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The Motor Vehicles Industry in Slovakia, 2005-2015

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Biswajit Banerjee† and Juraj Zeman§

Abstract

This note examines the evolution of the Slovak motor vehicles sector during 2005–2015, drawing on the latest update (December 2018) of OECD's Inter-Country Input-Output (ICIO) model database. The review takes a global value chain (GVC) approach and looks at the linkages from the gross production and value added perspectives. The overall contribution of the motor vehicles sector to Slovakia's gross production and domestic value added increased twofold during the reference period. There was an ongoing change in the structure of the GVC linkages. The reliance on domestically-sourced inputs increased over the years. The (indirect) value added created in the production of domestically-sourced inputs gradually approached the level of the (direct) value added generated within the motor vehicles sector. Subsequent to the global financial crisis, the share of intermediate goods in exports, the forward linkage of the GVC, and the upstreamness of the production process were all on a rising trend. The sourcing pattern of imports of intermediate inputs and the market for exports steadily shifted away from the euro area towards non-EU countries. It is estimated that a hypothetical 10 percent negative shock to global final demand for motor vehicles would lower Slovak GDP growth by 1 percentage point.

JEL code: D57, F14, F23, L62

Key words: Backward linkage, Forward linkage, GVC participation rate, Length of GVC, Position in GVC

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Introduction

Over the past two decades, the Slovak automotive industry has steadily grown to become an important global player. It currently comprises of four major car manufacturers and more than 350 automotive parts suppliers, including both first tier global suppliers with a local presence and lower tier purely local suppliers (SARIO, 2020).[1] The industry is characterized by a complex value chain. The automotive components segment has expanded over time along with the increase in car production. The car manufacturers as well as automotive parts suppliers operating in the country rely on a mix of domestic and imported intermediate inputs. The automotive parts suppliers not only provide components for the domestic assembly of cars but also produce for external markets. The cars manufactured in Slovakia are mostly exported.

This note adds to an earlier study on the Slovak automotive industry by Luptáčik et al. (2013). The aim of this note is to examine the evolution of the "Motor vehicles, trailers and semi-trailers" sector (Sector D29; motor vehicles sector hereafter) in Slovakia during 2005–2015, using input-output data from the December 2018 update of OECD's Inter-Country Input-Output (ICIO) model database (see Annex I).[2] The review takes a global value chain (GVC) approach and looks at the linkages from the gross production as well as value added perspectives (see Figure 1). It identifies the trends in the sourcing pattern of intermediate inputs, geographical origins of imported inputs and destinations of exports. The note also examines how the GVC participation of the motor vehicles sector, the length of the value chain and distance to final demand have unfolded over time.[3] Finally, building on these findings, the note assesses the potential impact of a negative demand shock in the motor vehicles sector on Slovakia's GDP.

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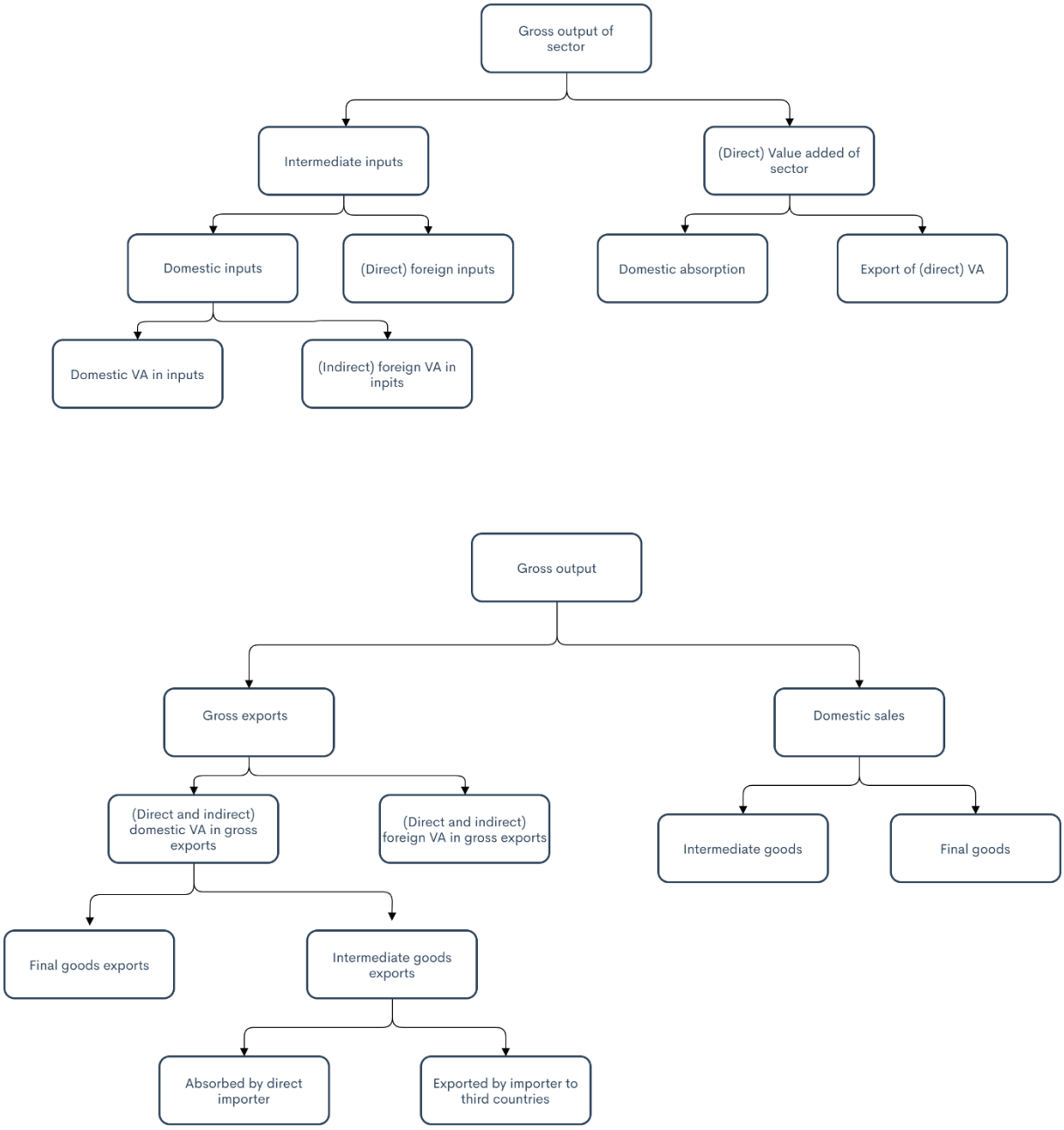
[1] The four major car manufacturers include Volkswagen Slovakia (production started in February 1992), PSA Peugeot Citroën Slovakia (production started in June 2006), Kia Motors Slovakia (production started in December 2006), and Jaguar Land Rover (production started in October 2018).

[2] See http://oe.cd/icio. The OECD's ICIO data base provides information on domestic transaction flows of intermediate goods and services across industries, and inter-country flows of intermediates in exports and imports. The ICIO is the principal data source used to produce trade in value added indicators (TiVA; http//oe.cd/tiva). The December 2018 update of the ICIO database is based on ISIC Revision 4 and the data is available annually for the period 2005–2015. Data for the years beyond 2015 are not yet available. An earlier release of the ICIO data base covered the period 1995–2011, but the data from this release are not compatible with the data from the 2018 update.

[3] These concepts are defined in later parts of the note, and are well documented in the GVC literature (e.g., see DeBacker and Miroudot, 2013; Kowalski et al., 2015; and OECD, 2019).

