The China effect on the productivity in Nordic countries

Daniel Lind*

Abstract

Using a linear panel data model with a fixed-effect estimator, this article investigates the causal effect of the growing use of Chinese intermediates on the labour productivity growth in Nordic manufacturing production processes. The main result – based on changes within more than 70 global value chains during the period 2000–2014 – is that the effect is positive and economically relevant. This productivity effect exists before and after the financial crisis, in all Nordic countries, and is well-spread among the sub-sectors of the manufacturing industry. The effect is mainly caused by reduced employment, not increased value added. This employment effect appears both in the manufacturing sub-sectors themselves and along their domestic supply chains. Finally, China does not seem to be special: the productivity effect of the growing use of Eastern European intermediates is equally pronounced.

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* *The author works as a research director at Arenagruppen, a think tank close to the Swedish trade union movement.* *Lind would like to thank seminar participants at the Department of Economics at Örebro University, Business Sweden, and the National Board of Economic Research for fruitful discussions and constructive comments.* *Contact details: daniel.lind@arenagruppen.se.*

1. Introduction

The literature on the China shock has grown fast during the last decade.[1] One under-researched aspect is, however, the macroeconomic effects of the trade with China on the productivity among the high-income countries. In particular, no attempt has been made to investigate this effect on the small, trade-dependent, and technologically sophisticated Nordic countries. The aim of this article is therefore to answer this main question: does the growing use of Chinese intermediates affect the labour productivity growth in the manufacturing sector in the Nordic countries? To shed further light on the answer, the following questions will also be addressed. Is there a Chinese trade effect on value added or employment – or both? In a comparison with Eastern Europe, is China´s intermediates a special case?

One insight from the recent research on the China shock is that a credible answer to the main question requires a vertically integrated perspective.[2] This means that the manufacturing sector should not be treated as an isolated unit, but as a chain of activities which connect sectors and countries through the trade in intermediates. Therefore, the existence, magnitude and character of a productivity effect is determined by the extent to which this network diffuses the initial effect to all parts of the economy.

Consequently, this article is also related to the renewed macroeconomic interest in input-output (IO) linkages. As argued by Acemoglu and Azar (2020), one aspect of this is that the connection between IO linkages and productivity is a topic that deserves more attention. Addressing the main question from a vertically integrated perspective, this article represents an attempt to take some small steps in this direction.

The productivity measure used is called vertical labour productivity and is defined as the ratio between the value added and employment generated within the domestic economy in order to produce a manufactured product. Accordingly, this measure includes all upstream activities along the domestic supply chain needed to finalize the product.[3]

Applying a well-established identification strategy in the China shock literature and using a linear panel model with a fixed effect estimator, the main result is that the growing use of Chinese intermediates has contributed to a faster labour productivity growth within the manufacturing production processes in the Nordics. This effect exists before and after the financial crisis, in all four individual countries, and is well-spread among the sub-sectors of the manufacturing industry. The effect is mainly caused by reduced employment, not increased value added. This employment effect is found both in the manufacturing sub-sectors themselves and along their domestic supply chains. However, the positive productivity effect from the growing use of Chinese intermediates does not seem to be unique: the effect of the growing use of Eastern European intermediates is equally significant and, if anything, larger in absolute terms.

The article proceeds as follows. The next section positions the article within the relevant literatures. Next follows two sections that describes the data, the main variables, and the empirical approach. Next follows the section containing the empirical results. The last section concludes and briefly discusses some avenues for future research.

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[1] *Autor et al. (2013, 2015, 2019, 2020a, 2020b, 2021), Dauth et al. (2014), Acemoglu et al. (2015), Bloom et al. (2016), Feenstra et al. (2019), Pierce and Schott (2020), Jaravel and Sager (2020), Amiti et al. (2020), Che et al. (2020) and Bloom et al. (2021).*

[2] *Autor et al. (2016), Pierce and Schott (2016), Acemoglu, Autor, Dorn, Hanson and Price (2016), Feenstra and Sasahara (2018), and Bloom et al. (2019). Autor and Salomons (2018) and Reijnders et al. (2021) use the same argument for the employment effects caused by technical change.*

[3] *Similar productivity measures have recently been used in Timmer (2017), Gu and Yan (2017), Timmer and Ye (2018, 2020), Pahl and Timmer (2019) and Buckley et al. (2020). However, this approach to productivity analysis is not new. Based on the domestic economy, it is found in early IO research on the US economy (Leontief 1953; Carter 1970). It is also a common theme in the evolutionary tradition (Nelson and Winter 1982; Rosenberg 1982) and in the post-Keynesian tradition (Pasinetti 1981, 1993). Other examples of this type of productivity research are found in Wolff (1994, 2011), Dietzenbacher (2000), De Juan and Febrero (2000), and Ten Raa and Wolff (2000, 2001, 2012).*

2. Related literatures

The starting point of this article is the literatures on the emergence and increased complexity of the GVCs and how China has become a central node within this global production network, dominated by the trade in intermediates.[4] With each production stage adding value to the final product, recent macroeconomic empirical GVC research has focused on how shocks, such as the China shock, are spread around the world through the trade in intermediates (Antras and Chor, 2021). The main conclusion is that the positive effect of trade is substantially increased when intermediates are included in quantitative trade models.[5] Along similar lines, the trade in intermediates is the core aspect in the recent research that endogenizes the IO structure and how it changes over time (Acemoglu and Azar, 2020).[6] When firms cost-minimize their use of intermediates, new input combinations will emerge, due to technical change. If these new combinations lead to price reductions, a small change in one sector can cause a major change in the organization of production and affect productivity in many sectors. This diffusion aspect of the trade in intermediates is also applied in the recent research on shock propagation and how a shock, in contrast to the averaging out-argument in Lucas (1977), may affect the macroeconomic volatility (Acemoglu et al. 2012, 2015, Acemoglu, Ozdaglar and Tahbaz-Salehi 2016; Carvalho 2019). This occurs when some sectors are particularly important as suppliers and when the use of intermediates is widespread. The empirical analysis in Acemoglu et al. (2015), focusing on US IO tables for 1992, shows that productivity shocks mainly propagate downstream, and their conclusion is that this amplification mechanism is more important than what is typically presumed in the macroeconomic literature.

