Erasmus University Rotterdam
Erasmus School of Economics

Master Thesis International Economics

Measuring trade in gross exports or value-added – the effects on economic growth

Analysis of the global trade slowdown

Abstract

This paper looks at the impact of trade on growth when using value-added trade measures instead of gross exports as the proxy for international trade. Defined as Trade in Value Added by Johnson & Noguera (2017), it is a more coherent way of measuring and recording the location of where value is added, compared to gross exports. With the rise in production fragmentation and complex Global Value Chains, this measurement has increased in relevance over the past few decades. However, recent years have seen a break in the trend of global trade and international production fragmentation. This begs the question, does the 'newer' measurement of global trade behave as expected in these unprecedented times? With the new WIOD 2016 release, which provides new data on this statistic through 2014, a research into this is now possible. The central question to this research is 'To what extent is the impact of international trade on economic growth influenced by measuring trade in 'value-added' terms?' This was tested through three hypotheses, which showed the following results: The general relationship between the ratio of value-added trade to gross exports remains negative, although there is evidence of the relationship changing during the Great Recession. Moreover, adding value-added trade as a second independent variable in research aimed at project economic growth does seem to be a valuable and statistically significant addition, indeed.

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Introduction

International trade, and the social relevance of this economic phenomenon, has been a hot topic in recent years, and still is. Especially with the election of Donald Trump as president of the United States of America and (the international political mess following) Brexit, one can argue that the topic has 'won' in breadth of interest all over the world. Moreover, the adjustment of the 'traditional' economic superpowers to the ongoing growth of 'new' economic superpowers like China and India (BBC, 2019) has been a topic that many people, not only politicians and economists, have opinions or worries about. Finally, with trade disputes between superpowers like the USA, China, Canada, Mexico and the recent developments in the EU (Brexit, the rise of populist politicians proposing leaving a customs union such as the EU), implications of changes in trade policies are widely discussed and reported in the media.

But, not only the social aspects of international trade have gotten more attention over the past years. With the world's economy struggling to overcome the financial crisis of 2007-2011, many interesting and, after a few years of collecting new data, now empirically researchable scientific questions have serviced (CNN Business, 2018). What is interesting about the years after the global crisis ended, and is one of the reasons this paper was written, is that global trade has seems to have broken with the trend of ever growing, see for instance (Timmer, Los, Stehrer, & de Vries, 2016). One expects, as is what happened, that during an economic crisis global trade 'dips', so a sharp decline followed by a sharp increase.

Figure 1. Import of goods and services (as percentage of world GDP)

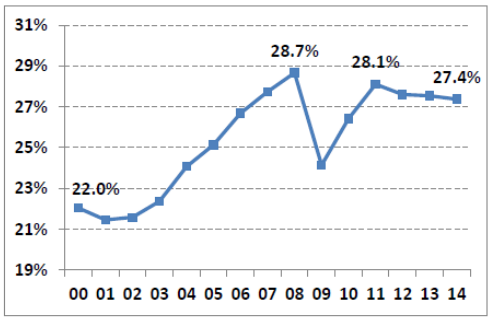


Figure 1. Source: Timmer, M. P., Los, B., Steher, R., & de Vries, G. J. - An Anatomy of the Global Trade Slowdown based on the WIOD 2016 release (Groningen growth and development centre).

This happened between 2007 and 2011, see figure 1. However, one expects that after this dip has passed, the trend of in this case sustainable growth is resumed. This did not happen. Whereas before the crisis here was an average global trade growth of 6.3 percent, and during the crisis this decreased to 3,5 percent, the average growth after the crisis declined even further

to 3.35 percent (Worldbank, 2019). Moreover, growth of global trade in 2018 (4.41 percent) has still not reached the before-crisis levels of growth, and has even declined from the global trade growth in 2017 (5.7 percent).

Next to this, international production fragmentation has declined with the global trade slowdown. This might be quite straight-forward but it is not necessarily so. Production fragmentation is dependent on much more, such as the geographical distance between economies and trade agreements, than aggregate global trade is. For a visual representation, figure 2 shows the clear difference in the trend of production fragmentation, with a dip during the crisis and a stagnation or even decline after the world economies recovered from the crisis. Moreover, the graph shows, for goods and services separately and aggregated, the ratio of the imported intermediates to the value of the final product.

Figure 2. International fragmentation of production of final goods and services, 2000-2014

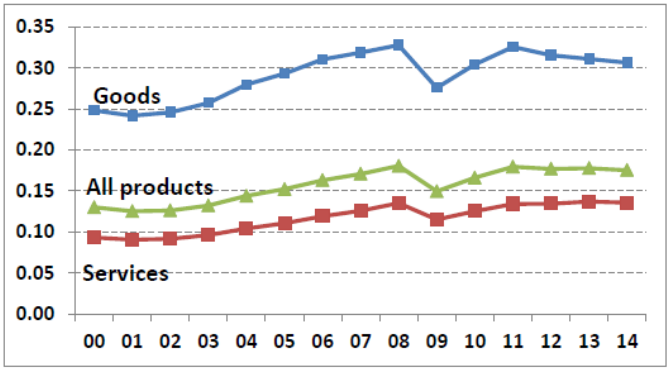


Figure 2. Source: Timmer, M. P., Los, B., Steher, R., & de Vries, G. J. - An Anatomy of the Global Trade Slowdown based on the WIOD 2016 release (Groningen growth and development centre).

Both of these economic phenomena are of great social importance, as shifts in the production fragmentation or global import demand (-trends) may impact both importing and exporting countries. Developed countries, which see a declined in the bundle of goods they can buy, and developing countries, which are hit with a decline in product demand, will be negatively influenced when international trade does not recover. Moreover, for geographically small countries such as the Netherlands, which are quite significantly dependent on global trade, these changes can have an exacerbated effect, compared to larger countries such as the United States of America. Next to this, one can argue that an economy, in the long run, is usually characterised by trends. Therefore, any time when a long-term trend seems to be broken, research is needed and interesting to perform into the factors that might have contributed to this, and the effects thereof.

These two phenomena are the basis of this paper. To research this and define the main academic topic, the concept of value-added trade is important to discuss. As this will further be elaborated on in the theoretical framework, at this stage only a description is presented as motivation for the main question. Since several decades, due to the growing importance of global value chains and the growth of international product fragmentation (which will also be explained further in the theoretical framework) quite a lot of research has been done on the 'correct' measurement of international trade. Whereas it is customary to use gross exports as a proxy for international trade when judging the effect of a trade policy change or political decision, this statistic suffers from some double counting, as production has been increasingly fragmented internationally over the past decades.