Figure 1. GVC linkages from the production and value added perspectives

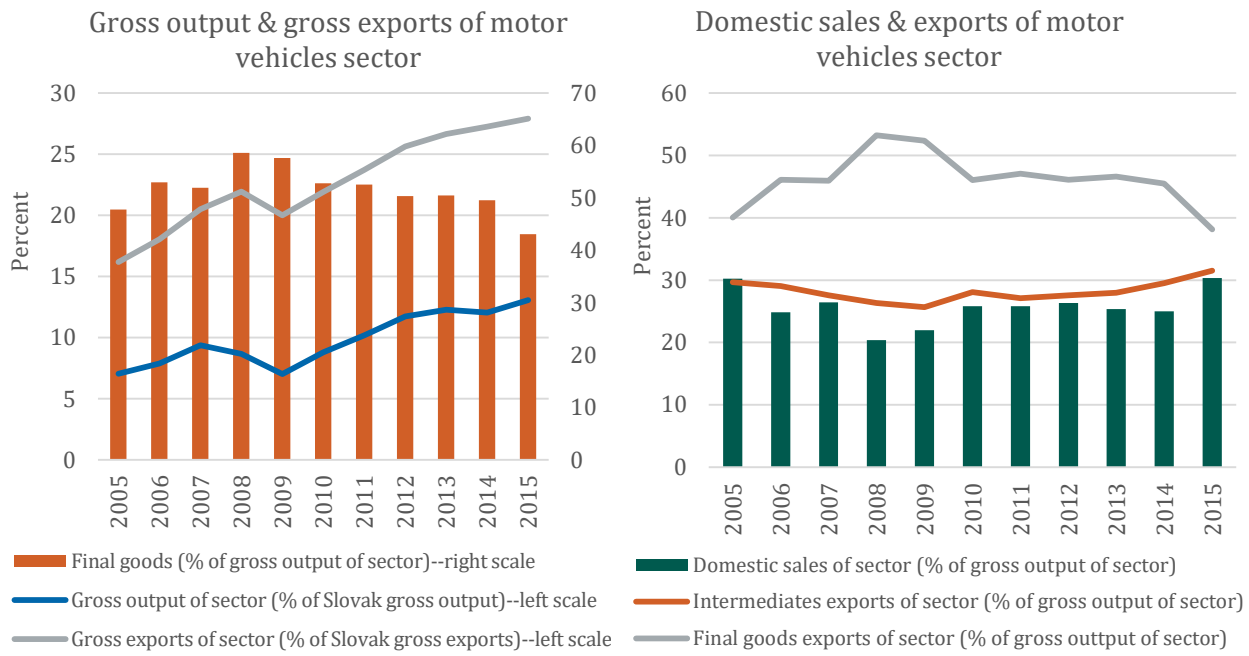


Source: Authors.

Gross production perspective

The importance of the motor vehicles sector in the Slovak economy has increased steadily over time. The share of this sector in gross output of the entire economy rose from about 7 percent in 2005 to 13 percent in 2015 (Figure 2 and Appendix Table 1). Both intermediate goods and final goods figure prominently in gross output of this sector. However, the share of final goods output has been on a downward trend since the onset of the global financial crisis, falling from a peak of 59 percent in 2008 to 43 percent in 2015. The decline in the share of final goods indicates increasing fragmentation of supply chains in the motor vehicles industry.

Figure 2. Gross output, domestic sales and export composition of motor vehicles sector



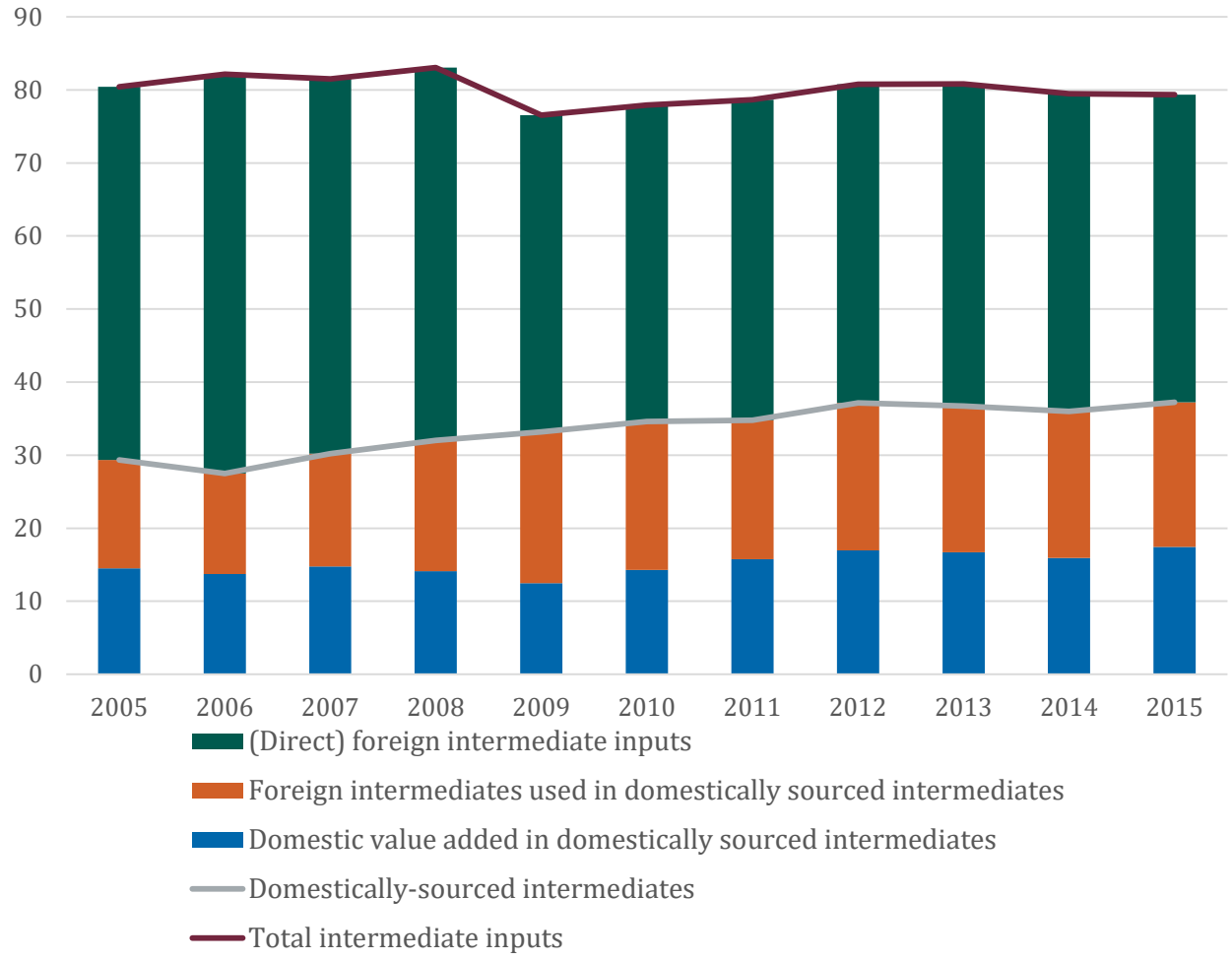
Source: ICIO 2018; authors' calculations

The motor vehicles sector is highly export oriented. The export propensity is higher for final goods output than for intermediate goods. On average, 90 percent of the final goods output and 60 percent of intermediate goods output were exported annually during 2005–2015. Domestic sales comprised primarily of intermediate products, reflecting the importance of linkages between the motor vehicles sector and other sectors of the domestic economy. However, the importance of exports of intermediates also was growing from 2009 onwards and could be attributed to the rise of global value chains. In view of the declining share of final goods in gross output as noted above, the share of exports of the motor vehicles sector in gross output of the sector was falling. Nevertheless, the export share remained in excess of 70 percent during the reference period. Although the importance of exports within the sector decreased, the contribution of the motor vehicles sector in total gross exports of Slovakia increased from 16 percent in 2005 to about 28 percent in 2015 on account of the rising share of the sector in gross output of the entire Slovak economy.