The vertically integrated perspective can create both positive and negative employment effects, indicating that the net effect of the China shock is ambiguous in sign. The empirical analysis in Acemoglu et al. (2016) shows that the negative employment effect is more than doubled, as compared to the effect within the manufacturing sector itself. They conclude (p. 145): "Thus, interindustry linkages magnify the employment effects from trade shocks…". Although the level and sign of this employment effect have been questioned, the standard approach in the macroeconomic literature on the China shock has become to apply a vertically integrated perspective, in the sense that the IO structure is included in the empirical analysis.[7]

To the best of my knowledge, no attempt has been made to study the macroeconomic effects of China's intermediate exports on the productivity within the manufacturing production processes among the Nordics. There are, however, some related research. From a microeconomic perspective, Bloom et al. (2016) investigates the productivity aspect of the China shock, and their main conclusion is that the effect is positive on firms' TFP growth in four European countries between 1996–2007. Using instrumental techniques, 30–60 per cent of the growth between 2000–07 are accounted for by the imports from China. Bloom et al. (2021) continues along a similar path and shows that firms in 11 European countries which are more exposed to trade from China increased their productivity enhancing efforts more than other firms between 1995 and 2005, while they also experienced a decline in sales. From a propagation perspective, Acemoglu et al. (2015) use the IO structure for the year

[4] *For recent general overviews, see Baldwin (2016, 2017, 2019), Ponte et al. (2019), IMF (2019), WTO (2019) and World Bank (2020). With the focus on trade in value added, see Johnson and Noguera (2012, 2017), among many others. Early analyses on the effects of the global trade in intermediates are, for example, found in Feenstra and Hanson (1996, 1999) and Feenstra (1998). On China, see Feenstra et al. (1999) and Brandstetter and Feenstra (2002).*

[5] *On the theoretical side, recent contributions are Caliendo and Parro (2015), Caliendo et al. (2017), Antras and Chor (2019) and Antras and de Gortari (2020). These frameworks have also been used in counterfactual exercises to quantity the effects of US-China trade tensions (e.g. Caceres et al. 2019; Ju et al. 2019), productivity shocks in the US economy when IO linkages are present (Caliendo et al. 2018), effects on the US economy from the China trade shock (Caliendo et al. 2019; Rodriguez-Clare et al. 2020) and the effect of global specialization on the sensitivity for productivity shocks in other countries (Caselli et al. 2020).*

[6] *See also Carvalho and Voigtländer (2015) and Oberfield (2018).*

[7] *Autor et al. (2016, p. 220) express this in the following way: "A full account of the impact of trade shocks thus requires incorporating input-output linkages between domestic industries." See also Pierce and Schott (2016), Bloom et al. (2016), and Feenstra and Sasahara (2018). Buera and Oberfield (2020) develop a model in which the diffusion of knowledge and innovation between sectors and countries is necessary to explain growth miracles like China. Using this IO perspective, they find that China's gains from its openness to trade doubles when this diffusion channel is included in the analysis. The same is the case for the trade effect on China's TFP growth.*

1991 to investigate how different types of shocks are spread to almost 400 sectors in the US economy and how they affect value added, employment and labour productivity. In terms of a trade shock from China, labour productivity is unaffected since the effects on value added and employment are both negative and of a similar magnitude.

From an IO perspective, Acemoglu and Azar (2020) investigate how changes in individual cells of the Leontief inverse affect TFP. They find that "large" changes, defined as being above the 20th percentile in terms of changes in the number of suppliers, in the composition of intermediates contribute to faster productivity growth in the US. Over the period 1987–2007, between 40–60 percent of the difference in TFP growth between sectors can be explained by these changes in the intermediate structure.[8] From a GVC perspective, and using vertically integrated productivity measures, one of the main conclusions in Timmer (2017) and Timmer and Ye (2018, 2020) is that a substantial part of the TFP growth within the manufacturing production process of the HICs since the 1990s is generated outside the manufacturing sector itself. Gu and Yan (2017) follow the same approach, and their main result is – among the HICs and during the period 1995–2007 – that there is a substantial difference between the conventional, sectoral-based TFP growth and the TFP measure that includes the supply chain. Moreover, due to more productive imported intermediates, Canada has gained more productivity than the EU countries and the US from participating in the GVCs. Pahl and Timmer (2019) define their vertically integrated productivity measure as the ratio between the value added and employment needed to produce an exported manufactured product. Based on 58 countries and the period 1970–2008, their main result is that a high level of imported intermediates correlates with a faster vertical labour productivity growth.

In line with the China shock research on the need of a vertically integrated perspective, following the recent macroeconomic GVC research on how shocks, through the trade in intermediates, are propagated within the global production network, and using recent measurement developments in the productivity literature, this article investigates the China shock on the productivity in the Nordics for the first time. The macroeconomic approach has two main advantages. First, it gives overall estimates of the productivity effect among the Nordic countries and their more than 70 global value chains. These aggregate estimates can, in turn, be broken down into analyses of separate countries and GVCs. Second, it makes it possible to fully exploit the vertical dimension of manufacturing production (Antras and Chor, 2021): how firms in different sectors and countries interact in order to finalize a product, and how this affects the productivity outcomes.

3. Data and variables

Data

The data used comes from the World Input-Output Database (WIOD). This database contains intermediate trade within and across countries, covers 43 countries, 56 sectors – of which 19 belong to the manufacturing sector – and 15 years (2000–2014).[9] Following Timmer et al. (2021), the data used in this article is expressed in constant prices with base year 2000.[10] Translation into a common currency (USD) is done by market exchange rates. Sectors are classified according to the ISIC Rev. 4 and the IO tables follow the 2008 version of the System of National Accounts (SNA).[11]

[8] *In a non-competitive (bargaining) framework, see Acemoglu et al. (2020) for a further theoretical discussion on how a TFP shock may affect the affected sector´s suppliers and customers.*

[9] *For a critical assessment of and a discussion on the usefulness of World Input-Output Tables (WIOT), see Antras and Chor (2021). Two important weaknesses are: (1) the rather high level of disaggregation, and (2) the strong assumptions needed to construct a coherent WIOT. One aspect of the strong assumptions particularly relevant for this article is that China´s intermediates are produced with the same technology regardless to where they are exported. Over the last decade, WIOT databases has, however, emerged as an indispensable empirical tool in the GVC literature and in more policy-oriented bodies, such as the OECD and WTO (Antras and Chor, 2021).*

[10] *For further details about the deflation method, see the online appendix.*

[11] *For further details about WIOD, see Dietzenbacher et al. (2013) and Timmer et al. (2015).*

Following Antras and Chor (2018) and Pahl and Timmer (2019) among others, each manufacturing sub-sector in each country, including its supply chain, is viewed as a separate GVC. These GVCs are the main unit of analysis. With four Nordic countries – Denmark, Finland, Norway, and Sweden – and 19 manufacturing sub-sectors in each country, the empirical analysis will, at most, be based on 76 GVCs.