Many papers, for instance Los & Timmer (2015, 2018) and Johnson & Noguera (2012a, 2017) discuss new measures of international trade, more focused on capturing the 'real' trade values. Moreover, they argue that, although they all develop numerous slightly different measures, these are a solution to measuring international trade better than gross exports including trade in intermediates. Johnson & Noguera (2017) discusses the development of one of such measures, Trade in Value Added, over four decades. Trade in value added can be seen as the ratio of the domestically added value content in gross exports of a country, which is also the ratio used as the independent variable of interest in most of this paper's analyses. Robert Johnson, in his paper '*Five facts about value-added exports and implications for macroeconomics and trade research*' (2014), discusses several implications of using Trade in Value Added over gross exports. He uses this to look at several economic questions and research fields such as specialization patterns, the factor content of trade and, more broadly, the impact of trade policy. As mentioned above, researchers by no means agree on the 'perfect' measurement, and all present different ways of capturing different problems that arise when using gross exports to measure trade. Trade in Value Added however, is a quite simple, intuitive and usable solution to improve the way one measures trade, in general.

This is a very relevant discussion because for the purpose of politics and in the media, statistics should be simple and understandable, but they should not be overseeing obvious aspects or caveats that can gravely change the implications of a political statement of research. In light of these researches and the above-mentioned economic phenomena and political climate, the central question for this research is:

To what extent is the impact of international trade on economic growth influenced by measuring trade in 'value-added' terms?

This research was done using a panel dataset containing 43 countries and spanning from 2000 to 2014. Following the release of the WIOD 2016 update, it is now possible to do such a research, whereas before 2017 this data was not available yet. While December 2016 (the release date of this database) has been quite a while, such a research has not been done yet and would thus be an addition to the existing literature. With fixed-effects panel data regressions, one can isolate both the year- and country-specific effects. In this way, the analysis of whether there are differences in the effect of international trade on economic growth when looking at these two different ways of measuring international trade can be done.

The aim of this paper is thus to show whether the value-added trade measurement has become more or less relevant, when comparing the ways of measuring trade in this unprecedented time of the global economy seemingly breaking with the long-term trends. This, in turn, could show whether it is more or less relevant to use this measurement as a proxy for international trade in (maybe turbulent) times to come in the international markets, following for example a definitive Brexit or when analysing the consequences of the trade war going on between China and USA. Moreover, the relevance and probably also the rise in popularity among researchers of these value-added measures is strongly correlated with the rise of global value chains and fragmentation of the 20th century. Determining whether the statistic keeps being more useful even when these, one might say, foundations change, could be of social and scientific importance.

The following chapters of the paper will be arranged as follows: The next chapter will present a theoretical framework, in which the existing literature, theoretical concepts and the hypotheses that were used in this research are presented. After this, the data and methodology that was used will be elaborated on. Thereafter, the results of the regressions will be presented and the confirmation or rejection of the hypotheses will be discussed. Finally, the conclusion will provide an answer for the main question and thereafter a discussion of this paper's shortcomings and recommendations for further research will be mentioned.

Theoretical framework

In this section, the theoretical concepts used in this research will be explained and elaborated on. Furthermore, an overview of the existing literature will be discussed. On the basis of this literature, several testable hypotheses are presented. The following paragraphs will discuss the theoretical concepts. First, international fragmentation and GVCs are shortly introduced, as they are paramount in the understanding of why value-added trade is of importance in times of growing or stalling growth in international trade.

International production fragmentation

Over the past several decades, the production of a single final good has been increasingly an international affair, because of several factors. First, transportation costs decreased significantly, for instance because of the invention of shipping containers and air transport. Second, many countries signed bilateral free trade agreements to lower tariffs and other non-tariff barriers, making it easier and cheaper to trade with one another. Third, customs unions and multilateral trade agreements such as NAFTA, the Eurasian Customs Union and the European Union have been signed. These agreements made it even more profitable to use an international view when planning or optimizing a production process. This way, countries and firms can profit from economies of scale and comparative advantages, ultimately leading to cheaper costs and thus (more often than not) lower prices that the consumers pay for the final good. Because of this, a final good which might be famously from a certain country, such as a Mercedes car, might represent a value which is only for a small part added in the country where the final good is bought or assembled and sold. In this case, a 2006 study found that only 33 percent of the value added to the German car was actually added in Germany (Sinn, 2006). One can imagine that over the past years this number has only decreased further.

Global Value Chain

A Global Value Chains (GVC) is a general term which encompasses the several factors that have been coined to describe the increase in the above-mentioned international production fragmentation. Next to production fragmentation, it includes terms such as task trade, vertical specialisation and outsourcing (Kummritz, 2016). It is used, as mentioned before, to describe the fact that the value chain, i.e. the process in which value is added in the production process of a final good, is often global. For instance, while the raw materials are from a certain country,

these will be only partly processed in the first country, then shipped to another, where an intermediate product will be added before it is shipped to a third country for the final assembly and sale. This is a simple example but this process, especially for high-tech products such as planes and smartphones, is of course much more complicated. It even occurs that a product is shipped back-and-forth between countries, within the same value chain.

Value-added trade

With the growth of global value chains and increasing international production fragmentation, it has become increasingly difficult to ascertain where the value of a final good has been added to this product. Using input-output tables, which measure the input and output of a certain sector within a country, one can calculate how much value is 'created' in a country in that sector. When one only looks at final expenditure on a country's products that are sold abroad (gross exports), one loses this possibility. This is quite relevant because usually, gross exports are a commonly used statistic to describe the state of a country's economy. The fact is, the percentage of the domestically added value in final goods consumption and exports differs quite significantly from one country to another (Johnson & Noguera, 2017).

This is quite intuitive; a large country, such as the USA or Russia, is quite heavily reliable on its own added value to consume many of the products it produces and sells as exports. After all, large countries have, more often than not, a relative abundance in raw materials, capital, human capital, high- and low-skilled labour, and so on. Therefore, one expects the percentage of domestically added value to a final good sold as exports to be high in a large country. Conversely, in a small country the afore-mentioned factors of production are relatively scarce. These countries, such as for instance Belgium or Austria, must rely heavily on the factors in other countries to produce goods that they want to sell or consume. Therefore, one expects these countries to have a lower ratio of value added to their produced final goods, which is, on average, the case (Johnson & Noguera, 2017). Another factor which influences this ratio is geographical location and close proximity to other countries. This, too, is intuitively explainable. If a country is remote and not close to many countries, such as Australia, having a GVC is far more expensive and thus less profitable than countries within close proximity to its trading partners. Therefore, we see a higher ratio of domestically added value to gross exports in Australia than for instance the Netherlands.