The motor vehicles sector of Slovakia depends heavily on imported intermediates, but the reliance on domestically produced intermediate inputs has increased over time. The share of direct imports in intermediate inputs of the motor vehicles sector decreased from 64 percent in 2005 to 53 percent in 2015 (Figure 3). The trend is indicative of Slovakia moving up the value chain in the production of motor vehicles, trailers and semi-trailers in the sense of substituting foreign value added by domestic value added in intermediates embodied in gross output. The domestic supply chain has been growing as an increasing number of automotive

parts suppliers have been setting up plants in Slovakia. Domestically sourced intermediates in turn have a large import content. Taking these (indirect) imports into account, the combined share of direct and indirect imports has been relatively stable since the global financial crisis at around 75 percent of intermediate inputs involved in the production of motor vehicles, compared with around 80 percent prior to the crisis.

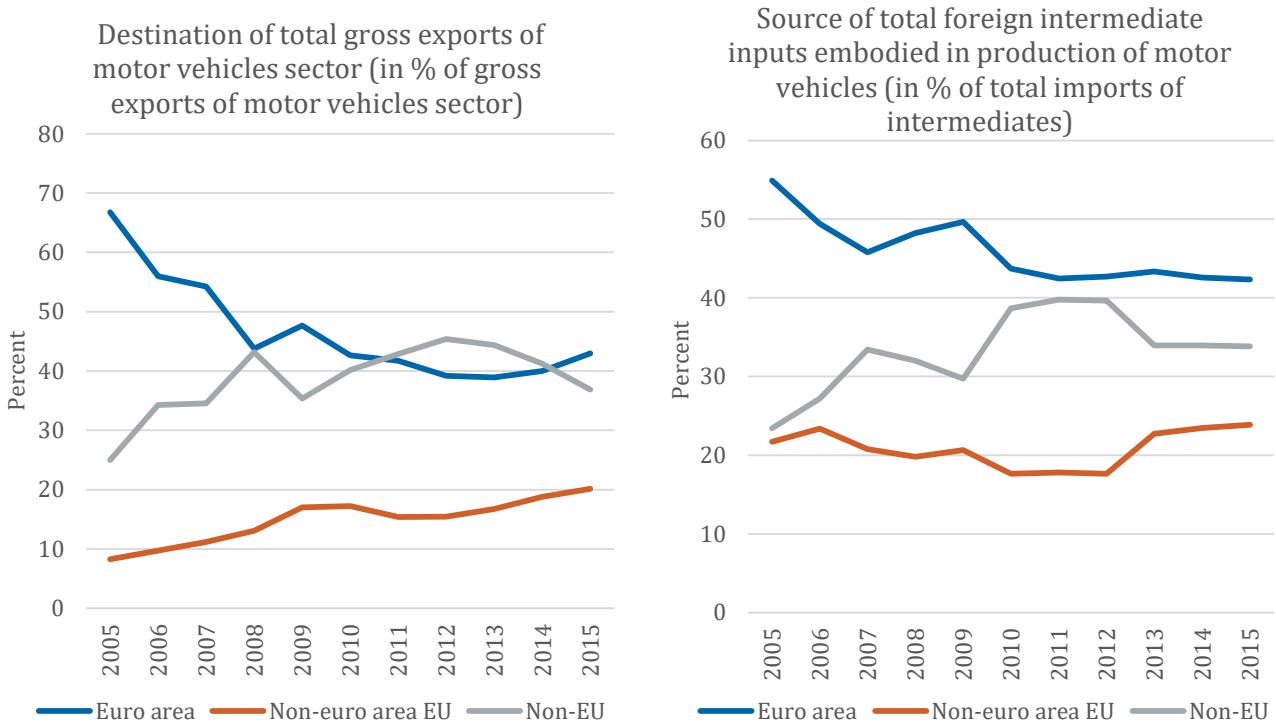
Figure 3. Intermediate inputs used in motor vehicles production (in % of gross output of sector)



Source: ICIO 2018; authors' calculations.

The market composition of both exports of the motor vehicles sector and imports of intermediate inputs changed noticeably during 2005–2015 (Figure 4). The European Union (EU) in the aggregate was the principal market for exports and a major source of imports of intermediate inputs, indicating a strong regional dimension of the supply chain. However, in both exports and imports, non-EU countries gained market share over time and this occurred at the expense of falling shares of the euro area. Much of the regional realignment occurred during 2005–2010, following the start of operations of Kia Motors Slovakia and PSA Peugeot Citroën Slovakia and the introduction of new models by Volkswagen Slovakia.

Figure 4. Market shares in total gross exports of motor vehicles sector and total imports of intermediate inputs



Source: ICIO 2018; authors' calculations.

The loss of market share of the euro area and the gain in market share of non-EU countries were particularly conspicuous in the exports of final goods. In the event, from 2010 onwards, the proportion of final goods exports to non-EU countries was higher than that to the euro area and almost equal to the share of the EU as a whole (see Appendix Table 1). The main non-EU markets were China, United States, and Russia. A majority of the new generation up-market models produced by Volkswagen Slovakia were exported to non-EU markets, especially China and the United States. For Kia Motors Slovakia, Russia was one of the biggest export markets (besides Germany and the United Kingdom). In addition, the Košice plant of Volkswagen Slovakia was also engaged in the exports of semi-knocked-down vehicles to Russia.

The gain in market share of non-EU countries in intermediate goods exports was minimal. The EU was the main export market for intermediate goods, but there was a shift away from the euro area towards non-euro EU countries. The market share of non-euro EU countries in intermediate goods exports increased while that of euro area countries decreased. A major driving force behind this development was the rising exports of car engines by Kia Motors Slovakia to the sister Hyundai plant in the Czech Republic.

Nearly one third of the imported intermediates originated from non-EU countries in 2015 compared with around one fourth in 2005. There was a slight rebalancing in the sourcing

pattern away from non-EU countries towards non-euro area EU members in 2013, and the relative market shares of the three country groupings remained broadly unchanged in the subsequent years.