Variables

Applying a vertically integrated perspective, the variables are constructed using IO techniques and Leontief's inverse matrix.[12] By pre- and/or post-multiplication, this matrix generates variables which include all upstream activities needed along the supply chain to produce the final product. Therefore, each GVC represents a "composite" sector, as if all production stages were totally vertically integrated (Timmer 2017; Timmer and Ye 2018, 2020).

More formally, let FD be a matrix of final demand of dimension G*G, with final demand on the main diagonal and zeros elsewhere, and with G indicating the number of sectors. Let A^D be the G*G domestic coefficient matrix with the typical element, a_{ijt}, indicating the amounts of domestic intermediates from sector i used to produce one unit of production in sector j in time t. From this is it possible to define a G*G matrix containing the gross output needed to produce final demand, as $GO=(I-A^D)^{-1}$ FD, where I is a G*G identity matrix with ones on the main diagonal, and zeros elsewhere. $(I-A^D)^{-1}$ is the Leontief inverse matrix, which ensures that all production needed along the domestic supply chain is taken into account.

Based on this, for each manufacturing sub-sector in each country (i.e., for each GVC), the main variables are the following:

Vertical labour productivity. The ratio between vertical value added and vertical employment generated within the domestic production process in order to produce final demand.[13] Formally, vertical value added is found by the equation $VVA=VA/GO\ (I-A^D)^{-1}$ FD , where VA/GO is a G*G matrix with the ratios between sectoral value added and sectoral gross output on the main diagonal, and zeros elsewhere. Accordingly, for each manufacturing sub-sector, the column sum in VVA is the vertical value added: the wages and profits generated anywhere in the domestic economy in order to produce the sector´s final demand. Vertical employment is constructed analogously but changing VA/GO for EMP/GO, where EMP represents sectoral employment.

Output multiplier. The gross output needed in the domestic economy in order to produce *one unit* of final demand, including all upstream stages of the domestic production process. For each manufacturing sub-sector, the output multiplier is measured by its column sum in the Leontief inverse.[14]

Import multiplier. The use of imported intermediates *per unit* of final demand, including all upstream stages of the domestic production process. Formally, this variable is found by the equation $IM=II/GO\ (I-A^D)^{-1}$, where II/GO is a G*G matrix with the ratios between sectoral intermediate imports and sectoral gross output on the main diagonal, and zeros elsewhere. For each manufacturing sub-sector, the import multiplier is measured by its column sum in IM.[15]

Import multiplier from China. The use of Chinese intermediates *per unit* of final demand, including all upstream stages of the domestic production process. Formally, this variable is found in the same way as the import multiplier but changing

[12] *See Miller and Blair (2009) for the fundamental ideas behind the IO analysis.*

[13] *As stated in the first section, this vertically integrated productivity measure is not new, but have attracted renewed interest in our era of GVCs.*

[14] *This variable can be seen as the domestic counterpart to the measure of upstreamness in the recent GVC research (Antras and Chor, 2018).*

[15] *This variable is closely related to the measures of foreign value added in exports in the GVC literature (Antras and Chor, 2021).*

II/GO for III/GO, where IIC is a G*G matrix with the ratios between sectoral intermediate imports from China and sectoral gross output on the main diagonal, and zeros elsewhere. For each manufacturing sub-sector, the import multiplier from China is therefore measured by its column sum in $IMC=IIC/GO\ (I-A^D)^{-1}$.

Overall multiplier. The gross output needed to produce *one unit* of final demand, irrespective if the intermediates are domestically or foreign sourced. This variable is an own construct and defined as the sum of the output multiplier and the import multiplier.

Capital multiplier. The use of the capital stock *per unit* of final demand, including all upstream stages of the domestic production process. Formally, this variable is found by the equation $CM=CS/GO\ (I-A^D)^{-1}$, where CS/GO is a G*G matrix with the ratios between the sectoral capital stock and sectoral gross output on the main diagonal, and zeros elsewhere. For each manufacturing sub-sector, the capital multiplier is measured by its column sum in CM.

Vertical gross output. The gross output needed to produce final demand, including all upstream stages of the domestic production process. For each manufacturing sub-sector, vertical gross output is measured by its column sum in GO, the gross output matrix defined above.

4. Descriptive statistics, empirical model, and IV-strategy

Descriptive statistics

Table 1 summarizes how the main variables have developed during the period 2000–2014.[16] First, with more than a five-fold increase in its absolute level, China's productivity convergence is substantial, and especially so after the financial crisis. Second, the increase in the import multiplier has stabilized after the financial crisis in the Nordics, while it has decreased in China, indicatively supporting the aim of a growing self-reliance on intermediates needed within its manufacturing production processes. With only a minor decrease in the output multiplier since 2000, the growing import multiplier in the Nordics implies that the relative importance of imported intermediates has grown, confirming the trend towards an intensified vertical specialization in the global economy. Third, the relative use of Chinese intermediates in the Nordics has increased more than six times, although from a low level. In absolute terms, the use of Chinese intermediates per unit of final demand increased by almost 620 percent between 2000–2014, to 0.0165. Fourth, despite the reduced absolute Chinese import multiplier since the financial crisis, the Chinese use of Nordic intermediates has increased substantially, in both absolute and relative terms. Finally, China's productivity convergence has occurred alongside a considerable decrease in its capital multiplier, indicating a strong growth in the vertical capital productivity.