The ratio of value-added trade to gross exports

In this paper, most analyses have been done with the ratio of value-added trade to gross exports as the independent variable. This is a measure that is used in the analyses of Johnson and Noguera as well, and it describes the domestically added value content of total trade. This shows whether a country's responsible for a larger or smaller share of its export value, and with that it is a different way of looking at trade, compared to gross exports. Rather than gross exports, which can change independently from the actual value that is created domestically, this shows whether a country's productivity has in fact increased or decreased, compared to total exports. Of course, this means that this ratio can be influenced by either a change in the productivity domestically or an increase in trade in intermediates, or trade with other countries, at all. However, first, this measure makes it possible to combine these two important characteristics of a domestic economy and second, when looking at the developed countries in this research, one would not expect gross exports to fluctuate as much. Therefore, domestic productivity should be highlighted more in this measure, compared to when one looks at developing countries.

Literature overview

In this section, an overview of existing literature in the field where this paper sits will be presented. On the basis of this literature, three hypotheses are presented, that will be tested in the rest of the paper.

First, as it is the most central theoretical concept in the paper, literature regarding value-added trade and its uses will be discussed. The most prominent researchers that wrote about this in the past decade are Robert C. Johnson and Guillermo Noguera. They first discussed accounting for intermediates and their measure for trade in value added using input-output tables in 2012. They presented several empirical applications of this measure in their paper 'A portrait of trade in value-added over four decades' which was written as a working paper in 2012 and later published in 2017. In this paper, they look at trends in international trade using this novel measure instead of gross exports. On the need for this measurement, Johnson and Noguera (2017) argue: "As inputs pass through (…) global supply chains, they typically cross borders multiple times. Since the national accounts record gross shipments across the border, not the locations at which value is added at different stages of the production process,

conventional trade data obscure how value added, and the primary factors embodied therein, is trade in the global economy." This touches upon an important subject, when they mention 'primary factors embodied therein'. Trade policy is, or at least should be, focused on the consequences of a trade policy (change) for the owners of production factors, the population. When analysing trade policy as a researcher, one should thus also look at where value has been added to a certain final good, instead of only using gross exports as a measurement of international trade.

Moreover, Johnson and Noguera (2017) discuss five stylized facts regarding trade in value-added. They are quite intuitive, and underpin the previous sections. Typically, the ratio of value-added to gross exports has declined drastically since the 1970s and the ratios differ between sectors. Moreover, fast-growing economies, proximate trading partners and countries that agreed upon signing trading agreements have seen the largest decline (Johnson and Noguera, 2017). Next to this research, Kummritz (2016) discusses the relationship between participation in Global Value Chains and economic growth by presenting a value-added trade resistance index, combining third country trading costs with industry specific statistics to look at the influence of GVC participation (Kummritz, 2016). He finds that the relationship between GVC participation (international production fragmentation) and industry productivity is positive, in general. When one translates this finding into a relationship between the ratio of value-added trade to gross exports and economic growth, one would expect this relationship to be negative. Moreover, when a country is more involved in GVC's, it has a lower ratio of value-added trade to gross exports because it is trading intermediate products instead of adding that value domestically. However valuable this measure is, it is not feasible to use such a measure in the global setting this paper has. The research of Kummritz (2016) was more focused on industry specific factors, whereas it is not possible to do a general and international comparison in this way, with the data and timescale of this research.

Furhtermore, Johnson and Noguera (2017) find that more developed nations have experienced a stronger decline in the ratio of value-added trade to gross exports. However, the research period of their paper is from 1970 to 2007. With the trend of production fragmentation so specifically breaking at the latest point in time that this research found their finding, it would be interesting to see if this trend can still be seen in this (broader) dataset. To test this, the following is the first hypothesis:

H_1: There is a negative relationship between the ratio of value-added trade to gross exports and economic growth

One can imagine the afore-mentioned stylized facts and results being true as in the researched period, 1970-2007, international trade and therefore global value chains became much more profitable. A decline in the ratio of value added domestically to gross exports is a result from this. However, Marcel P. Timmer, Bart Los, Robert Stehrer and Gaaitzen J. de Vries, from the Groningen growth and development centre (2016) find that, based on the world input-output tables of the WIOD release of 2016, there is evidence of a halt to the international production fragmentation following the global trade slowdown after the Great Recession. They argue that, when looking at production fragmentation, one might see three different trends in the recent 2 decades. Until 2008, there was a period of increasing production fragmentation. From 2008 to 2011, during the crisis, there was a period of a dip, as discussed before. But after that, production fragmentation has still not reverted to its trend of the period leading up to the economic crisis (Timmer et al., 2016). Whereas comparable research on the influence of international production fragmentation was done in a period where this variable (and the economies themselves) was generally growing increasingly, it would be interesting to see if the same relationship can be seen when production fragmentation halts or even decreases. Moreover, when the relationship of the ratio of value-added trade to exports and economic growth is negative, as hypothesized in the previous section, one would expect a positive shift in the ratio of value-added trade to gross exports, due to stagnating or even decreasing international production fragmentation, to have an additional decreasing effect on economic growth. Therefore, the second hypothesis is:

H_2: The change in the long-term trend of international production fragmentation results in an additional negative effect on economic growth after the economic crisis

In another paper, Robert C. Johnson (2014) discusses several facts and implications of using value-added exports in research on the impact of trade. He emphasizes the relevance of this topic once more, by referring to an article in the Financial Times by Lamy (2011) which emphasizes that looking at trade in value-added terms is a way of understanding and

overcoming the mercantilist view of trade. He also discusses the fact that value-added exports can exceed gross exports, when looking at bilateral trading patterns. This is, for instance, the case with Japan's exports to the USA. This can occur when a country (Japan) exports a lot of intermediates to a third country (China) which than exports the assembled final goods to the USA. Therefore, bilateral trade patterns are not included in this research, as it often dilutes the actual fact that trade in value-added is a more valuable way of looking at international trade to assess non-bilateral economic variables like national economic growth or welfare.

Frankel and Romer (1999), in their seminal paper 'Does trade cause growth?' use geographical factors, such as population and land area size, as instrumental variables to find that trade does have a robust, but statistically only marginally significant, positive effect on GDP per capita. They focus on the geographical factors as instrumental variables of a country because they do not change. However, they do not add control for any other variables in the regressions, as they are confident in their instrumental variables and therefore expect no other variables to be of significant influence on GDP per capita growth (Frankel & Romer, 1999). What these papers do not discuss, however, and in fact Johnson (2014) mentions that there is little research done on it, is that the relationship between trade frictions and value-added trade remains unclear.