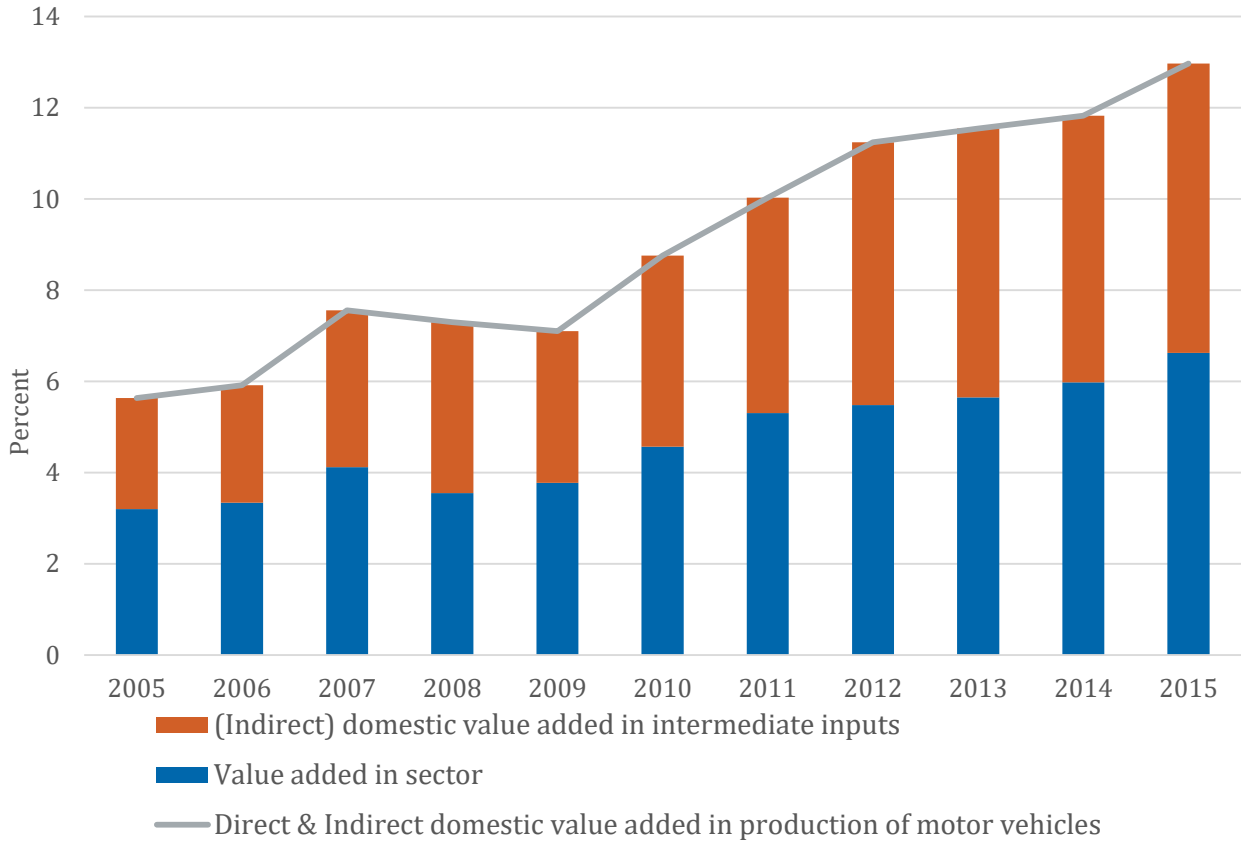
Value added perspective

While the gross production perspective provides some insight into the importance of the motor vehicles for the Slovak economy and an initial assessment of its participation in GVC, a rigorous evaluation of the motor vehicles sector's contribution to growth, its exposure to shocks and GVC participation requires an examination of domestic value added in production and exports. A sector's exposure to shocks in final demand would be smaller if the production process entailed the last stages of the value chain and the production process relied mostly on foreign inputs.

The motor vehicles sector in Slovakia is intensive in the use of intermediate inputs. Over the years, value added directly within this sector has typically accounted for only one fifth of gross production. Thus, reflecting the sectoral growth of gross production, the share of direct value added in the motor vehicles sector in total value added generated in the Slovak economy (i.e., Slovak GDP) increased during the reference period from 3.2 percent in 2005 to 6.6 percent in 2015 (Figure 5 and Appendix Table 2).

Total domestic value added embedded in gross production of the motor vehicles sector is much higher than the value added directly generated within the sector. It also includes the domestic value added created in the production of domestically-sourced intermediates used in the manufacture of motor vehicles (the so-called indirect value added). Typically, the indirect value added accounted for about one half of the gross amount of domestically-sourced intermediates. In effect, this has meant that the magnitudes of the indirect value added component and the direct value added generated in the motor vehicles sector were broadly similar over the reference period. As a result, the combined share of the direct and indirect value added components in total value added in the Slovak economy increased from 5.6 percent in 2005 to 13 percent in 2015—i.e., twice as large as the contribution of the direct value added in the motor vehicles sector. While the higher value added share is a sign of the maturity of the motor vehicles industry in Slovakia and its agglomeration economies, the multiplier effect on the Slovak economy of any demand shock to the motor vehicles sector would be larger than if Slovakia was merely a processing center of a global supply chain mostly reliant on imported intermediate inputs.

Figure 5. Direct & Indirect value added in production of motor vehicles (in % of total value added in Slovak economy)



Source: ICIO 2018; authors' calculations.

Participation in the GVC

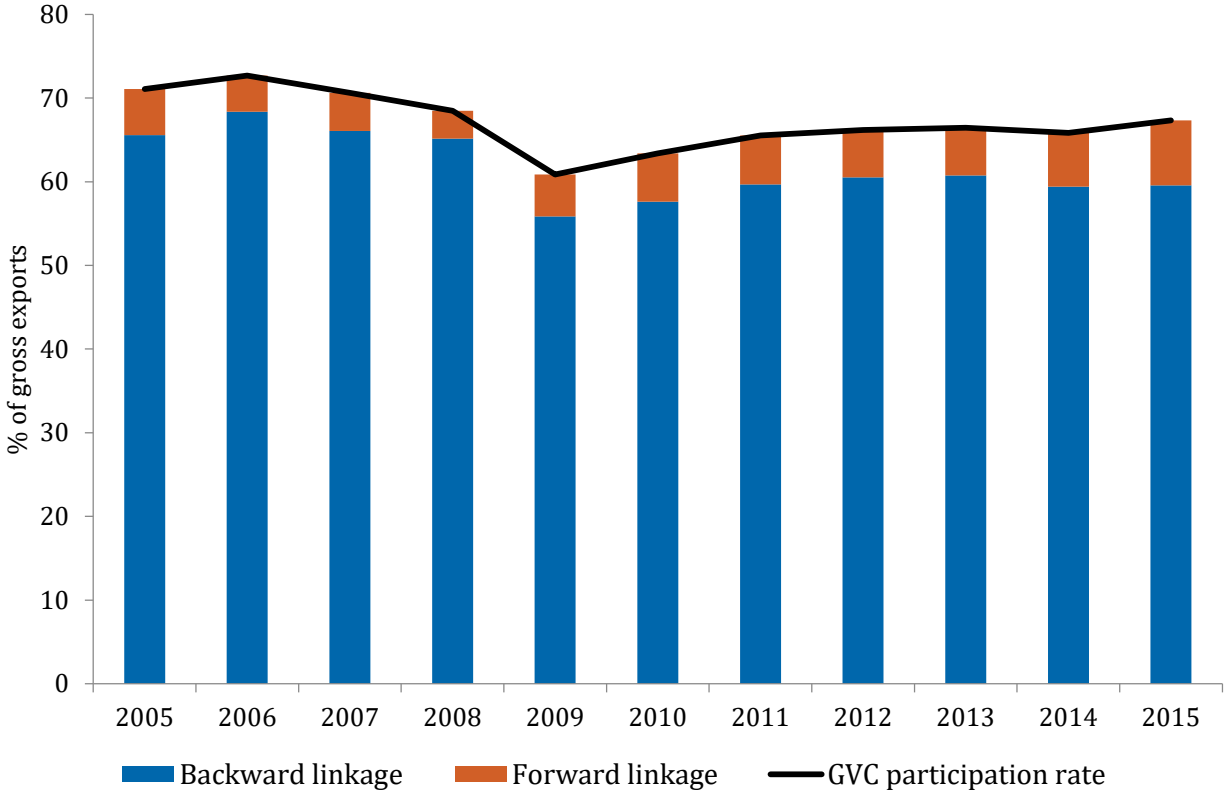
The degree of GVC participation of a country or industry is usually determined by looking at the share of gross exports involved in a vertically fragmented production process. The measure, which is expressed as a percentage of gross exports, is based on two components: (i) the foreign value added content of intermediate inputs embodied in gross exports (i.e., backward participation) and (ii) the domestic value added embodied in intermediates re-exported by trade partners to third countries (i.e., forward participation). The higher is the backward participation and forward participation, the higher is the participation of a country or industry in the global value chain (see De Backer and Miroudot, 2013).