[16] *For the statistics on the separate Nordic countries, see the online appendix.*

Table 1. *Descriptive statistics: Nordic countries and China*

Nordic countries	**2000**	**2008**	**2014**
Vertical labour productivity level (1000s, USD)	61.8	120.4	138.9
Output multiplier	1.68	1.65	1.65
Import multiplier	0.29	0.33	0.33
Overall multiplier (output + import multiplier)	1.97	1.98	1.97
Import multiplier from China	0.0023	0.0107	0.0165
Import multiplier/Output multiplier	0.17	0.20	0.20
Import multiplier from China/Import multiplier	0.008	0.032	0.050
Capital multiplier	1.34	1.09	1.12
China			
Vertical labour productivity level (1000s, USD)	2.7	7.5	15.0
Productivity convergence: China/Nordics (share)	0.044	0.062	0.108
Output multiplier	2.55	2.62	2.96
Import multiplier	0.15	0.20	0.16
Overall multiplier (output + import multiplier)	2.70	2.82	3.12
Import multiplier from Nordics	0.0048	0.0109	0.0167
Import multiplier/Output multiplier	0.059	0.076	0.054
Import multiplier from Nordics/Import multiplier	0.032	0.055	0.104
Capital multiplier	1.54	0.53	0.31

Note. The figures of the Nordic countries are the unweighted averages among the four countries and the 19 manufacturing sub-sectors in each of the countries, including their domestic supply chains (i.e., 76 GVCs). The figures for China are the unweighted averages among its 19 manufacturing sub-sectors, including their domestic supply chains. The multiplier variables should be interpreted as: a unit change in final demand generates xx units of the variable in question, including all upstream stages of the domestic production process.

Empirical model

Following much of the recent research on the China shock, a linear panel model with a fixed effect estimator will be used to empirically analyze the causal effect of the growing use of Chinese intermediates on the vertical labour productivity growth within the GVCs among the Nordics. Accordingly, the following equation will be the empirical backbone of the article:

$$VLP_{ijt} = \beta_1 X_{1,ijt} + \beta_k X_{k,ijt} + \alpha_i + \varepsilon_{ijt} \quad (1)$$

where VLP_{ijt} is the vertical labour productivity level in GVC_i in country j at time t. β_1 is the main coefficient, indicating the average effect of the change in the use of Chinese intermediates on the change in vertical labour productivity. The β_k vector will contain different coefficients depending on which regressors that are included in the particular specification. α_i is the GVC-specific intercept which controls for the time-invariant differences between the GVCs that are not included in the regressions. ε_{ijt} is the "usual" disturbance which varies between GVCs and over time.

Identification

How can it be made likely that any correlation between the growing use of Chinese intermediates and the vertical labour productivity growth among the Nordics can be interpreted in causal terms? Within the recent China shock literature, a well-used identification strategy has been established during the last decade. The starting point of this strategy is found

in Autor et al. (2013).[17] In this paper they analyze how the China shock affects the US labour market. To solve the ever-existing endogeneity problem, it is argued that the China shock is mainly supply-driven, in the sense that it is primarily caused by political and economic reforms within China. This has led to a very strong productivity growth, in particular in the manufacturing sector (Autor et al. 2016).[18] As a consequence, foreign demand for Chinese intermediates almost exploded, not the least from the mid-1990s and onwards, with the membership in WTO in 2001 as a vehicle for further improvements in China´s global competitiveness. Accordingly, from a rank position close to 30 in the mid-1990s, China is now ranked number 2 in the world in Unido´s competitive industrial performance index.[19] Between 1995 and 2018, and from a vertically integrated perspective, China´s share of the value added generated in any sector in any country in the world in order to satisfy world final demand for manufactured products increased from 4 to 27 percent.[20] Gradually, China emerged as the factory of the world.[21]

To isolate the domestic, Chinese component of this development from any change in the US demand for Chinese exports, Autor et al. (2013) exploits the change in exports from China to other high-income countries. This identification strategy is therefore based on the argument that the growth in imports from China that simultaneously occurs in the US and other high-income countries are primarily caused by China´s strong productivity performance and reduced trade barriers following the accession to the WTO. The exclusion restriction underlying this IV-strategy is, accordingly, that the common component of the fast-growing imports from China among these nine high-income countries is found within China, in particular in the form of very strong output and productivity growth in the manufacturing sector.

To account for the potential endogeneity problem in this article, the instrument will, analogously, be the imports of Chinese intermediates among 13 other high-income countries than the Nordics.[22] More precisely, the source of exogenous variation within the (76) manufacturing GVCs in the Nordics will come from the change in the import multiplier from China – i.e. the change in the use of Chinese intermediates per unit of final demand, including all upstream stages of the manufacturing production process – among these countries. As will be seen, the correlation of the import multiplier from China is strong between the Nordics and the 13 high-income countries (0.8). Consequently, this IV-strategy generates highly significant first-stage regressions and satisfying F-values.

There are, however, several potential threats to this IV strategy. First, there might be that import demand shocks are correlated across the high-income countries. If this is the case, the estimated elasticity between the import multiplier from China and the Nordic vertical labour productivity would be lower than what it truly is. However, by the use of a gravity model of trade induced instrument that neutralizes the foreign demand component of the Chinese export surge, Autor et al. (2013) among others have shown that the results with the two different IV strategies are similar. Consequently, the

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[17] *After this seminal work, the strategy has been used in Autor et al. (2015), Autor et al. (2016), Autor et al. (2019), Autor et al. (2020a), Autor et al. (2020b), and Autor et al. (2021). See also Acemoglu et al. (2016), Antras et al. (2017), Bloom et al. (2019), Acemoglu and Restrepo (2019), Constantinescu et al. (2019), Timmer and de Vries (2019), Acemoglu and Azar (2020), Acemoglu and Azar (2020), and Bloom et al. (2021).*

[18] *From a vertically integrated perspective, the impressive Chinese manufacturing productivity performance finds support in Table 1. The importance of productivity for the China shock is also found in Antras et al. (2017), where they model this shock as a rapid increase in the productivity growth within the Chinese production of intermediates. Hsieh and Klenov (2009) shows that reduced misallocation of resources between firms (1998–2005) is one reason behind the strong TFP growth in Chinese manufacturing. With further improvements in global competitiveness, continuing political reforms and the ongoing ICT revolution, it is likely that this – absolute and relative – increased efficiency is one reason behind China´s strong vertical labour productivity growth. However, it is not possible to investigate this further in this article.*