One might argue that, although we do not know what the exact cause of it is, the global trade slowdown and international fragmentation decline can be seen as the result of a trade friction. In fact, in their world economic outlook of 2016, the International Monetary Fund (IMF) mentions the fact that both economic growth and trade have differed from its trends since 2012 and one can see the rise of protectionism. Moreover, Johnson (2014) discusses several ways to improve the discussion on the relationship between trade and other economic factors, by using value-added trade instead of gross exports. Therefore, to further assess the relationship between these phenomena, the final hypothesis was chosen to be:

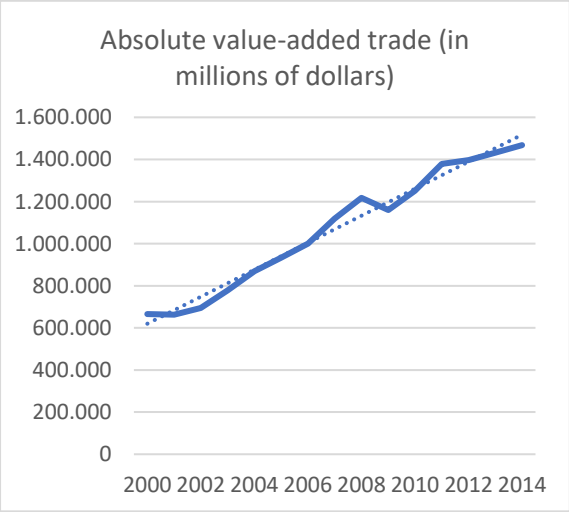
H_3: Value-added trade has had a stronger effect on economic growth than gross exports

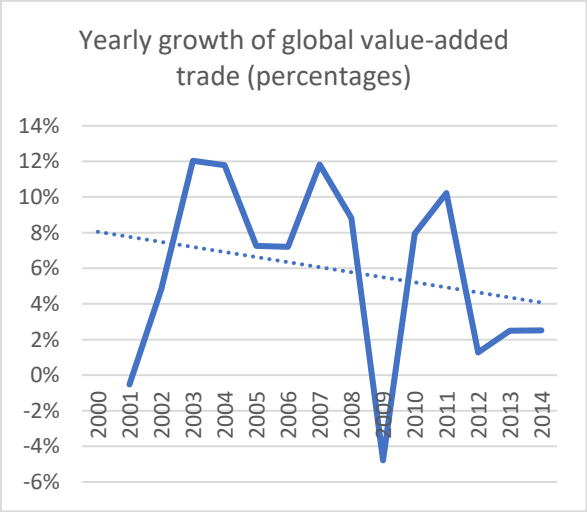
Data

Data on the central concept of this paper, value-added trade, was retrieved from the World Input Output Database (WIOD). This database has published its newest release in December

2016, which saw a significant augmentation in breadth of the source. With this new release, a comprehensive dataset of national input-output tables on 43 countries, spanning 15 years, is now publicly available. Moreover, the countries in the dataset contain the 28 EU countries, and 15 other big economies, namely Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Norway, Russia, South Korea, Taiwan, Turkey and the United States of America. For this research, no countries were left out of the dataset for geographical reasons, because value-added trade is an aggregated worldwide statistic and the scope of this research is not focused on a specific region. However, one commonality of these countries is that they are all relatively large and stable, compared to the rest of the world. The reason for this is, of course, that this kind of data is registered more comprehensively in the more developed economies.

The researched period is, as mentioned above, 2000-2014. This is the broadest period possible with this database. This period covers the three different sections of international trade 'behaviour', as argued by Timmer, Los, Stehrer & de Vries (2016). First, a period of increasing fragmentation and economic growth (2000-2008), the period of economic recovery of the Great Recession (2008-2011), and the period of stalling fragmentation and international trade (2011-2016). With yearly data on 43 countries over several years in each period, this suffices to analyse the entire period as well as compare the different periods using dummy variables that will be discussed in the methodology section.





Graphs 1 & 2; Global trade in value-added – absolute (millions of US dollars) and percentage growth.

Graphs 1 and 2 show the global trends in value-added trade. As expected, the absolute value of global value-added trade (graph 2) seems to grow steadily. However, when looking at the percentage growth (graph 1), one can see that this is not necessarily the case. We see the dip in growth around the Great Recession, but also that growth has been below average since the recovery in 2011, as mentioned in the introduction. Moreover, when looking at the trendline one can see that it decreases, of course mainly due to the sharp dip during the recession, but still the growth after the recession has been below the long-term trend.

Data on the dependent variable, economic (GDP) growth, and the control variables were retrieved from the World Bank Open Database. This database provides all necessary data on a wide range of social and economic variables. From this database, data on GDP and GDP growth was retrieved for every country-year pair in the dataset, so for the 43 countries spanning from 2000 to 2014. Moreover, to compare the effects of value-added trade and gross exports on economic growth, data on this variable and its growth was retrieved from the same database.

Furthermore, Taiwan had to be dropped from the research. Taiwan was added to the 2016 release of the data on value-added trade, but the World Bank database does not contain any records for Taiwan of all other variables that were used in the research. This means that, after dropping Taiwan out of the dataset, the analyses could be done with 42 countries, spanning 15 years, containing 630 datapoints on value-added trade.

Control variables

Several variables were considered as control variables, but were found insignificant and thus left out of the regressions. Population and the Most Favoured Nation (MFN) tariff rate, however were found to be of significant influence and were subsequently used as control variables in the regressions. Population seems to be a fairly obvious control variable, as this paper is about the effect of measuring trade in value-added terms. The amount of value-added trade a country can produce is obviously partly dependent on the population. Moreover, as the analyses use GDP (growth) as the main dependent variable of interest, but not GDP per capita, this is a way of adding this component to the regression. The MFN tariff rate used in this paper is the weighted mean over all products. This variable has been added as a control as to isolate the effect of countries joining (or exiting or changing) their bilateral and regional trade agreements. When looking at, for instance, the ratio of value added in a country to gross exports, there is an apparent influence of the trade agreements that a country is in.

Moreover, total population was gathered from the aforementioned Worldbank Database for every country-year pair. However, the MFN tariffs were not available for nine country-year pairs. Seeing as these absent values were not concentrated on a certain country or year, all countries and years remained in the dataset for the regressions. But, to balance the panel data set, and to avoid selection bias when building from a baseline model, without control variables, to the final model with control variables, the country-year pairs with missing MFN datapoints were left out of the regressions.