The Slovak motor vehicles sector is highly integrated in the GVC, with the GVC participation rate standing at about 67 percent of gross exports in 2015. The main channel for integration is backward participation. The forward participation channel has been growing slowly and is relatively weak, with the index measuring 8 percent of gross exports in 2015 (Figure 6).[4] This implies that about four fifths of the domestic value added embodied in exports of final goods

[4] As Guilhoto et al. (2019) note, forward participation generally adjusts more slowly to changing economic conditions than backward linkage.

and intermediates are absorbed by direct importers.[5] Backward participation and, by association, GVC participation fell sharply in 2009 following the onset of the global financial crisis, but rebounded in the subsequent years. Nevertheless, both backward participation and GVC participation indicators in 2015 were lower than the 2005 level. Forward participation also suffered during the crisis but recovered quickly to above the pre-crisis levels.

Figure 6. Participation of the motor vehicles sector in the GVC



Source: ICIO 2018; authors' calculations.

The length of GVC

A complementary measure to the degree of GVC participation is the length of the GVC, which indicates the number of production stages involved in the chain. We follow the methodology proposed by Antràs et al. (2012), Fally (2012) and Wang et al. (2017) to calculate the index of the length of the GVC and decompose the index according to domestic and foreign production stages (see Annex II). The index takes the value of 1 when no intermediate inputs are used to produce a final good, and the value increases when inputs from the same industry or other industries are used. Since the index is calculated at the aggregate industry level and is not

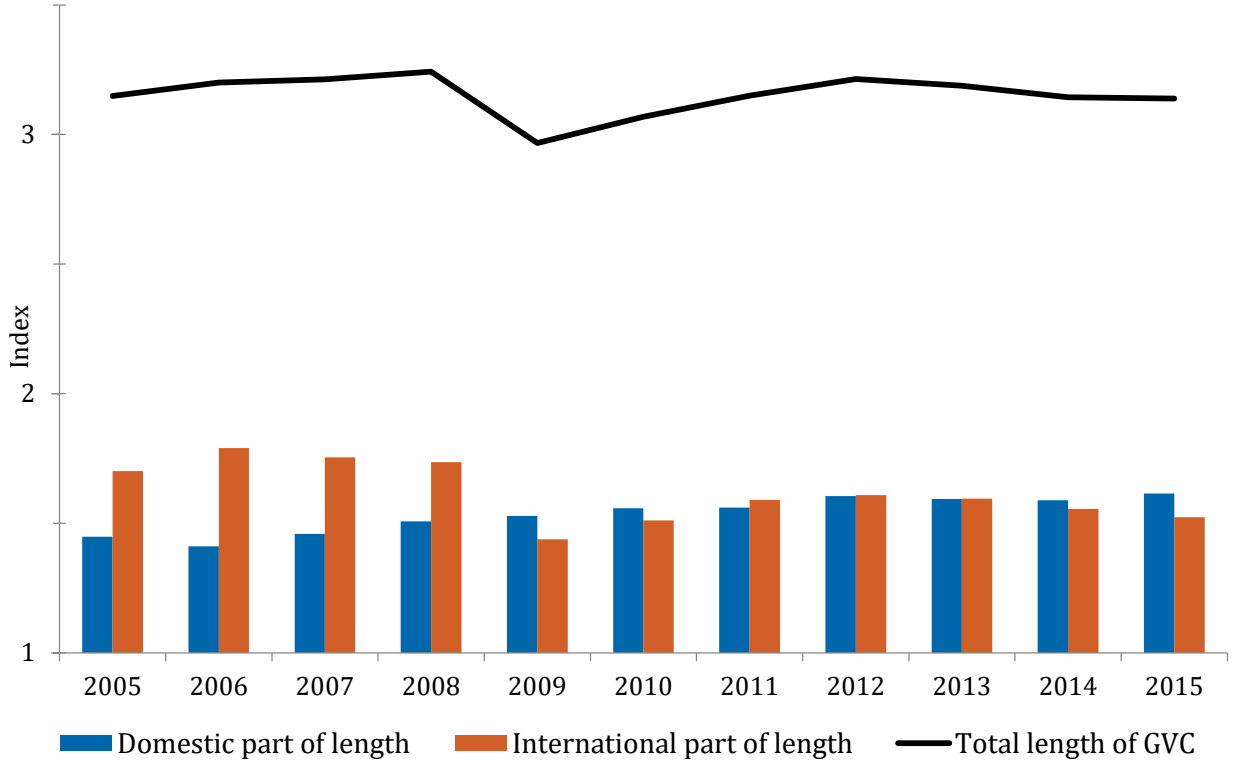
[5] For example, in 2015, the share of foreign value added in gross exports (backward participation) was 59.6 percent, implying that the share of domestic value added in gross exports (commonly known as the VAX ratio) was 40.4 percent. Of this, the share of domestic value added embodied in intermediates re-exported by trade partners to third countries (i.e., forward participation) was 7.8 percent. Thus, domestic value added absorbed by direct importers amounted to 32.6 percent of gross exports, equivalent to four fifths of the VAX ratio.

based on plant-level information, the value of the index should not be interpreted as the actual number of production stages but seen as an index of fragmentation.

The fragmentation of production in the motor vehicles industry in Slovakia is among the highest in the world.[6] The index of length of GVC was above 3 in all years but one during 2005–2015. There was no discernible trend in the intertemporal variation in the index. In other words, there was no significant change in the length of GVC over time. With the financial crisis and trade collapse in 2009, there was a noticeable temporary reduction in the length of the GVC chain. The international part of the chain was the driver of the observed decline which occurred even while there was an increase in the domestic length. The consolidation of the GVC chain in 2009 was cyclical but there was an ongoing structural change in the GVC chain during 2005–2015. The international part of the value chain was becoming shorter over time while the domestic part of the chain was lengthening (Figure 7). This is consistent with the finding reported in the previous section that the reliance on domestically-sourced intermediate inputs had increased over time. Prior to the global financial crisis, a larger part of the production stages was located abroad. However, during the crisis years and in the later years of the reference period, the domestic length of the chain was longer than the international length implying that a larger part of the production stages was located in Slovakia.

[6] De Backer and Miroudot (2013) found that in 2009 the index of length of GVC for Slovakia's motor vehicles sector was the fifth highest among 51 countries in the sample.