[19] *https://stat.unido.org/*

[20] *https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm#access*

[21] *Autor et al. (2016) argues that this described development makes it easier to overcome the problem with causality, since the remarkable development was unexpected up until the beginning of the 1990s, that the long period of economic isolation created large opportunities for economic catch up, and that China´s improved comparative advantage so closely is related to manufacturing production.*

[22] *These countries are Austria, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Switzerland, United Kingdom, and US.*

demand dimension of the growing Chinese intermediate exports to the Nordics is unlikely to invalidate the results in this article. Moreover, within the setting of this article, the estimations will include a variable containing the demand for imported intermediates (import multiplier), as well as a variable containing final demand (vertical gross output). This contributes to the neutralization of the foreign demand dimension of the China shock, as the results will rest on the control for demand dimensions that potentially could be correlated among the high-income countries. Another threat to identification is that a weak productivity growth in the Nordics might have led to a growing demand for Chinese intermediates. As can be seen from Table 1, two arguments can be made: by any reasonable standard, the vertical labour productivity growth has not been weak in the Nordics, and the Chinese productivity growth has by far outpaced the Nordics; the Chinese convergence is clear. Also, Autor et al. (2015) argues that their gravity model of trade induced instrument addresses this productivity-based threat to identification, since it controls for the relative change in productivity between China and the US. With the similarity of results between the two IV strategies in Autor et al. (2013, 2015) among others, the productivity-based threat to identification should not invalidate the results in this article. Third, if technical change (e.g., ICT) in the Nordics leads to a change towards more capital and less labour used in the production processes, this might lead to a growing demand for Chinese intermediates. This possibility cannot be categorically rejected, but recent history suggests, as mentioned, that China´s strong export growth is likely to be strongly related to factors within China, in particular the rapidly improved global competitiveness of the manufacturing sector. Moreover, withing the setting of this article, an attempt to reduce this threat to specification is made. This is done by the inclusion of the capital stock (capital multiplier) as a control.

5. Results

Benchmark estimations

Does the growing use of Chinese intermediates affect the labour productivity growth within the manufacturing production processes in the Nordics? To answer this question, the first steps are taken in Table 2. In the first column, however, Nordics' productivity is – apart from the control for the business cycle – only regressed against the two variables that describe the overall network of intermediate trade: the output multiplier and the import multiplier. The result is clear: when keeping the output multiplier (import multiplier) constant, a growing use of imported (domestic) intermediates is positively (negatively) and significantly correlated with a faster productivity growth.[23] Accordingly, this estimation indicates that a growing use of imported intermediates – the core aspect of a new global economy dominated by the GVCs – has been rewarding in terms of vertical labour productivity.

What happens to the import multiplier when the import multiplier from China is included in the estimation? Column 2 shows that the positive elasticity of the import multiplier turns into an equally large and significant negative elasticity. On the other hand, the elasticity of the import multiplier from China becomes positively significant. Consequently, when the import multiplier from China is held constant (i.e., no China shock), there is a negative correlation between a growing use of imported intermediates and a faster productivity growth. This is a first indication that the positive productivity contribution from the growing use of foreign intermediates in general seems to be associated with the growing use of Chinese intermediates. The next question is: what happens to the elasticities in column 2 when the IV strategy is applied? First, the negative elasticity of the import multiplier becomes even more substantial, further emphasizing the importance of the trade with China when analyzing the productivity effects from a more vertically specialized global economy. Second, the elasticity of the import multiplier from China also becomes larger, indicating the importance of using an appropriate IV strategy. Based on a satisfying F-value of the first-stage regression, a one percent increase in the use of Chinese intermediates leads, on average, to a 0.5 percent increase in the labour productivity growth within the manufacturing production processes in the Nordics. In terms of magnitudes, what does this elasticity imply? The average Nordic import

[23] *Obviously, there is a negative correlation between the output and import multiplier. During the period 2000–2014, the average among the Nordics is -0.38. However, there are also considerable differences between different manufacturing production processes. In 2014, for example, the lowest (highest) overall multiplier was 1.44 (2.57).*

multiplier from China amounts to 0.0089 over the years 2000–2014, and the average vertical labour productivity level amounts to 103.6 USD over the same period. When the average import multiplier from China increases with one percent, the average vertical labour productivity level therefore improves with 0.5 USD (103.6 * 1.0051 = 104.1).

Table 2. *Benchmark estimations of the effect of the China shock on the vertical labour productivity growth*

Dependent variable: Nordic vertical labour productivity	Without Chinese intermediates	With Chinese intermediates	With Chinese intermediates, (IV)	With Chinese intermediates, overall multiplier, (IV)	With Chinese intermediates and a capital multiplier, (IV)
Output multiplier	-1.815**	-0.757*	-0.547		0.010
	(0.594)	(0.352)	(0.377)		(0.406)
Import multiplier	0.751***	-0.753***	-1.051***		-1.006***
	(0.158)	(0.157)	(0.165)		(0.155)
Import multiplier from China		0.418***	0.501***	0.415***	0.458***
		(0.023)	(0.026)	(0.023)	(0.027)
Overall multiplier				-1.781***	
				(0.330)	
Capital multiplier					-0.433***
					(0.122)
Instrument	No	No	Yes	Yes	Yes
R2 - within	0.27	0.72	0.70	0.68	0.73
N	1027	1027	1027	1027	1027
F-value: first-stage regression	No	No	401	353	317

*Note. Linear fixed effect (IV) estimations (2SLS). Robust standard errors in parentheses, adjusted for 74 clusters (GVCs). The instrumental variable is the import multiplier from China among 13 high-income countries other than the Nordics. Vertical gross output is included to control for the business cycle. Years: 2000–2014. Log values. * = p<0.05, ** = p<0.01, *** = p<0.001. In column 3, the elasticity of the instrumental variable in the first-stage regression is significant at p<0.001 and amounts to 0.939. In column 4-5, the level of significance is the same, and the elasticities amounts to 1.044 and 0.927, respectively. These first-stage regressions show that the intermediate import from China by the 13 high-income countries strongly predicts the intermediate imports from China by the Nordics. All three IV-estimations pass the under-identification test (Kleibergen-Papp rk LM statistic) and the weak identification test (Cragg-Donald Wald F statistic). When following the IV-strategy in Bloom et al. (2021), and only using the US intermediate imports from China as the instrument in the estimation in column 3, the results remain unchanged, but the F-value in the first-stage regression is reduced to 217. Weighted estimations – in terms of vertical gross output, vertical value added and vertical employment, respectively – give the same results as in this table (see online appendix).*