Methodology

The hypotheses in this paper were tested using panel data OLS regressions with time and country fixed effects. These fixed effects entail that the factors that are country- or year specific are controlled for by the regression itself. Therefore, all factors that are specific to a country or year, but do not change, are excluded from the regression. To better understand this, two examples are discussed next. First, the geographical location of a country is (barring wars about territory) constant. This constant factor influences trade and other economic phenomena, nonetheless. For instance, a location near water gives a country an advantage as a trading partner, as it is easily reached by ships. Moreover, a location in a well-suited location for agriculture improves the countries own possibilities of producing and trading in this sector. A factor which might be year-specific, but not country-specific, is for instance a global economic recession like the one that happened a decade ago. This is not specific to one or two countries, but to all, in certain years.

By controlling for this, one need not to, for instance, add dummy variables for a global economic crisis into the regression as a control variable. Conversely, the variables that were added as control variables, population and most favoured nation tariffs, cán and will change over time and between countries. The adaptation of an increasing number of bilateral and regional free trade agreements and the persisting (albeit it often quite constant) growth of the population all over the world make it variables that are not caught in the fixed effects in the OLS panel data regression.

The data had to be transformed in several ways. To cover extreme coefficients in the results, that are hard to interpret, the large values of the national statistics and population were transformed to natural logarithms. Next to this, the national value added had to be calculated

for each year and country pair, using the data from the National Input-Output Tables of the WIOD (2016) release mentioned in the previous chapter. This data had to be aggregated for each year and country, for as the dependent variable, GDP growth, is also an aggregated and non-bilateral statistic.

In order to address reverse causality and endogeneity, the first lag of the independent variable of interest, trade in value added (TiVA), was used in the regressions. Although it is difficult to test whether this first lag is uncorrelated with the error term, it is however strongly correlated with the non-lagged value. Therefore, the lag is seen as an improvement, as far as endogeneity goes, of the model without using a lagged independent variable. Using a lagged independent variable, however, does limit the timespan of the research in this case. This is because the WIOD 2016 release spans the years 2000 to 2014. When one uses a lag of this variable, the year 2000 'falls out' of the regression. Thus, effectively, the research was done on the years 2001 to 2014, limiting the research to 579 datapoint for every variable in the balanced panel dataset.

The baseline regression that was performed to test the hypotheses has the following form:

$$GDP\ growth_{i,t} = \beta_0 + \beta_1 * (value\text{-}added\ trade/gross\ exports)_{i,t-1} + \beta_x * X_{i,t} + \alpha_i + \alpha_t + \varepsilon_{i,t}$$

In this regression, β_0 is the constant, β_1 is the coefficient of interest, and β_x is the coefficient of the several control variables, here denoted by X. α_i and α_t depict the fixed effects of country (i) and time (t). $\varepsilon_{i,t}$ is the error term.

To test each of the hypotheses, a similar strategy was used to build up the models and present the results. First, a baseline model was made with only the variables of interest in the regression. No fixed effects or control variables are added in this first regression. Subsequently, the fixed effects are added and thereafter the control variables. This is done to show the progression of the coefficients of interest, when one adds these controls. To compare significance, the standard 10 percent-, 5 percent- and 1 percent levels were used. As the data is in a balanced panel data format, covering several countries and spanning several years, White diagonal heteroskedastic standard errors were used in the regression analyses.

To be more specific, for the first hypothesis, the above-mentioned method was used exactly. The baseline model was gradually built up to the most comprehensive one, with the same dependent and independent main variables in all three models, on the entire balanced panel dataset. So, the GDP growth rate (in percentages) was regressed on the ratio of domestically added value to gross exports (also in percentages), the control variables and the fixed effects.

For the second hypothesis, a dummy variable was added for the period after the Great Recession, so for the years from 2011 to 2014. This dummy was then interacted with the main independent variable of interest and added to the regression. To show and compare the hypothesized effect of this dummy interaction term, two other models were presented. In these models, a dummy interaction term for the previous two 'periods' were added to the baseline regression model. These are dummy variables for the periods before and during the Great Recession. This was done to research whether the relationship between the main variables of interest seems to be impacted by the Great Recession. The periods used as dummy variable have been mentioned above, and are based on Los, et al. (2016).

To test the third hypothesis, more advanced and different models were used. First of all, next to a value-added trade related independent variable, a gross exports related independent variable was used. This was used in two ways, as a logarithm and as a growth value in percentages. The first regression is a regression focused on growth rates, with GDP growth as the dependent and the ratio of value-added to gross exports and the growth rate of gross exports as independent variables. The independent variables were first added to the regression separately and thereafter a regression with both independent variables was done.

Finally, a log-log model was built, with the logarithm of GDP as the dependent variable and the logarithms of value-added trade and gross exports as the independent variables. Next to this, a dummy variable for the period after the recession was interacted with the independent variables was added to the model, to test whether there is evidence of an additional effect after 2011. This is comparable to the method used in the previous hypothesis and shows the additional effect both variables had on economic growth, after the Great Recession ended. In this model, the two 'pairs' of variables, the dummy and the independent variable, are added separately before joined together in one model. This was done to see whether the coefficients of the dummy variables change after adding the dummy for the other independent variable of interest. Using a log-log model as an addition made it possible to research the percentage effects

of the independent variables on economic growth, all else held constant, and to compare the two effects both for the entire dataset and for the period after the Great Recession.

Results

In this section, the results of the testing of the hypotheses are presented. This is done in coherence with the methodology discussed in the previous section, with the different models presented from baseline to the model with both the control variables and the country- and time fixed effects.

To reiterate, hypothesis one was stated as follows:

> H_1: *There is a negative relationship between the ratio of value-added trade to gross exports and economic growth*

Using a fixed effects OLS regression with White heteroskedastic diagonal standard errors, the different models are presented in table 2. The dependent variable is presented in the top row. Significance is indicated by * for significance at the 10 percent level, ** for significance at the 5 percent level and *** for significance at the 1 percent level. The standard errors are presented within brackets after the coefficient of the independent variable of interest.