Figure 7. Index of length of GVC

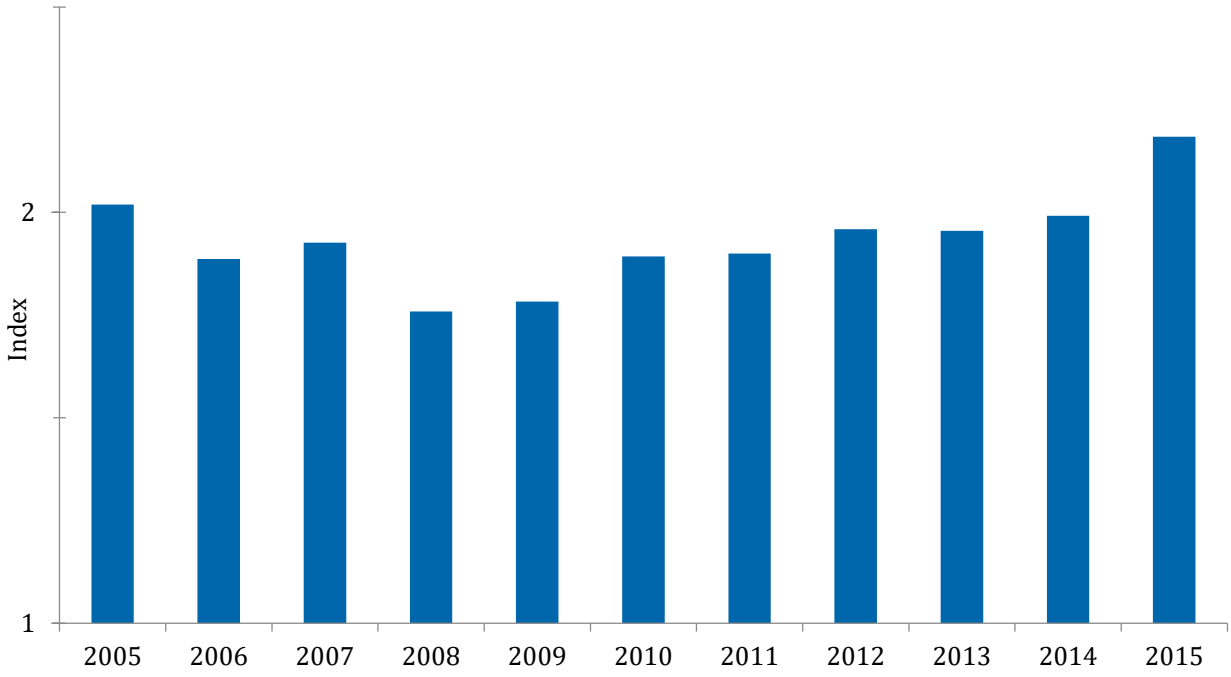


Source: ICIO 2018, authors' calculations.

Position in the GVC

Position in the GVC indicates how far the production process is from final demand. This measure, based on the methodology developed by Antràs et al. (2012), Fally (2012) and Wang et al. (2017) (see Annex II), shows that the production process in the motor vehicles industry in Slovakia was moving downstream (i.e., the distance to final demand was decreasing) prior to the global financial crisis. However, there was a turnaround subsequent to the crisis with the distance to final demand index exhibiting a rising trend. The distance to final demand index was 2.18 in 2015 compared to 1.76 in 2008 and 2.02 in 2005 (Figure 8). This implies that the production process was moving upstream in the post-crisis period, which is manifested in the growing importance of intermediates in exports (reported in the second Section above) and in the increase in forward participation in the GVC. The U-shaped trend path of the distance to final demand index was strongly correlated with similar trend paths of share of intermediates in exports ($\rho = 0.946$; $p = 0.000$) and forward linkage ($\rho = 0.838$; $p = 0.001$).

Figure 8. Distance to final demand



Source: ICIO 2018; authors' calculations.

Effect of negative demand shock on value added

Given its high export orientation and GVC participation, the Slovak motor vehicles sector is vulnerable to negative shocks to final demand for motor vehicles. Such a shock would result in a fall in the (direct) value added generated in the production of motor vehicles which also would have a negative knock-on effect on the (indirect) value added created in the production of domestically-sourced inputs. The total impact on the Slovak economy would be significant in view of the relatively large contribution of the combined direct and indirect domestic value added embodied in the production of motor vehicles (13 percent of Slovak GDP in 2015).

We calculate the impact on domestic value added of a hypothetical 10 percent negative shock to the final demand for motor vehicles, using the methodology elaborated by Garcia et al. (2020) (see Annex III). The size of the impact is also classified according to the geographical origin of the shock. An underlying assumption of the calculations is that the structure of the global supply chain does not change on account of the negative demand shock. The estimated impact varies linearly with the size of the final demand shock. Thus, a doubling of the demand shock would double the size of the loss in value added.

As Table 1 below shows, a 10 percent decline in the global final demand for motor vehicles would result in a drop of nearly 8 percent in the direct and indirect domestic value added embodied in the production of motor vehicles in Slovakia. This is equivalent to a fall of about 1 percent in Slovak GDP. A 10 percent negative demand shock emanating from the EU would

lower Slovak GDP growth by almost 0.5 percentage point, with the contribution of the shock originating in the euro area being 0.34 percentage point. The exposure to a shock from non-EU markets in the aggregate is only somewhat smaller than to a shock from the EU, but this market segment is more diverse than the EU. The United States and China are the largest markets outside the EU for Slovak motor vehicles. A 10 percent demand shock originating from these two countries would lower Slovak GDP by 0.13 percent and 0.1 percent, respectively. The impact of a domestic demand shock is assessed to be rather small.

Table 1. Impact of a negative 10% shock in demand for cars by origin of the shock

Origin of shock	Change in direct and indirect domestic value added embedded in production of motor vehicles (in percent of combined direct and indirect value added in 2015)	Change in the Slovak GDP (in % of total Slovak GDP in 2015)
Domestic	-0.64%	-0.07%
European Union (excluding Slovakia)	-3.80%	-0.49%
Euro area	-2.68%	-0.34%
Non-euro area EU countries	-1.13%	-0.15%
Rest of the world	-3.39%	-0.44%
USA	-1.00%	-0.13%
China	-0.86%	-0.10%
Russia	-0.23%	-0.02%
Total world	-7.81%	-0.99%

Source: Authors' calculations.

Conclusions

The importance of the motor vehicles sector in value added and exports of the Slovak economy has grown over the past two decades. The motor vehicles industry in Slovakia is highly integrated into the GVC, and there has been an ongoing change in the structure of the supply chain. The domestic part of the supply chain has lengthened as the reliance of the sector on domestically-sourced inputs has grown, and the international part of the length of the GVC has shortened. The upstreamness of the production process has been increasing, and the forward linkage in the GVC has slowly crept up. The sourcing of imported inputs and the export market have become more diversified. While the EU remains a major source of imports of intermediate inputs and destination for exports, the market share of non-EU countries in both imports of intermediates and exports of final goods have risen over time.

Given the huge dependence of the motor vehicle sector on exports and the lengthening of the domestic supply chain over time, the vulnerability of the Slovak economy to negative shocks to the demand for motor vehicles originating from abroad has increased. Although Slovak motor vehicles are exported to many countries, the main export markets for Slovak cars are Germany, China, the United States and Russia. Thus, the sector is particularly exposed to idiosyncratic demand shocks originating from these countries.

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Appendix Table 1. Selected Indicators from the gross production perspective for the Slovak motor vehicles sector