Are the results in column 3 dependent on how the trade in intermediates is defined? Substituting the output and import multiplier for the overall multiplier, column 4 shows that this reduces the elasticity of the use of Chinese intermediates but is still significant at p<0.001. Another obvious concern is possible omitted variables. Due to the main question of this article, an important aspect is related to the exclusion of the capital stock.[24] Therefore, the estimation in the last column includes the capital multiplier. As can be seen, its elasticity turns out to be negatively significant, while the elasticity of the import multiplier from China is reduced, as compared to the benchmark estimation in column 3. How should this negative capital multiplier elasticity be interpreted? From the IO literature, a reduction in the capital multiplier means that less capital is used to finalize a product, indicating a positive capital productivity growth (Timmer, 2017). The

[24] *Furthermore, the distinction between intermediates and the capital stock can be questioned (Jones, 2013). Both types of "capital" can be viewed as produced factors of production with the same purpose: contributing productively to the finalization of a product. The only difference is the time dimension, with the more short-lived intermediates defined as current consumption (and not as a capital investment). Corrado et al. (2020) argues that this distinction is particularly difficult to uphold when it comes to the knowledge-based capital – a type of capital particularly important for the Nordics and other high-income countries.*

negative capital multiplier elasticity in Table 3 therefore, and according to theory, suggests that a slower growth in the capital productivity leads to a slower growth in the vertical labour productivity.

Sub-periods and lags

With the financial crisis in 2008, the period studied in this article is characterized by two very different sub-periods. The period before the crisis is often described as a period of hyper-globalization, with China´s membership of WTO in 2001 as a defining change in the global economy. The period after the crisis is, after the initial negative shock and the first bounce back, instead characterized by a slow and gradual global comeback in terms of intermediate trade and GVCs in general. Therefore, the estimated model in Table 2 should be split into these two sub-periods.

Also, with a vertically integrated perspective and its focus on the process of diffusion within and between countries, it is reasonable to add lags to the analysis.[25] There are two main reasons for this. First, it reduces the potential problem of reversed causality. Second, it is theoretically reasonable to believe that the productivity effect of the growing use of use of Chinese intermediates is not instantaneous: that the (strongest) effect does not necessarily show up in the same year as the transaction is registered.

The estimations in Table 3 try to address these extensions: sub-periods and lags. This is done using the model estimated in column 3 in Table 2. As can be seen, the benchmark result holds both before and after the financial crisis, although the elasticity of the import multiplier from China and the explanatory power of the model are significantly reduced after the crisis. Also, the predictive power of the instrumental variable is significantly reduced after the financial crisis but is still above any reasonable threshold. Consequently, the China shock seems to be particularly pronounced during the period of hyper-globalization.

Table 3. *The effect of the China shock on the vertical labour productivity growth: sub-periods and lags*

Dependent variable: Nordic vertical labour productivity	2000–2008	2009–2014	2000–2014, lag 1	2000–2014, lag 3	2000–2014, lag 5	2000–2014, lag 7
Output multiplier	-0.819	-1.039***	-0.249	0.347	0.930**	0.618*
	(0.465)	(0.262)	(0.393)	(0.320)	(0.326)	(0.306)
Import multiplier	-0.766***	-0.769***	-0.998***	-0.848***	-0.546***	-0.322**
	(0.160)	(0.165)	(0.169)	(0.151)	(0.123)	(0.103)
Import multiplier from China	0.494***	0.326***	0.489***	0.360***	0.214***	0.145***
	(0.025)	(0.059)	(0.025)	(0.020)	(0.020)	(0.022)
R2 - within	0.75	0.26	0.67	0.57	0.33	0.16
N	623	404	934	792	656	529
F-value: first-stage regression	402	136	318	158	128	76

*Note. Linear fixed effect (IV) estimations (2SLS). Robust standard errors in parentheses, adjusted for 74 clusters (GVCs). The instrumental variable is the import multiplier from China among 13 high-income countries other than the Nordics. Vertical gross output is included to control for the business cycle. Log values. * = p<0.05, ** = p<0.01, *** = p<0.001. In each of the estimations with lags, the independent variables are imposed with the same length of the lag.*

[25] *Autor et al. (2013), Acemoglu et al. (2015), Bloom et al. (2016), Autor et al. (2016), Acemoglu and Azar (2020) and Autor et al. (2020a).*

When it comes to the estimations with lags in Table 3, one conclusion is that the positive productivity effect from the growing use of Chinese intermediates seems to be rather persistent: with a lag of seven years, the effect is still highly significant and economically relevant. Second, a similar pattern is found for the import multiplier: with different lags and keeping the import multiplier from China unchanged, a growing use of imported intermediates leads to a weaker productivity growth. Finally, when adding lags and keeping the import multiplier unchanged, a growing domestic specialization in terms of a growing output multiplier seems to lead to a faster productivity growth. If this is the case, it would support the notion that using more intermediates per manufactured product, and hence focusing more on the core activities along the chain of production, is beneficial for the labour productivity growth within the manufacturing production processes in the Nordics. In the online appendix, the delayed effect is further analyzed by the use of the longest possible lags: first difference estimations (i.e analyzing changes between two periods in time) using the years in the beginning and the end of the period studied. This exercise strengthens the indication of a rather long-term positive productivity effect from the growing use of Chinese intermediates. Also, the more years that are included in the average of the two periods, i.e., the more information that are included in the variables, the larger becomes the effect.

Separate countries

Does the positive productivity effect identified in the two previous sections exist in all the separate Nordic countries? The results in Table 4 point in some directions. First, the chosen IV-strategy seems to be appropriate for all countries. Second, the positive productivity effect from the growing use of Chinese intermediates exists in all individual countries. This general pattern holds when lags are included, and the size of the elasticity is reduced in a similar way in all countries. When it comes to the import multiplier, Denmark turns out to be the exception, in the sense that it is the only country without a negative elasticity. This suggests that Denmark´s productivity effect from imports of intermediates is less dependent on the imports from China: when keeping the import multiplier from China unchanged, the general import effect on productivity is not negative. Finally, no pattern is identified for the output multiplier. Therefore, a growing domestic specialization – when controlling for the change in the use of imported intermediates – has an ambiguous effect on the vertical productivity growth within the manufacturing processes in the separate Nordic countries. One reason for this is likely to be that the yearly changes in the output multiplier are so small that they cannot generate any robust results.