	GDP growth (in percentages)	GDP growth (in percentages)	GDP growth (in percentages)
Model	Baseline	Fixed effects	Fixed effects and control variables
TiVA/gross exports (in percentages) $_{t-1}$	0.089 (.064)	-0.544** (.213)	-0.779*** (.267)
Country- and year fixed effects	NO	YES	YES
Control variables (logarithm of population, MFN).	NO	NO	YES
R^2	.002	.554	.569
Observations	579	579	579

Table 2: Results of the models testing the first hypothesis. *, ** and * are coefficients significant at the 10 percent, 5 percent and 1 percent level, respectively. White diagonal standard errors in parentheses.**

The results of the first regressions show that there is indeed a negative relationship between the two main variables of interest, as was hypothesized on the basis of Johnson & Noguera (2017). Whereas they found a negative correlation between the ratio of value-added trade to total exports and 'larger and fast-growing countries', the same can be said about the relationship between the ratio of value-added trade to gross exports and the growth rate of a country's economy. In the baseline model, the coefficient is positive but insignificant. When adding the fixed effects, one can see a negative and significant coefficient at the 5-percent level. This shows that the baseline model is, as expected, heavily influenced by factors included in the fixed effect, thus validating the method of using these in the regression. In the final model, after also including the control variables on the Most Favoured Nation mean tariff and population, the significance of the coefficient increases to a significance at the 1-percent level. This means that, on the basis of this research, this dataset and this time span, one can expect the growth rate of GDP to be 0.779 percentage points lower when the ratio of value-added to gross exports increases by 1 percentage point, all else held constant. On that basis, the first hypothesis, that stated that there would be 'a negative relationship between the ratio of value-added trade to gross exports and economic growth', is confirmed.

The second hypothesis was researched in a similar way, but with the addition of a dummy variable for the period after the Great Recession. The hypothesis in question, stated in the theoretical framework, was:

> H_2: *The change in the long-term trend of international production fragmentation results in an additional negative effect on economic growth after the economic crisis*

In table 3, the results of the different models that were built are shown.

Here, we see some interesting results. In the testing of the first hypothesis, there was evidence of a negative relationship between the ratio of value-added trade to gross exports. One would expect that, with the global trend of stagnating international production fragmentation in the period after the Great Recession, this effect would have exacerbated. To elaborate, the hypothesis states that the decrease in value-added trade to gross exports ratio of the years after the Great Recession would result in a positive effect on growth, thus that the coefficient should be negative.

	GDP growth (in percentages	GDP growth (in percentages	GDP growth (in percentages
Model	Baseline	Fixed effects	Fixed effects and control variables
TiVA/Gross exports (in percentages) $_{t-1}$	0.129** (.067)	-0.541** (.217)	-0.819*** (0.279)
Dummy (after crisis) * Tiva/Gross exports $_{t-1}$	-0.214** (.091)	0.016 (.115)	-0.139 (.128)
Country- and year fixed effects	NO	YES	YES
Control variables (logarithm of population, MFN).	NO	NO	YES
R^2	.009	.554	.570
Observations	579	579	579

Table 3: Results of the models testing the second hypothesis. *, ** and * are coefficients significant at the 10 percent, 5 percent and 1 percent level, respectively. White diagonal standard errors in parentheses.**

Moreover, GDP growth is, as we know, still positive, as the global economy is not in a recession anymore since a decade. Moreover, (Timmer, Los, Stehrer, & de Vries, 2016) found a slowdown, a decrease, in international production fragmentation. Value-added trade has decreased, and this seems, on average, to have had a positive influence on GDP growth. This means that, after the Great Recession came to an end, we do see evidence of the trend of international fragmentation being broken, but also of the relationship between value-added trade and GDP growth nót being broken. After all, recall that Johnson & Noguera (2017) found that countries with stronger GDP growth showed lower percentage value-added trade, in general.

However, as we can see in the table shown above, the hypothesized coefficient of the dummy variable is not seen in this regression. In the baseline model, to start, the coefficient of the dummy variable in question is negative, as expected and hypothesized. However, after adding fixed effects and control variables, the effect of the dummy variable after the recession is shown to be insignificant, although only slightly less significant than the 10-percent level. To look into the development of the, if ever apparent, additional effect of the independent

variable in a certain period, table 4 shows the results of the models (with fixed effects and control variables) when tested in the two other periods identified by Timmer, Los, Stehrer & de Vries (2016).

The results show something quite interesting. Whereas the dummy variable for the period before the crisis has an insignificant (negative) coefficient, just like the dummy variable for the period after the crisis, the coefficient of the dummy variable for the period during the recession (2007-2010) is significant at the 10-percent level, and positive. This indicates that, on average, during the crisis, the countries with a higher ratio of trade in value-added to gross exports experienced a higher economic growth. This is a result that is seen and discussed a few times in this paper. It indicates that countries that did not depend as much on trade, experienced a lower impact of the global crisis, all else held constant.

	GDP growth (in percentages)	GDP growth (in percentages)
Model	Fixed effects and control variables	Fixed effects and control variables
TiVA/Gross exports (in percentages) $_{t-1}$	-0.639* (.336)	-0.749*** (.269)
Dummy (before crisis) * Tiva/Gross exports $_{t-1}$	-0.099 (.110)	
Dummy (during crisis) * Tiva/Gross exports $_{t-1}$		0.233* (.136)
Country- and year fixed effects	YES	YES
Control variables (logarithm of population, MFN).	YES	YES
R^2	.569	.571
Observations	579	579

Table 4: Results of models with fixed effects and control variables before and during the Great Recession. *, ** and * are coefficients significant at the 10 percent, 5 percent and 1 percent level, respectively. White diagonal standard errors in parentheses.**

To translate this into the real world, this means that, on average, countries that added more value compared to their exports domestically suffered less from the recession, in terms of GDP growth. Moreover, a country like the USA, which is less dependent on foreign trade and thus has a higher value-added to gross exports ratio compared to for instance the Netherlands,

experienced a higher GDP growth, on average. We do see, in practice, that these countries have recovered relatively more quickly, compared to for instance the EU states, in terms of GDP growth.

However, to confirm the second hypothesis stated in this paper, one needed to see a significant negative coefficient for the dummy variable after the recession or at least a difference in significance after the recession compared to before and during. Whereas the latter is arguably the case, because the significant coefficient for the dummy during the recession, the former is not. On the basis of this analysis, no additional effect of the ratio of value-added to gross exports on GDP growth was found. Therefore, the second hypothesis needs to be rejected.

The third hypothesis is the hypothesis that compares the two measurements of international trade, gross exports and value-added trade. This hypothesis stated:

> *H_3: Value-added trade has had a stronger effect on economic growth than gross exports*

As stated in the methodology, several therefore different models were built to test this hypothesis, as this is a difficult hypothesis to test. These models are summarized in tables 5 through 7. The first model, shows the results of the regression testing the relationship between GDP growth as dependent variable and the ratio of value-added to gross exports and the gross exports growth rate as independent variables, likewise to the testing of the first two hypotheses with the addition of gross exports. This can be seen in table 5, which is presented on the next page.

