustness check, we restrict the sample to countries that eventually signed a BIT with China. This addresses the concern that our baseline estimates could partly reflect unobserved and persistent differences between countries that signed a BIT and those that never did, rather than the effects of the treaty itself. In the treated-only sample, identification comes from differences in treaty timing across countries that all eventually receive the treatment, so the comparison is made within a more homogeneous set of economies and is less exposed to selection based on permanent cross-country characteristics.

Results are reported in Figure 6. We continue to find positive and statistically significant productivity effects of broadly similar magnitude to those in the baseline specification. This suggests that the main findings are not driven by a simple distinction between BIT-signing and

non-signing countries. At the same time, this exercise does not by itself rule out all sources of endogeneity in treaty timing, since the decision of when to ratify a BIT may still be related to time-varying country-specific factors. Even so, the similarity of the treated-only estimates to the baseline results provides additional support for the interpretation that BITs are associated with economically meaningful productivity gains.

Figure 6: Development of TFP after BITs agreement enters into force, countries that eventually signed a BIT with China



Note: The dots are event coefficients and the bars their bootstrapped 95 % confidence intervals clustered at unit level. The pre-treatment coefficients are blue and the post-treatment coefficients red.

A.3 Additional model moments and comparative statics

This Appendix reports a compact set of additional model moments that complement Section 6. Table 20 summarizes selected non-targeted Step 0 to Step 1 changes. These moments are useful for comparing the model with the broader patterns in the BIT analysis. In particular, the model implies a marked increase in Europe’s business-capability measures, both for domestic capability a_E and for the effective business bundle A_E , together with a sizeable increase in European output Y_E and manufacturing production q_E . By contrast, the effective technology bundle Z_E is unchanged.

This ordering is close to the reduced-form evidence in Section 5, where the most robust responses concern VC TFP and business-related intangibles, while the direct technology-intangible response is weaker. The comparison should not be interpreted one-for-one, since the model’s Step 0 to Step 1 transition summarizes a broader liberalization episode rather than a single event-study coefficient, but it is reassuring that the non-targeted implications point in the same direction.

Table 20: Selected non-targeted Step 0 to Step 1 moments

	Step 0	Step 1	% change (0→1)
EU domestic business capability (a_E)	0.0738	0.0853	15.57
EU effective business bundle (A_E)	0.1085	0.1214	11.86
EU effective tech bundle (Z_E)	4.5983	4.5983	0.00
EU final output (Y_E)	2.0880	2.6056	24.79
EU manufacturing output (q_E)	1.9900	2.3223	16.70

Notes: These moments are not directly targeted in the calibration. They describe the model-implied transition from the pre-liberalization equilibrium (Step 0) to the liberalized equilibrium (Step 1). The distinction between a_E and A_E is useful in the present context: a_E is domestic business capability, whereas A_E is the effective business-capability bundle entering production once domestic and foreign business services are combined.

Table 21 then reports a small set of additional Step 2 comparative statics around the Step 1 equilibrium. The focus is on shocks that can be interpreted as partial geoeconomic fragmentation: higher trade costs in manufacturing goods (τ_M), in business-intangible services (τ_A), and in technology services (τ_Z). These exercises are best read as local comparative statics around the post-liberalization steady state. They are informative about the model’s mechanisms, but not about a unique decomposition of the post-2008 slowdown.

The pattern in Table 21 is consistent with the discussion in the main text. Increases in manufacturing or business-services trade costs reduce output and TFP in both regions by shrinking the scale of cross-border production. The business-services margin remains especially relevant for the capability block, because higher τ_A lowers the effective business bundle directly. By contrast, higher technology-services frictions have more uneven effects across regions in this calibration. This asymmetry is useful for interpretation, but it is one reason to read the Step 2 exercises mainly as disciplined comparative statics rather than as a literal account of a single post-2008 shock.

Table 21: Additional Step 2 comparative statics: fragmentation around Step 1

	$\tau_{M,2}+0.01$	$\tau_{A,2}+0.01$	$\tau_{Z,2}+0.01$
EU TFP (T_E)	-0.158	-0.229	0.000
CN TFP (T_C)	-0.066	-0.219	-0.174
EU output (Y_E)	-0.575	-0.350	-0.024
CN output (Y_C)	-1.036	-0.339	-0.218
EU business cap. (A_E)	-0.231	-0.333	0.010
CN business cap. (A_C)	-0.202	-0.667	0.019
EU scale (S_E)	-0.558	-0.352	-0.005
CN scale (S_C)	-0.846	-0.337	-0.254

Notes: Each column reports the percent change of endogenous variables relative to the Step 1 steady state when the indicated Step 2 exogenous object increases by the stated amount and the economy is re-solved. Trade costs are iceberg. The results continue to show that higher goods-trade and business-services frictions are contractionary for both regions, while technology-services frictions are more asymmetric.