Table 4. *The effect of the China shock on the vertical labour productivity growth in the separate Nordic countries*

Dependent variable: Vertical labour productivity			
Denmark	**No lag**	**Lag 1**	**Lag 2**
Output multiplier	-1.594**	-1.218*	-1.256*
	(0.030)	(0.592)	(0.558)
Import multiplier	-0.371	-0.235	-0.230
	(0.204)	(0.188)	(0.169)
Import multiplier from China	0.546***	0.533***	0.484***
	(0.030)	(0.030)	(0.033)
R2 - within	0.75	0.78	0.74
N	276	249	229
F-value: first-stage regression	256	216	157
Finland	**No lag**	**Lag 1**	**Lag 2**
Output multiplier	-0.836	-0.431	-0.109
	(0.039)	(0.491)	(0.442)
Import multiplier	-1.000***	-1.045***	-1.080***
	(0.223)	(0.213)	(0.189)
Import multiplier from China	0.385***	0.375***	0.341***
	(0.039)	(0.039)	(0.030)
R2 - within	0.85	0.81	0.71
N	282	261	241
F-value: first-stage regression	160	180	167
Norway	**No lag**	**Lag 1**	**Lag 2**
Output multiplier	1.738*	1.452	0.847
	(0.704)	(0.820)	(0.671)
Import multiplier	-1.667**	-1.448**	-1.428**
	(0.517)	(0.484)	(0.442)
Import multiplier from China	0.783***	0.773***	0.657***
	(0.077)	(0.078)	(0.061)
R2 - within	0.65	0.67	0.71
N	185	160	145
F-value: first-stage regression	150	107	87
Sweden	**No lag**	**Lag 1**	**Lag 2**
Output multiplier	-1.349***	-1.176***	-1.033***
	(0.239)	(0.022)	(0.280)
Import multiplier	-0.635***	-0.608***	-0.661***
	(0.089)	(0.104)	(0.096)
Import multiplier from China	0.400***	0.400***	0.382***
	(0.019)	(0.022)	(0.020)
R2 - within	0.86	0.81	0.76
N	284	264	245
F-value: first-stage regression	814	829	688

*Note. Linear fixed effect (IV) estimations (2SLS). Robust standard errors in parentheses, adjusted for 19 clusters (GVCs) in all countries except Norway (17 clusters). The instrumental variable is the import multiplier from China among 13 high-income countries other than the Nordics. Vertical gross output is included to control for the business cycle. Years: 2000–2014. Log values. * = p<0.05, ** = p<0.01, *** = p<0.001. In each of the estimations using lags, the independent variables are imposed with the same length of the lag.*

When it comes to the separate manufacturing sub-sectors, estimations presented in the online appendix show that the positive productivity effect from the growing use of Chinese intermediates seems to exist in all 19 sub-sectors, although the results for Coke and refined petroleum looks less robust. Within 14 of the 19 sub-sectors, the elasticity of the import multiplier turns out to be negatively significant, indicating that the intermediate imports from China is important for the overall assessment of the productivity effect from the recent globalization in most of the sub-sectors.

Value added or employment?

The welfare consequences of the Chinese productivity effect depend on the channels by which the intermediates affect the productivity growth in the Nordics. Therefore, and along the lines of Acemoglu et al. (2015) and their argument on the need for more research on the interplay between value added and employment in an IO setting: is the Chinese productivity effect driven by a positive effect on vertical value added or a negative effect on vertical employment – or both?[26] Using the same econometric approach and the same IV strategy as in Tables 2–4, the results in Table 5 indicates that the main channel is reduced employment. In terms of value added, the upper part of the table indicates that there might be a temporary positive effect on vertical value added, but the general conclusion should be that there is no effect on the growth in value added from the growing use of Chinese intermediates. The lower part of Table 5 shows, however, that a growing use of Chinese intermediates seems to have an immediate and longer-term negative effect on the growth in vertical employment. With a seven years lag, the elasticity still amounts to -0.176 and is significant at p<0.01.

Table 5. *The effect of the China shock on vertical value added and vertical employment*

Dependent variable: Nordic vertical value added	**No lag**	**Lag 1**	**Lag 3**	**Lag 5**	**Lag 7**
Output multiplier	-0.803***	-0.251	0.048	0.327	-0.515
	(0.110)	(0.617)	(0.620)	(1.009)	(1.223)
Import multiplier	-0.584***	-0.696**	-1.156***	-0.493	-0.009
	(0.059)	(0.272)	(0.318)	(0.359)	(0.534)
Import multiplier from China	0.011	0.172***	0.230**	0.019	-0.031
	(0.006)	(0.056)	(0.079)	(0.082)	(0.066)
R2 - within	0.99	0.33	0.06	0.02	0.01
N	1027	934	792	656	529
F-value: first-stage regression	401	318	158	128	107
Dependent variable: Nordic vertical employment	**No lag**	**Lag 1**	**Lag 3**	**Lag 5**	**Lag 7**
Output multiplier	-0.256	-0.002	-0.343	-0.603	-1.133
	(0.027)	(0.616)	(0.591)	(0.891)	(1.153)
Import multiplier	0.467*	0.302	-0.307	-0.053	0.332
	(0.183)	(0.266)	(0.303)	(0.317)	(0.512)
Import multiplier from China	-0.490***	-0.317***	-0.130#	-0.195*	-0.176**
	(0.027)	(0.045)	(0.078)	(0.078)	(0.065)
R2 - within	0.90	0.25	0.04	0.06	0.04
N	1027	934	792	658	529
F-value: first-stage regression	401	318	158	128	107

*Note. Linear fixed effect (IV) estimations (2SLS). Robust standard errors in parentheses, adjusted for 74 clusters (GVCs). The instrumental variable is the import multiplier from China among 13 high-income countries other than the Nordics. Vertical gross output is included to control for the business cycle. Years: 2000-2014. Log values. # = p<0.1, * = p<0.05, ** = p<0.01, *** = p<0.001. In each of the estimations using lags, the independent variables are imposed with the same length of the lag.*

[26] *The same interplay has also recently been used when studying the effects on labour productivity of a growing use of robots within (US) sectors (Acemoglu and Restrepo, 2020).*

The effect on value added and employment can be separated into effects along the supply chains of the manufacturing sector and effects in the manufacturing sub-sector itself (i.e. the final stage of the production process, or, equivalently, the main diagonal in the Leontief inverse).[27] Estimations presented in the online appendix indicate that underneath the general picture in Table 5, the longer-term effect on value added seems to be insignificant in both the manufacturing sub-sectors themselves and along their domestic supply chains. Similarly, in terms of employment, the negative effect seems to be prevalent on both parts of the production process. Consequently, this suggests that the loss in terms of employment occurs in all parts of the manufacturing production process.

