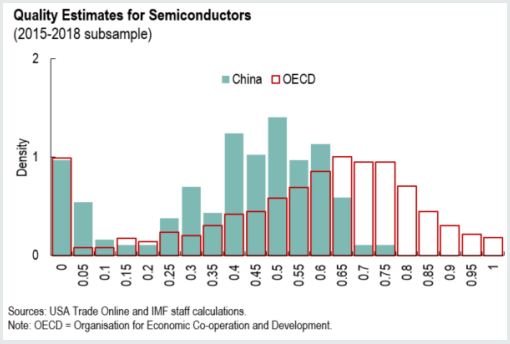
Online Box 3.1. Export Restrictions and Quality Downgrading[1]

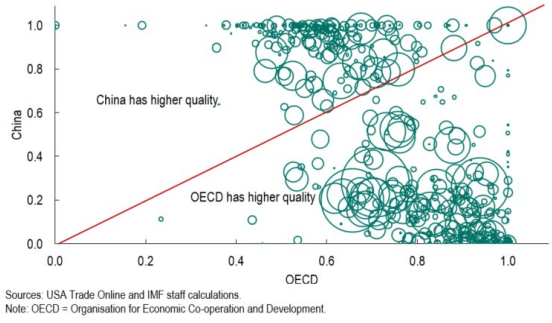
Recent export restrictions have increasingly targeted access of countries to high-quality inputs. The intention, for example, is to prevent China from being able to procure logic chips with design rules under certain nanometer thresholds (see, for example, Shivakumar, Wessner, and Howell [2022]). In this case, China faces the possibility of quality downgrading in its inputs, potentially being forced to produce lower-quality outputs, such as slower artificial intelligence models or phones.

Evaluating the effect of these export restrictions requires a framework to estimate quality differentials at a detailed product level. This box estimates quality differentials for 200,000 products at the Harmonized System (HS) 10-digit level using trade data for the US over 2002–18. Following the approach in Khadelwal (2010), IMF staff identified quality by comparing market shares conditional on price: if two products with the same price had different market shares, then it was inferred that the product with a higher market share is higher quality (see online appendix for further details on methods and data). The estimated quality at the product-year level was normalized between 0 and 1, with 1 indicating that the country has the highest quality for that product.

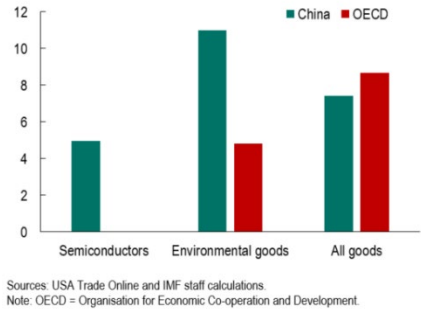


Everyone stands to lose from broadening restrictions—both in the aggregate and in critical areas such as the environment—as the quality frontier is highly product specific. In the specific case of semiconductor sectors, the median estimated Chinese product quality is about one-third lower than the median quality for the OECD. In a hypothetical situation in which China and the OECD cut off all access to each other's semiconductor products, and assuming that both parties can easily substitute each other with a good-quality (75th percentile) product from the rest of the world, the trade-weighted drop in quality is of about 5 percent for China and zero for the OECD.[2] However, such a stark asymmetry does not hold in general. In the case of environmental goods, the trade-weighted average quality loss is of about 11 percent for China and as high as 5 percent for the OECD, as different economies specialize in the production of different environmental goods. For all goods combined, both sides would see input quality drop by about 8 percent. For firms with a high-skilled labor force, such as those in high-tech sectors, these drops in input quality can result in output-quality reductions of similar proportions (Bas and Paunov, 2021, Table 6).

Quality Estimates for Environmental Goods
(2015-2018 average)



Quality Downgrading from Loss of Access Others' Inputs
(percent, accounting for ROW sourcing)



Online Annex

1. Eora world input-output matrix: value-added indicators, and sector classification

The chapter uses Eora's multi-region input-output table (Lenzen and others, 2012 and 2013). The world input-output table covers 189 countries, 26 sectors, and the years 1990-2021. Several indicators, such as trade in intermediates or in final demand goods by origin, are extracted directly from the raw database. Value-added indicators, including e.g. backward and forward GVC trade, were constructed using Stata's *icio* command, developed by Belotti and others (2020).