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Destination of total gross exports of motor vehicles sector (in % of gross exports of motor vehicles sector)											
Euro area	66.8	55.9	54.2	43.8	47.7	42.6	41.7	39.2	38.9	40.0	43.0
Non-euro area EU	8.2	9.8	11.2	13.0	17.0	17.2	15.4	15.4	16.7	18.8	20.1
Non EU	25.0	34.3	34.6	43.2	35.3	40.2	42.8	45.4	44.4	41.2	36.9
of which:											
United States	11.7	15.5	10.4	6.7	3.2	4.8	4.7	5.5	5.4	6.3	8.8
China	1.0	2.8	4.9	5.9	6.9	10.2	16.9	16.8	15.4	14.9	10.0
Destination of intermediate gross exports of motor vehicles sector (in % of gross exports of motor vehicles sector)											
Euro area	29.3	22.9	20.7	14.9	16.0	18.4	16.8	16.4	15.9	16.9	22.4
Non-euro area EU	3.8	4.2	4.6	5.0	8.2	8.9	8.1	8.3	9.0	10.0	11.3
Non EU	9.4	11.5	12.2	13.2	8.7	10.6	11.6	12.7	12.6	12.4	11.6
of which:											
United States	5.3	5.9	5.3	2.6	1.3	1.8	1.8	1.9	1.4	1.9	1.5
China	0.5	1.3	2.3	2.2	2.4	2.7	4.7	4.9	4.7	4.8	3.7
Destination of final goods gross exports of motor vehicles sector (in % of total gross exports of motor vehicles sector)											
Euro area	37.5	33.0	33.6	28.8	31.7	24.2	24.9	22.8	23.0	23.1	20.6
Non-euro area EU	4.4	5.5	6.6	8.1	8.8	8.3	7.3	7.1	7.7	8.7	8.8
Non EU	15.6	22.8	22.3	30.0	26.7	29.5	31.2	32.7	31.8	28.8	25.3
of which:											
United States	6.4	9.6	5.2	4.1	1.9	3.0	2.9	3.5	4.0	4.4	7.3
China	0.5	1.5	2.6	3.6	4.4	7.5	12.3	11.9	10.7	10.1	6.3
Source of total (direct & indirect) foreign intermediate inputs embodied in production of motor vehicles (in % of total imports of intermediates)											
Euro area	54.9	49.4	45.8	48.2	49.7	43.7	42.4	42.7	43.4	42.6	42.3
Non-euro area EU	21.7	23.4	20.8	19.8	20.6	17.6	17.8	17.6	22.7	23.4	23.8
Non EU	23.4	27.2	33.4	32.0	29.7	38.7	39.8	39.7	33.9	34.0	33.8

(continued)

Appendix Table 1 (continued). Selected Indicators from the gross production perspective for the Slovak motor vehicles sector

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Destination of total gross exports of motor vehicles sector (in % of gross exports of motor vehicles sector)											
Euro area	66.8	55.9	54.2	43.8	47.7	42.6	41.7	39.2	38.9	40.0	43.0
Non-euro area EU	8.2	9.8	11.2	13.0	17.0	17.2	15.4	15.4	16.7	18.8	20.1
Non EU	25.0	34.3	34.6	43.2	35.3	40.2	42.8	45.4	44.4	41.2	36.9
of which:											
United States	11.7	15.5	10.4	6.7	3.2	4.8	4.7	5.5	5.4	6.3	8.8
China	1.0	2.8	4.9	5.9	6.9	10.2	16.9	16.8	15.4	14.9	10.0
Destination of intermediate gross exports of motor vehicles sector (in % of gross exports of motor vehicles sector)											
Euro area	29.3	22.9	20.7	14.9	16.0	18.4	16.8	16.4	15.9	16.9	22.4
Non-euro area EU	3.8	4.2	4.6	5.0	8.2	8.9	8.1	8.3	9.0	10.0	11.3
Non EU	9.4	11.5	12.2	13.2	8.7	10.6	11.6	12.7	12.6	12.4	11.6
of which:											
United States	5.3	5.9	5.3	2.6	1.3	1.8	1.8	1.9	1.4	1.9	1.5
China	0.5	1.3	2.3	2.2	2.4	2.7	4.7	4.9	4.7	4.8	3.7
Destination of final goods gross exports of motor vehicles sector (in % of total gross exports of motor vehicles sector)											
Euro area	37.5	33.0	33.6	28.8	31.7	24.2	24.9	22.8	23.0	23.1	20.6
Non-euro area EU	4.4	5.5	6.6	8.1	8.8	8.3	7.3	7.1	7.7	8.7	8.8
Non EU	15.6	22.8	22.3	30.0	26.7	29.5	31.2	32.7	31.8	28.8	25.3
of which:											
United States	6.4	9.6	5.2	4.1	1.9	3.0	2.9	3.5	4.0	4.4	7.3
China	0.5	1.5	2.6	3.6	4.4	7.5	12.3	11.9	10.7	10.1	6.3
Source of total (direct & indirect) foreign intermediate inputs embodied in production of motor vehicles (in % of total imports of intermediates)											
Euro area	54.9	49.4	45.8	48.2	49.7	43.7	42.4	42.7	43.4	42.6	42.3
Non-euro area EU	21.7	23.4	20.8	19.8	20.6	17.6	17.8	17.6	22.7	23.4	23.8
Non EU	23.4	27.2	33.4	32.0	29.7	38.7	39.8	39.7	33.9	34.0	33.8

Source: OECD ICIO Model database; authors' calculations.

Appendix Table 2. Selected Indicators from the value added perspective for the Slovak motor vehicles sector

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(Direct) value added in motor vehicles sector (in % of gross output of motor vehicles sector)	19.6	17.9	18.5	17.0	23.5	22.1	21.3	19.2	19.2	20.5	20.7
(Direct) value added in motor vehicles sector (in % of total value added in Slovak economy)	3.2	3.3	4.1	3.6	3.8	4.6	5.3	5.5	5.6	6.0	6.6
(Indirect) domestic value added in intermediate inputs used in production of motor vehicles (in % of gross output of motor vehicles sector)	14.9	13.8	15.4	17.9	20.7	20.3	19.0	20.2	20.0	20.1	19.8
(Indirect) domestic value added in intermediate inputs used in production of motor vehicles (in % of domestic intermediate inputs used in production of motor vehicles)	50.7	50.1	51.1	55.9	62.4	58.7	54.7	54.4	54.5	55.8	53.1
(Indirect) domestic value added in intermediate inputs used in production of motor vehicles (in % of total value added in Slovak economy)	2.4	2.6	3.4	3.7	3.3	4.2	4.7	5.8	5.9	5.8	6.3
Direct & Indirect value added in production of motor vehicles (in % of total value added in Slovak economy)	5.6	5.9	7.6	7.3	7.1	8.8	10.0	11.2	11.5	11.8	13.0
Backward linkage (Foreign value added in exports in % of gross exports of motor vehicles)	65.6	68.4	66.0	65.1	55.9	57.6	59.7	60.5	60.8	59.4	59.6
Forward linkage (Export value added used in third countries in % of gross exports of motor vehicles)	5.5	4.3	4.6	3.3	5.0	5.8	5.9	5.7	5.7	6.4	7.8
GVC participation index (in % of gross exports of motor vehicles)	71.1	72.7	70.6	68.5	60.9	63.4	65.5	66.2	66.5	65.8	67.3
Length of GVC Total	3.1	3.2	3.2	3.2	3.0	3.1	3.2	3.2	3.2	3.1	3.1
Domestic part of length of GVC	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6
International part of length of GVC	1.7	1.8	1.8	1.7	1.4	1.5	1.6	1.6	1.6	1.6	1.5
Distance to final demand Total	2.0	1.9	1.9	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.2

Source: OECD ICIO Model database; authors' calculations.

Appendix Table 3. Regressions on time trends in selected indicators of the Slovak motor vehicles sector