Is China special?

Another aspect in the recent China shock literature is whether the China effect differs from the effect caused by the imports from other emerging countries?[28] The question addressed in this sub-section is therefore the following: how does the Chinese productivity effect compares to the effect of the use of Eastern European intermediates and high-income countries´ intermediates, respectively?[29] Two main conclusions emerge from Table 6. First, in relation to Eastern Europe, the China shock is not special. On the contrary, and in line with the results in Dauth et al. (2014), Bloom et al. (2016) and Bloom et al. (2021), the productivity effect from the growing use of Eastern European intermediates is large (and even larger) and equally significant. Moreover, as with the China effect, the import multiplier is significantly negative when the import of Eastern European intermediates is unchanged. Second, Eastern Europe and China are special in relation to the productivity effect from the intermediate trade with the high-income countries. In this case, when the import multiplier is held constant, a growing use of intermediates imported from high-income countries lead to a substantial decrease in the vertical labour productivity growth in the Nordics.[30] And the other way around, when the intra-trade of intermediates among the high-income countries is unchanged, a growing use of imported intermediates has a strong and highly significant positive productivity effect.

[27] *Similar empirical distinctions are used in Acemoglu et al. (2015), Timmer (2017), Timmer and Ye (2018), Buckley et. al. (2019), and Acemoglu and Azar (2020).*

[28] *Dauth et al. (2014), Bloom et al. (2016) and Bloom et al. (2021).*

[29] *These two variables are defined in the same way as the import multiplier from China. In the Nordics, the use of Eastern European intermediates per unit of final demand increased from 0.042 to 0.049 between 2000 and 2014, while the import multiplier from the high-income countries was reduced from 0.054 to 0.032.*

[30] *With the empirical model and estimator used, an undefined R2 value is congruent with efficient and consistent estimation results.*

Table 6. *The productivity effect of the intermediate imports from three countries/country groups*

Dependent variable: Nordic vertical labour productivity	**No lag**	**Lag 1**	**Lag 2**
China			
Import multiplier	-1.039***	-1.032***	-1.135***
Import multiplier from China	(0.168)	(0.173)	(0.166)
	0.498***	0.499***	0.477***
R2 – within	(0.026)	(0.025)	(0.023)
F-value: first-stage regression	0.70	0.66	0.62
	471	345	223
Eastern Europe			
Import multiplier	-0.939***	-0.917***	-0.983***
	(0.178)	(0.180)	(0.177)
Import multiplier from Eastern Europe	0.766***	0.763***	0.723***
	(0.052)	(0.048)	(0.045)
R2 – within	0.62	0.56	0.52
F-value: first-stage regression	306	298	279
High-income countries			
Import multiplier	2.840***	2.663***	2.493***
	(0.357)	(0.328)	(0.335)
Import multiplier from high-income countries	-4.064***	-3.874***	-3.897***
	(0.544)	(0.493)	(0.521)
R2 – within	..	..	..
F-value: first-stage regression	44	37	38
N	1027	934	860

*Note. Linear fixed effect (IV) estimations (2SLS). Other included regressors are: output multiplier and vertical gross output. Robust standard errors, adjusted for 74 clusters (GVCs). Years: 2000-2014. Log values. *** = p<0.001. Analogously with the reasoning in section 3 about the identification strategy, the instrumental variable is the import multiplier from China among the 21 non-high-income countries in the WIOD. Eastern Europe consists of Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Rumania, Slovakia, and Slovenia. The high-income countries are: EU15 before the 2004 enlargement, USA, Canada, Australia, Japan, South Korea, Switzerland, and Norway.*

6. Conclusions

The answer to the main question is: the growing use of Chinese intermediates has contributed to a faster vertical labour productivity growth within the manufacturing production processes in the Nordics. This result holds before and after the financial crisis, is robust to alternative instrumental variables, exists in all Nordic countries, and in all manufacturing sub-sectors. The result is further strengthened when different lags are used, and when weighted estimations are performed. The positive productivity effect from the growing use of Eastern European countries seems, however, to be even larger and equally significant. The productivity effect from the China shock is mainly caused by reduced employment growth, not faster growth in value added. The reduced employment growth seems to occur in the final, manufacturing stage of the production process as well as along the domestic supply chains.

These results provide some new insights about the Nordics, their manufacturing production processes and their engagement in the global economy, dominated by the trade in intermediates. However, the questions answered in this article only touches upon one of many dimensions of the general equilibrium effects on the Nordics from China emerging as the factory of the world. Obviously, there are also many unanswered questions within the narrow framework chosen in this article. Some of the more obvious are: (1) What would happen if a vertical TFP measure is used? (2) What would happen with the China effect when longer times series are used? (3) What would happen if the growing imports from China of

the type of capital included in the capital stock is included in the analysis? (4) Does the positive productivity effect differ between different parts of the manufacturing production process? (5) Does the China shock lead to a change in the composition of activities within the manufacturing production processes, towards knowledge-intensive business services?

From a broader perspective, this article can be seen as an example of using the China shock as a rare natural experiment (Autor et al. 2016): how a causal chain of events can be made likely, from the Chinese reforms beginning in the late 1970s to the manufacturing production processes in the Nordics more than 30 years later. In so doing, this article tries to contribute to the emerging literature on the effects of shocks spread through the global network of IO linkages. With the potential for further Chinese productivity catch-up, and with the Trump administration and Brexit behind us, I hope that in the years to come we will see a more constructive – but not naïve – discussion on the influence that China is likely to continue to impose on the world economy, and how the geo-political and global economic infrastructure should be framed in a post-covid and post-Ukraine war era. □

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