Where necessary, Eora sectors were mapped to the GVC classification as noted in Annex Table 3.1.1.

Construction of domestic and international trade data broken down by GVC goods, non-GVC goods, investment goods, and consumption goods is done as follows.

GVC and non-GVC goods are intermediate-input sales, i.e. they are taken from the square intermediate-input trade matrix of the world input-output matrix. In order to account for all intermediate trade, sales between GVC and non-GVC sectors are assigned to the sector classification of the purchasing sector. For instance, sales from the agricultural (non-GVC) sector in a country to the transport equipment (GVC) sector of another country are considered GVC goods.

Investment and consumption goods correspond to sales to final demand, i.e. they are taken from the rectangular final demand matrix. Eora end uses that are considered investment are gross fixed capital formation, changes in inventories, and acquisitions less disposals of valuables. Eora end uses that are considered consumption are household final consumption, non-profit institutions serving households, and government final consumption.

[1] This box was prepared by Diego A. Cerdeiro, Parisa Kamali and Siddharth Kothari.

[2] This summary indicator should be taken as a rough gauge of the impact of restrictions, as it does not account e.g. for different elasticities of substitution at the product level.

Annex Table 3.1.1. Eora Sectors' Classification

Eora sector	Classification
Agriculture	Tradable non-GVC
Fishing	Tradable non-GVC
Mining and Quarrying	GVC
Food & Beverages	Tradable non-GVC
Textiles and Wearing Apparel	GVC
Wood and Paper	GVC
Petroleum, Chemical and Non-Metallic Mineral Products	GVC
Metal Products	GVC
Electrical and Machinery	GVC
Transport Equipment	GVC
Other Manufacturing	GVC
Recycling	Non-tradable
Electricity, Gas and Water	Non-tradable
Construction	Non-tradable
Maintenance and Repair	Non-tradable
Wholesale Trade	Non-tradable
Retail Trade	Non-tradable
Hotels and Restaurants	Tradable non-GVC
Transport	Tradable non-GVC
Post and Telecommunications	Non-tradable
Financial Intermediation and Business Activities	Tradable non-GVC
Public Administration	Non-tradable
Education, Health and Other Services	Non-tradable
Private Households	Non-tradable
Others	Non-tradable
Re-export & Re-import	GVC

Sources: Eora; MRIO; authors' classification.

2. The GIMF-GVC model

Summary of the Model Structure

GIMF is an annual, multi-region, micro-founded dynamic stochastic general equilibrium model (DSGE) of the global economy. In this chapter, GIMF comprises 10 regions: the United States, EU+, the other advanced economies, China, India, Indonesia, Japan, Korea, other Southeast Asia, and the rest of the world. Alongside the standard elements, a tradable sector related to global value chains (GVC) has been added for this chapter, referred to hereafter as "the GVC sector." More detailed expositions of the model can be found in Kumhof and others (2010) and Anderson and others (2013).

Some households are modeled as non-Ricardian, finitely lived, overlapping generations, as found, for example, in Blanchard (1985). These saving households choose consumption, savings, and labor supply. The remaining households are liquidity constrained, consume all their income every period and set their labor supply in proportional to that of the saving households and reinforce the short-term non-Ricardian properties of the model.

Profit-maximizing firms (owned by households) operate in monopolistically competitive markets, and produce goods in non-tradable, tradable, and the GVC sectors. These three types of goods are based on sectors from the OECD Inter-Country Input-Output Database (OECD 2021; presented in Annex Table 3.2.1).

Non-tradable goods and domestically produced tradable goods are produced using some combination of labor and capital.

Annex Table 3.2.1. Definition of GIMF's Production Sectors

Nontradables		Tradables		GVC goods	
Code	Sector Name	Code	Sector Name	Code	Sector Name
D35	Electricity and natural gas	D01T02	Agriculture, hunting, forestry	D05T06	Mining (energy)
D36T39	Water	D03	Fishing	D07T08	Mining (non-energy)
D41T43	Construction	D09	Mining (support)	D13T15	Textiles, leather and footwear
D45T47	Wholesale and retail trade	D10T12	Food	D16	Wood and wood products
D53	Postal services	D23	Other non-metallic products	D17T18	Paper products and printing
D61	Telecommunications	D49	Land transport	D19	Coke and refined oil products
D68	Real estate	D52	Warehousing	D20	Chemicals
D77T82	Administration	D55T56	Hotels and restaurants	D21	Pharmaceutical products
D84	Public administration	D58T60	Publishing and broadcasting	D22	Rubber and plastics
D85	Education	D64T66	Finance and insurance	D24	Basic metals
D86T88	Health			D25	Fabricated metal products
D90T93	Arts			D26	Computers and electronics
D94T96	Other services			D27	Electrical equipment
D97T98	Households as employers			D28	Other machinery
				D29	Motor vehicles
				D30	Other transport equipment
				D31T33	Repair
				D50	Water transport
				D51	Air transport
				D62T63	Information Technology
				D69T75	Professional