As discussed in the methodology, the independent variables of interest are first regressed on the dependent variable separately and then together, to show the change in the coefficients when adding the other independent variable. As we can see from the results, the coefficients only minutely change when combining the two independent variables in one regression. Moreover, the build-up of the model is not shown from a baseline upwards, as this was done similarly and presented in the discussing of the previous hypotheses. Therefore, all

models presented here include the time- and country fixed effects and control variables on MFN mean tariffs and population.

	GDP growth (in percentages	GDP growth (in percentages	GDP growth (in percentages
TiVA/Gross Exports (in percentages) $_{t-1}$	-0.779*** (.267)		-0.795*** (.277)
Gross Exports growth rate (in percentages) $_{t-1}$		8.840*** (2.258)	8.895*** (1.715)
Country- and year fixed effects	YES	YES	YES
Control variables	YES	YES	YES
R^2	.569	.583	.594
Observations	579	579	579

Table 5: First table of results of the models to answer hypothesis 3. White diagonal standard errors in parentheses, *, ** and * to indicate significance at the 10 percent, 5 percent and 1 percent level, respectively.**

The results show that the relationship between the trade in value-added ratio to gross exports is still significant (at the 1-percent level) and negative, as was found in the first hypothesis. The addition of the second independent variable does not change this at all. The relationship between the growth rates of gross exports and GDP is, as expected, positive and significant at the 1-percent level. This is fairly intuitive, as GDP encompasses gross exports, but the reasoning behind this regression is to find out if there is a significant change in the coefficient of the value-added trade ratio to gross exports, when one adds the growth rate of gross exports as a second independent variable. The fact that the coefficient of the main independent variable of interest does not change tells us that the relationship of the value-added trade ratio to gross exports and economic growth can be seen as fairly independent of the growth rate of gross exports.

The following table 6 shows the results of a seemingly similar series of regressions, but in fact a quite different one.

	Log (GDP)	Log (GDP)	Log (GDP)
Log (TiVA) $_{t-1}$	0.877*** (.028)		0.607*** (.045)
Dummy (after crisis) * log(TiVA) $_{t-1}$	0.012*** (.004)		0.043*** (.013)
Log (Gross Exports) $_{t-1}$		0.888*** (.039)	0.388*** (.040)
Dummy (after crisis) * log(Gross Exports) $_{t-1}$		0.026*** (.008)	-0.034*** (.015)
Country- and year fixed effects	YES	YES	YES
Control variables	YES	YES	YES
R^2	.998	.997	.998
Observations	579	579	579

Table 6: Second table of results of the models to answer hypothesis 3. White diagonal standard errors in parentheses, *, ** and * to indicate significance at the 10 percent, 5 percent and 1 percent level, respectively.**

Here, as discussed in the methodology, the model is changed to a log-log form. Therefore, GDP growth rate is no longer the dependent variable, instead the logarithm of GDP is used. This research is therefore more comparable with Frankel and Romer (1999), whereas the first model has a stronger liking to the analyses performed by Johnson and Noguera (2017). As the independent variables of interest, the logarithms of value-added trade and gross exports are used. By using a log-log model in this way, an interpretation of percentage changes can be made (with care) and compared, all else held constant. Next to this, a dummy variable was added next to the two independent variables, to assess whether there is evidence of an additional significant effect of these two variables on GDP in the period after the Great Recession. After all, the premise of this paper is to assess first the relationship and importance of using value-added trade as a proxy for economic growth, but also testing this for changes against the background of the recession the world just overcame.

The model is presented similarly to the previous model, with first the two independent variables in a separate regression, followed by the two combined into one final regression. Moreover, as mentioned before, this way of presenting the models makes it possible to see the changes of the coefficients after adding the second independent variable to a regression.

The results show the additional effect of the independent variables in the aftermath of the recession. These effects are not entirely as expected, but therefore not less noteworthy. Like

in the previous models, first the dummy and independent variable 'pairs' are added to the regression separately. We can see that the coefficients of the independent variables do not change much after adding the dummy variable. However, the coefficients of the dummy variables are both significant at the 1-percent level, and positive. This indicates that there is, in fact, evidence of an additional effect of the independent variables on GDP after the crisis. Moreover, both of these effects seem to be positive.

When combining both independent variables into one regression, this changes. Whereas both coefficients of the logarithm of value-added trade and its dummy remain positive, the coefficient for the dummy variable of the logarithm of gross exports is negative. Moreover, all coefficients remain significant at the 1-percent level. This indicates that there is indeed evidence of an additional effect of the two independent variables after the crisis, and in fact these effects have different signs. On the basis of this analysis, the effect of value-added trade on GDP has increased after the crisis, and the effect of gross exports on GDP has decreased. It seems that the effect of percentage changes in gross exports have been dampened after the crisis, whereas the effect of value-added trade has remained (increasingly) positive after the crisis, compared to before.

An explanation for the negative coefficient of the dummy variable regarding gross exports could be that, due to the global trade slowdown, countries less dependent on trade experienced higher GDP growth, compared to countries that are more dependent on trade. This interpretation thus reverses the intuitive interpretation of the sign of the coefficient. This result and interpretation are similar to the results discussed regarding the first hypothesis. Countries that are less dependent on trade (large or isolated countries) have experienced higher economic growth in recent years, compared to for instance the EU states.

Moreover, while the coefficients of the independent variables in the first two 'separate' models are quite similar (0.877 compared to 0.888), in the model where the two independent variables and their respective dummy variables are joined in the regression this is no longer the case. In fact, the coefficient of the logarithm of value-added trade is almost twice as large (0.638) compared to the coefficient of the logarithm of gross exports (0.355). As we can see in table 6, the standard deviations are quite comparable (0.40 as opposed to 0.45). While they are not the same, we can carefully make an interpretation of the coefficients, given that the standard errors are so comparable. So, we see that the coefficient of the logarithm of gross exports decreases by more than 100 percent, compared to when value-added is left out of the regression,

this time with exactly the same standard error. This indicates that, in this setting and when the independent variables increase by 1 percent, the effect of the increase in value-added trade would be roughly twice as large as the effect of the increase in gross exports, all else held constant. Of course, this does not prove that value-added trade is a better variable to use in projecting changes in GDP. However, it does show that the relationship between value-added trade and GDP is significant even when one 'controls' for the relationship between gross exports and GDP, and that arguably a change in value-added trade of a certain percentage will have a more significant and profound effect on economic growth, compared to a similar change in gross exports.

All the previously presented models on this hypothesis were aimed to reject or confirm the hypothesis 'Value-added trade has had a stronger effect on economic growth than gross exports.' In contrast to the models that were built to test the first two hypotheses, which had GDP growth as the independent variable, log-log models found the most conclusive and interesting results. This can be explained, as discussed before, by the nature of the two independent variables used in the first regression (table 5). However, table 6 showed that, in log-log models, one can clearly see that there is a difference in the relationship between the independent variables and the dependent variable. As discussed before, on the basis of this research, there seems to be evidence of the relationship of value-added trade and GDP being stronger than the relationship between gross exports and GDP.