Dependent variable	Constant		TIME		TIMESQ		Adjusted R-Squared	F statistic	
Gross output of motor vehicles sector (in % of gross output of entire Slovak economy)	6.2955		0.5887				0.7879	38.15	***
	(0.6465)	***	(0.0953)	***					
Share of final goods in gross output of motor vehicles sector (%)	46.0271		3.5844		-0.3467		0.7000	12.67	***
	(2.5783)	***	(0.9875)	***	(0.0802)	***			
Domestic sales of motor vehicles sector (in % of gross output of motor vehicles sector)	30.6407		-2.4970		0.2182		0.3639	3.86	*
	(2.5752)	***	(0.9863)	**	(0.0801)	**			
Gross exports of motor vehicles sector (in % of total gross exports of Slovakia)	15.8817		1.1363				0.9370	149.85	***
	(0.6296)	***	(0.0928)	***					
Gross exports of intermediate goods (in % of gross output of motor vehicles sector)	31.3979		-1.7387		0.1571		0.8139	22.87	***
	(0.7880)	***	(0.3018)	***	(0.0245)	***			
Domestically-sourced intermediate inputs used to produce motor vehicles (in % of gross output of motor vehicles sector)	25.9780		1.7911		-0.0698		0.8980	45.03	***
	(1.1815)	***	(0.4525)	***	(0.0367)	*			
(Indirect) domestic value added in intermediate inputs used in production of motor vehicles (in % of total value added in Slovak economy)	1.9105		0.4130				0.9418	162.74	***
	(0.2196)	***	(0.0324)	***					
Direct & Indirect value added in production of motor vehicles (in % of total value added in Slovak economy)	4.5471		0.7552				0.9502	191.80	***
	(0.3699)	***	(0.0545)	***					
GVC participation index (in % of gross exports of motor vehicles)	76.1007		-3.1990		0.2222		0.5215	6.45	**
	(2.6222)	***	(1.0043)	**	(0.0815)	**			
Backward linkage (Foreign value added in exports in % of gross exports of motor vehicles)	70.8960		-2.8480		0.1712		0.5000	6.00	**
	(3.0795)	***	(1.1795)	**	(0.0957)				
Forward linkage (Export value added used in third countries in % of gross exports of motor vehicles)	5.2047		-0.3510		0.0510		0.6557	10.52	***
	(0.7470)	***	(0.2861)		(0.0232)	*			
Length of GVC Total	3.1650		-0.0021				-0.1024	0.07	
	(0.0529)	***	(0.0078)						
Domestic part of length of GVC	1.4156		0.0198				0.8789	73.56	***
	(0.0156)	***	(0.0023)	***					
International part of length of GVC	1.7494		-0.0218				0.3504	6.39	**
	(0.0586)	***	(0.0086)	**					
Distance to final demand Total	2.0757		-0.0959		0.0094		0.7539	16.32	***
	(0.0628)	***	(0.0240)	***	(0.0020)	***			

*Note: Figures in parentheses are standard errors. ***, **, * denote significance at 1%, 5%, and 10% level.*

Annex I. Using the Inter-Country Input-Output (ICIO) model database

In the ICIO model, the relationship between gross output X and final demand Y is given by

$$X = B * Y$$

where B is the well-known (global) Leontief inverse matrix, and the relationship between value added Va and final demand is given by

$$Va = \hat{V} * B * Y$$

where $\hat{V}$ is a diagonal matrix with sectors' value added coefficients in its diagonal.

Matrix $\hat{V} * B$ is crucial in the calculation of the country´s origin of value added for variables that are listed in Figure 1 of the main text.

To calculate the origin of the Va in inputs of the Slovak automotive sector we use the matrix

$$\hat{V} * B * INP$$

where INP is a diagonal matrix with inputs to Slovak automotive sector from all domestic and foreign sectors on its diagonal.

Calculation of origin of the Va of exports of the automotive sector rests on the matrix

$$\hat{V} * B * EXP$$

where EXP is a diagonal matrix with total export of each domestic and foreign sector on its diagonal.

The origin of the Va of the Slovak automotive sector´s final demand can be determined from the matrix

$$\hat{V} * B * Y$$

Annex II. Measuring the length of GVC and distance to final demand

This annex sets out the methodology for the calculation of the indices for the length of global value chains (GVC) and distance to final demand. The length of GVC reflects the number of stages involved in the entire production process between the primary inputs in a country-sector pair to the final product in another country-sector pair. The distance to final demand indicates the position of the country in the value chain; i.e., it measures the number of stages still left before the goods produced by the industry reach the final consumer. We follow the methodology proposed by Antràs et al. (2012), Fally (2012) and Wang et al. (2016).

The accounting framework

The average production length of value added from sector *i* of country *s* to the final product of sector *j* in country *r* can be computed from the matrix

$$PLvy = \frac{\hat{V} * B * B * \hat{Y}}{\hat{V} * B * \hat{Y}}$$

where B is the well-known (global) Leontief inverse matrix, and $\hat{V}$ and $\hat{Y}$ are diagonal matrices with sectors' value added coefficients and final demand, respectively, in their diagonals.

The elements of the matrix $PLvy$ are

$$plvy_{ij}^{sr} = \frac{v_i^s \sum_{tk} b_{ik}^{st} b_{kj}^{tr} y_j^r}{v_i^s b_{ij}^{sr} y_j^r}$$

The numerator $v_i^s \sum_{tk} b_{ik}^{st} b_{kj}^{tr} y_j^r$ is the total output generated by the production chain from sector *i*'s value added in country *s* and finally absorbed by the final product of sector *j* in country *r*. The denominator $v_i^s b_{ij}^{sr} y_j^r$ is the total (direct and indirect) value added of sector *i* in country *s* embodied in the final product produced by sector *j* of country *r*.

Thus, the length of a production chain $plvy_{ij}^{sr}$ signifies the number of times a value added is counted as output in the production chain, from the first time it is used as the primary input of a country/sector (*s, i*) until it is absorbed by a final product of a country/sector (*r, j*).

The matrix $PLvy$ enables us to construct the indices for the length of GVC and distance to final demand.

Measuring the length of GVC index

Aggregating matrix $PLvy$ along the column *(r, j)* over value-added from all sectors *i* of country *s* that have contributed to the final goods and services produced by sector *j* of country r, we obtain the average production length measure of sector *j* in country *r* — D_j^r, based on backward linkage. By matrix manipulation, it can be shown that D_j^r is the sum of elements on the column *(r, j)* of Leontief inverse matrix *B*:

$$D_j^r = \sum_{si} b_{ij}^{sr}$$

The sum along the columns of the Leontief inverse matrix equals the total value of inputs generated by a unit of final product produced in a particular sector. Therefore, index *D* measures total intermediate inputs generated by a unit value of a particular final product throughout all upstream sectors in the economy, which the literature usually refers to as the footprint of final goods and services. The longer is the production chain, the greater is the number of upstream production stages that a particular final product has in the economy.

Measuring the distance to final demand index

Aggregating matrix $PLvy$ along the row (*s, i*) over all products *j* of country *r*, we obtain the total average production length of value added generated in sector *i* of country *s*, i.e., the average production length measure of sector *i* in country *s* — U_i^s, based on forward linkage. By matrix manipulation, it can be shown that U_i^s is the sum of elements on the row (*s, i*) of a matrix $G = \hat{X}^{-1} * B * \hat{X}$ (called Ghosh inverse[7]):

[7]Ghosh, A. 1958. Input-output approach in an allocation system. *Economica* 25: 58-64

$$U_j^r = \sum_{rj} g_{ij}^{sr}$$

It is the sum along the rows of the Ghosh inverse matrix, which equals the total value of gross outputs that are related to one unit of value added created by primary inputs from a particular sector. Thus, the index U measures total gross outputs generated by one unit of value added at the sector level, which are the footprints of each sector's value added in the economy as a whole. The longer is the production chain, the greater is the number of downstream production stages that a sector's value added is counted as gross output in the economy.

Annex III. Quantifying the impact on the motor vehicles sector of a shock to final demand

Assuming that the structure of the global supply chain remains unchanged, the impact of a shock to final demand for cars by consumers across the world on the (direct and indirect) domestic value added embodied in the production of motor vehicles can be computed as follows:

$$\Delta\, Va = \hat{V} * B * \left(Y^{cars}_{t=shock,WR} - Y^{cars}_{2015,WR}\right)$$

where Va is the (direct and indirect) domestic value added; $\hat{V}$ is a diagonal matrix with sectors' value added coefficients in its diagonal; B is the well-known (global) Leontief inverse matrix; and $Y^{cars}_{2015,WR}$ denotes the demand for cars in 2015 by specified world regions (individual countries, EA, EU, world).