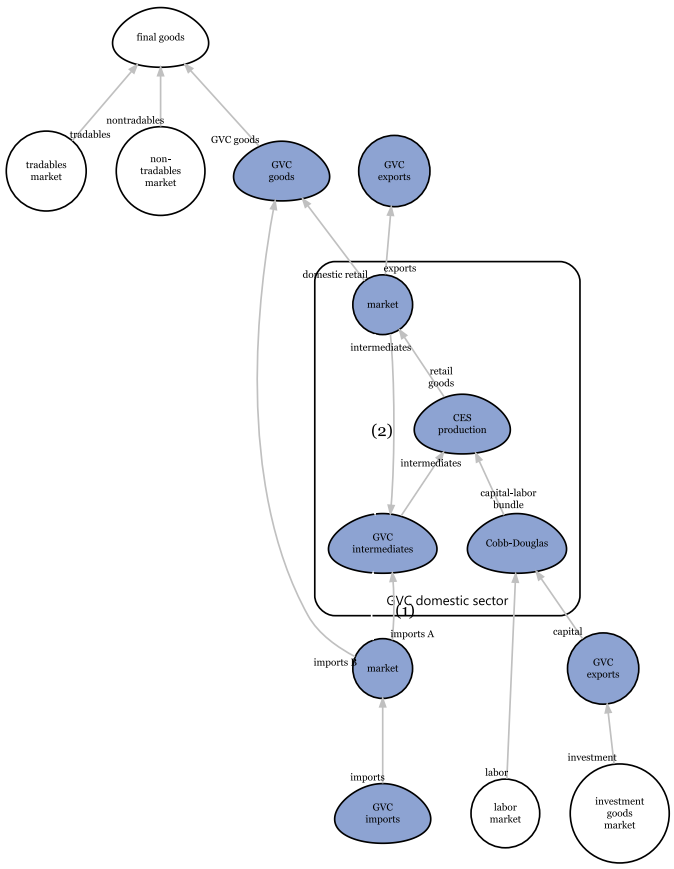
Source: OECD (2021) and IMF staff calculations.

The GVC sector is more complex than the other two sectors, as seen in Annex Figure 3.2.1, as GVC goods are used both in final goods and as inputs in the production of other GVC goods. The sector is intended to represent industries such as semiconductors, with chips going into the production of computers sold to consumers (a final good), or as inputs into auto-parts (another GVC good). Production in the GVC sector combines capital and labor (bundled using a Cobb-Douglas function) with already produced GVC goods, which are both imported (labeled (1)) and domestically sourced (labeled (2)). The produced output is then split between inputs into final goods or cycled back as inputs into the production of other GVC goods, both domestically and abroad.

Regions trade final goods (consumption and investment), and tradable and GVC intermediate goods. The flows of these goods are tracked bilaterally. Trade flows react to demand, supply and pricing (i.e., the terms of trade and bilateral real exchange rates) conditions. The model captures barriers to trade using "non-tariff barriers" (NTB), which affects the model's importers and exporters in ways similar to tariffs but does not generate fiscal revenues.

Monetary and fiscal policies are set to passively respond to shocks according to inflation targeting and debt-GDP ratio targeting rules respectively.

Annex Figure 3.2.1 GIMF's Global Value Chain Sector



Summary of the Calibration

Each region's economy is calibrated using the OECD Inter-Country Input-Output Database for 2018 (OECD 2021), drawing on its national accounts and fiscal ratios. The size of the various sectors works in tandem with more specific parameterizations in the various sectors, such as consumption and international trade, discussed below.