Even after adding dummy variables, to test whether the additional effects after the crisis have changed, one can state that the coefficient of the dummy variable for value-added trade is larger (in absolute value) compared to the coefficient of the dummy variable for gross exports. Moreover, the effect of trade in value added on GDP has increased after the economic crisis, whereas the effect of gross exports on GDP has decreased, due to the different signs of the variable and its dummy for the period after the recession. On the basis of these and the abovementioned results, the third hypothesis is confirmed. The next section summarizes and concludes the paper, followed by a discussion of the shortcomings of the paper and relevant additional topics for further research.

Conclusion

The aim of this paper was to add to existing literature around the subject of value-added trade, by finding out if there is any evidence of a difference in the effect of trade on economic growth, measured by the GDP growth rate, compared to using gross exports. As an extension of, and roughly based on papers like Johnson & Noguera (2017), Johnson (2014) and Frankel and Romer (1999), the paper contains several regressions on this topic. Moreover, the relationship between the two main variables of interest were tested against a global trade slowdown described in, amongst others, Timmer, Los, Stehrer and de Vries (2016). There were several reasons to choose this topic. First, the world input output database (WIOD) release of 2016 made new data available past 2012 to 2014, which makes it possible to perform researches with considerably more available data on value-added trade after the recession ended. Moreover, the period after the recession saw many countries struggling with recovering the economy and trade growth slowed down substantially. Next to this, many countries are, or are in the process of, rethinking their trade agreements. Several of them, for instance the United States of America, tend to steer away from free trade towards more protectionist policies. This influences economic growth and therefore it is a relevant topic to discuss, also the measurements involved in projecting its growth.

Most regression were done with GDP growth as the dependent variable and the ratio of value-added trade to gross exports as the main independent variable of interest. Next to this, log-log models were built in order to test the difference between the effects of gross exports and value-added trade on economic growth. This was done using a panel dataset containing data on 42 countries worldwide, spanning 15 years. The countries are the 28 EU countries plus 14 large economies worldwide. By using the first lag of the dependent variable of interest, causality was tried to be improved and endogeneity controlled. Moreover, with country- and year fixed effects and controls variables on the Most Favoured Nation (MFN) mean tariff and population, the effects were tried to be isolate as best as possible.

The first hypothesis, regarding the relationship between the ratio of value-added trade to gross exports and GDP growth rate, was tested to assure that in this dataset, and spanning a period that includes the Great Recession, the relationship between the ratio of value-added trade to exports and the GDP growth rate remained negative, as suggested by Johnson and Noguera (2017). As their research only spans in time period to up to the financial crisis of 2007,

this was deemed a valuable addition and starting point of the paper. Based on the regressions performed in this regard, the hypothesis was accepted.

The second hypothesis focused on whether there is evidence of this relationship, tested in the first hypothesis, changing after the Great Recession, three dummy variables for the time periods before, during and after the Great Recession were created. The regressions showed evidence of this additional effect changing through the recession. But, seeing as the additional effect of the dummy variable was insignificant before the recession, significantly positive during the recession and again insignificant after the recession, the results remained inconclusive. Therefore, the second hypothesis was rejected.

The third hypothesis required the most extensive research, as it was stated quite broadly and formed more or less the culmination of the paper. The hypothesis stated that the relationship between value-added trade and GDP was stronger compared to the relationship between gross exports and GDP. This was tested first by using a similar model, with regressing the ratio mentioned before on the GDP growth rate and adding the growth rate of gross exports to the regression as a second independent variable. The results were, as one might expect, difficult to interpret and inconclusive, however a good starting point as a comparison with previous hypotheses. Therefore, two new models were built in a log-log configuration, where it was easier to interpret and compare the coefficients. The second of the two log-log models featured dummy-variables for the period after the recession to, again, assess whether the effects found in the first models were robust after the recession. In both models, a stronger relationship between value-added trade and GDP was found compared to its relationship with gross exports. Therefore, the third hypothesis was confirmed.

The main research question, which stated ‘To what extent is the impact of international trade on economic growth influenced by measuring trade in ‘value-added’ terms?’, can now answered. However, as will be discussed in the next chapter, this remains difficult. Nevertheless, on the basis of this research, one can state that measuring trade in value-added terms, whether it is the in a log-log model or when one looks at the ratio of value-added trade to gross exports, can change the relationship compared to using gross exports as the independent variable for projecting economic growth. Especially the ratio is interesting as it can change in several ways (due to changes in the numerator and denominator) and following many different events in politics, the global economy or even broader concepts such as the

climate. Understanding this concept, and using it as an addition to gross exports as an influence on economic growth, seems to be the perfect middle ground.

Discussion

As no paper is perfect, neither is this one. The biggest problem that needs addressing, is causality. How can we be sure that there is a causal relationship between broad economic concepts like aggregated value-added trade and national economic growth? The short answer is that this is, and remains, difficult. This paper aimed to tackle this problem by using the first lag of the dependent variable as a proxy for value-added trade, instead of using another instrumental variable. One could also use other instrumental variables as a proxy for the dependent variable, however this often has many drawbacks. As most instrumental variables (see for instance Kummritz (2016)) have a theoretical nature, it is difficult to use them in a panel data regression with such a broad scope such as this one, as it would be very time consuming, cumbersome and not that interesting to use in a research covering tens of countries from all around the world. However, if one such proxy would ever be found, an instrumental variable that isolates the effect value-added trade (as a ratio to gross exports) has on economic growth, this would be a very welcome addition, indeed. However, until then, papers like this one should be seen in the light of papers like Johnson (2014), which discuss the relevance of using value-added trade as a, possibly, better indicator of the real value of exports.

Next to this, this paper has a 'national' or global character, as in that it compares statistics from national accounts. This was made possible through the vast database of the world bank and the new release of the World Input Output Database. However, as it still is difficult to find regional statistics on the variables other than value-added trade, comparing value-added trade within regions is still very difficult. When regional statistics become available on a greater scale, it would be quite interesting to research how regional economies react to changes in (trends of) value-added trade. Moreover, this research was made possible, again, because of the WIOD 2016 release which includes data up until 2014. Luckily, this was late enough to find interesting results during and after the Great Recession. But, as for now we do not know how long the global slowdown will continue or, for that matter, if it will at all. Therefore, a similar research of this period in 10- or 20-years' time, would be a very interesting addition and control of this paper, indeed.

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