For consumption, the intertemporal elasticity of substitution is common across regions at 0.2. The share of liquidity constrained households varies based on level of financial market development, and is set at 25 percent for the United States, EU+, the other advanced economies, and China, and at 50 percent for the remaining regions. Regions with high shares of liquidity constrained households have more volatility in GDP, as they are less able to smooth their consumption under temporary shocks or implement gradual adjustments under permanent shocks.

Region size and openness to trade also differentiate the role of regions in the global economy. Regions with smaller shares of global GDP will have less impact on the global neutral interest rate. A region's degree of openness determines how activity in the rest of the world will spill over onto it, and how that region influences the rest of the world.

Many of the elasticities in GIMF are calibrated the same across regions, including for trade and the combination of various goods to produce final goods. However, each region has a unique set of related bias parameters, which, given the elasticities, are computed based on the calibration of key steady-state ratios based on OECD (2021).

Annex Table 3.2.2. Key Production and Trade Elasticities

Elasticity between =>	*Capital-Labor / GVC*	*Domestic / Imported*	*Different Regions*
Consumption	-	1.5	1.5
Investment	-	1.5	1.5
Tradables	-	1.5	1.5
GVC Goods	0.5	0.8*	0.8

Source: IMF staff calculations.

* Elasticity between domestic and imported when using GVC goods in the production of final goods or of other GVC goods.

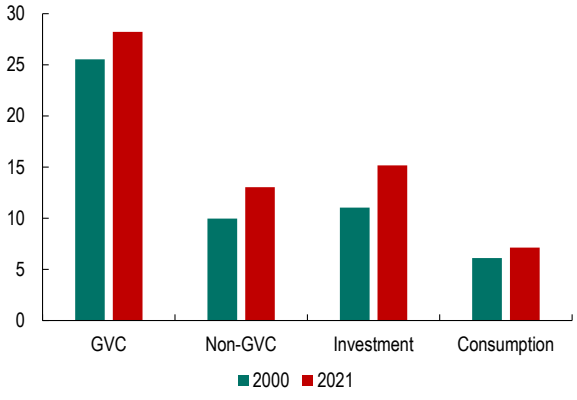
For this chapter, the most important elasticities are related to trade and combining imports and domestically produced goods to produce intermediate and final goods (Annex Table 3.2.2). Demand for goods in the GVC sector are assumed to be relatively inelastic (about 0.8), compared to other elasticities of demand and trade for final consumption and investment goods and tradable intermediate goods, which are usually elastic at about 1.5. Final goods are a combination of nontradable goods and a tradable goods bundle, with an elasticity of 0.5. The tradable goods bundle is assembled from tradable intermediate goods and GVC goods with an elasticity of 0.95.

Calibration of the Re-shoring and Friend-shoring Scenario in GIMF

Annex Figure 3.2.2. Re-Shoring and Friend-Shoring Margins

Over the past two decades, there has been an increased reliance on foreign sourcing in general…

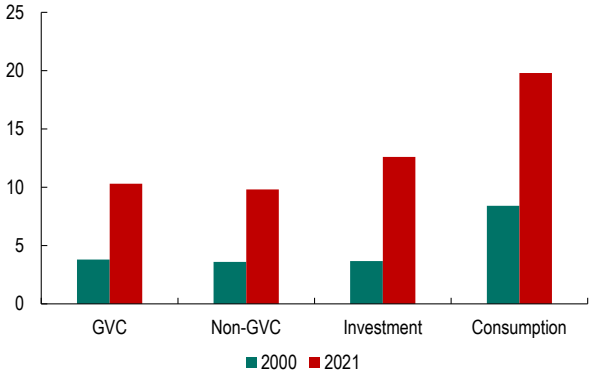
1. Foreign Sourcing as Share of Total Sourcing
(OECD countries, percent, by type of goods and services trade)



Source: EORA GVC and IMF staff calculations.

… and on specific foreign economies..

2. Sourcing from China as Share of Foreign Sourcing
(OECD countries, percent, by type of goods and services trade)



Source: EORA GVC, and IMF staff calculations.

Panel 1 in Annex Figure 3.2.2 shows the observed changes along the "re-shoring" dimension. Specifically, it shows the OECD' foreign sourcing as percent of total (foreign plus domestic) sourcing.[3] The shares are shown separately for the different types of goods and services used in the GIMF model, namely GVC intermediates, non-GVC intermediates, investment goods, and consumption goods. OECD countries have, in aggregate, increased their share of foreign sourcing (from OECD countries and from the rest of the world) by about 3 percentage points for GVC, non-GVC and investment goods, and by about 1 percentage point for consumption goods.

Panel 2 in Annex Figure 3.2.2 shows the observed changes over the past two decades along the "friend-shoring" dimension. China's share in OECD sourcing increased by about 5 percentage points for GVC and non-GVC intermediates, and by about 10 percentage points for investment and consumption goods.

3. Upside scenario with rebalancing

In addition to productivity-enhancing reforms, rebalancing toward consumption and away from investment would result in more sustainable, less debt-intensive growth in China. While rebalancing will unambiguously enhance consumption and welfare for China in the short and medium term, the effect on GDP is uncertain. GDP is likely to rise in the short term, especially as the economy is currently below potential; over the medium term, rebalancing could be negative for GDP as capital accumulation slows. This welfare-enhancing growth path would also have implications for the rest of Asia.

To assess spillovers from rebalancing, public investment in China is reduced in the model by 0.5 percentage points of GDP per year for 15 years (halving China's public investment), offsetting it by an increase in social protection for households (represented by lump-sum transfers in GIMF). The scenario assumes that the public investment that is cut is of low quality and does not directly reduce productivity in the private sector.

While in the short-term rebalancing provides a boost to growth in China by lifting consumption demand by more than the decline in public investment, over the long term, rebalancing is GDP neutral in China. For the rest of the world, rebalancing results in very small yet negative spillovers.

4. Quality estimation

As in Khandelwal (2010, eq. (15)), our estimating equation at the industry (NAICS 6-digit) level is:

$$ln(s_{cht}) - ln(s_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \alpha\ p_{cht} + \sigma\ ln(ns_{cht}) + \gamma \ln(pop_{ct}) + \lambda_{3,cht},$$

where s_{cht} is the market share of variety (i.e. the HS10 product from a specific country) ch at time t in the industry, s_{0t} is the market share of the domestic variety, $\lambda_{1,ch}$ is a variety-specific fixed effect, $\lambda_{2,t}$ is a time fixed effect, p_{cht} is the price (unit values inclusive of cost of insurance and freight and tariff duties), ns_{cht} is the market share of the variety within the HS10 product, pop_{ct} is the population of the country producing the variety, and $\lambda_{3,cht}$ is an unobserved variety-time error. We refer the reader to Khandelwal (2010) for the derivation of the equation.

Quality is defined as the expectation of the relative market share conditional on price, nested share and population, i.e.:

$$\lambda_{cht} \equiv \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,cht}.$$

[3] We focus on the observed changes for the OECD because in the case of China, as a result of its far-above-average growth, over these past two decades it saw a decline in its foreign sourcing just by virtue of becoming a larger, and therefore organically more closed, economy. Similarly, as the rest of the world grew faster than the OECD, China also increased its relative sourcing from non-OECD countries.

Khandelwal estimates qualities for the period 1989-2001. We update his work and estimate qualities for the period 2002-2018. U.S. 10-digit trade data are from USA Trade Online. We perform the same trims to the trade data as in the original paper. Population data are from the World Bank World Development Indicators, and industry-level domestic shares are from the NBER domestic shipments data. Price is endogenous and is instrumented using variety-specific unit transportation costs (available in the trade dataset), exchange rates (from the World Economic Outlook database), and oil prices (from Haver). ns_{cht} is instrumented with the number of varieties within the product and the number of varieties exported by this partner.

When estimating quality for the OECD as a whole, we use, for each product, the 90th percentile of quality across all OECD economies. To calculate the potential quality losses should China and the OECD restrict access to each other's products, we assume that both sets of economies can substitute towards inputs from the rest of the world with quality in the 75th percentile across all non-China, non-OECD economies. Specifically, let $j\epsilon\{CHN, OECD\}$, with $k = \{CHN, OECD\} - \{j\}$ (e.g. k is China when j is the OECD), q denote the normalized quality (location in ladder), and suffix $ROWp75$ denote the 75th percentile of non-China non-OECD, then the percent loss in quality for j is calculated as:

$$loss_j = 1(q_k > q_j)\left[1(q_j > q_{ROWp75}) \times (q_k - q_j) + 1(q_j \leq q_{ROWp75}) \times 1(q_k > q_{ROWp75}) \times (q_k - q_{ROWp75})\right]/q_k \times 100.$$