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China's Imports Slowdown: Spillovers, Spillins, and Spillbacks

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China's Imports Slowdown: Spillovers, Spillins, and Spillbacks

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Abstract

The paper models international spillovers from a hypothetical drop of China's imports as a result of China's rebalancing of its growth model. A network-based model used in the paper allows capturing higher round network effects of the shock, which are largely unaccounted for in the existing literature. Such effects include direct spillovers from China on its trading partners, subsequent spillins among them, and spillbacks on China itself. The paper finds that the network effects most likely will be substantial, may amplify initial shock, and change the direction of its propagation. The impact on Asia and Pacific will be the strongest followed by the Middle East and Central Asia. The impact on sub-Saharan Africa would be noticeable only for some countries. Spillovers on Europe, including the Euro area, will be moderate, and spillovers on the Western Hemisphere, including the United States, would be very marginal. Metal and non-fuel commodity exporters may experience the largest negative impact.

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Main Findings

- A hypothetical drop of China's imports by 10 percent below the baseline in 2016 and 2017 would lead to a loss of about 1.2 percent GDP of export revenue in 2016 for all countries, which with network effects may increase to 2.0 percent of GDP in 2017 before abating gradually by 2020 to about 0.2 percent of GDP in 2020.

- The network effects are defined as higher-round effects generated by the network structure of trade. Such effects consist of *spillovers* of the nominal shock in China to its trading partners; *spillin* effects among all countries other than China, propagating secondary shocks to each other; and *spillback* effects from all countries on China itself. Individual countries in China's trade network might augment, attenuate, or block the initial shock.

- The network effects might augment the initial shock. The spillover of 0.4 percent of world's GDP in 2016 and 2017 from the original import demand shock in China might be augmented by spillins from the rest of the network in the amount of 0.4 and 1 percent of the world's GDP. The spillback effect on China would amount to 0.5 and 1.1 percent of its GDP in each of these years. These findings are consistent with the findings of the slowdown scenario in emerging market scenario (WEO, October 2015) and the risk scenario in the 2015 Article IV consultations with China.

- Robustness checks and sensitivity analysis suggests that the classification of countries as shock amplifiers, absorbers and blockers can have an impact on the higher round effects, in particular in the early years of shock proliferation. On average, the presented baseline model may underestimate the magnitude of higher round effects.

- The impact on individual regions would depend on their economic size and relative position in China's trade network. Asia and Pacific will be affected the most, because of their high exposure to trade with China, followed by the Middle East and Central Asia. The impact on sub-Saharan Africa would be also noticeable because of its small economic size and growing trade with China. The spillovers on Europe, including the euro area, will be moderate relative to its economic size; and spillovers on the Western Hemisphere, including the United States, would be marginal.

- Commodity exporters would be hit the most by the import demand shock in China. Metal exporters might be most affected by spillovers, as China is the largest metal importer in the world. Non-fuel primary commodity exporters may also experience substantial losses. The impact on fuel exporters most likely will be marginal.

- Among individual countries, the strongest negative spillovers in terms of the impact on GDP should be expected in Hong Kong SAR, Singapore, Mauritania, Republic of Congo, Mongolia, and Solomon Islands.

- More research is needed to differentiate between price and volume effects in nominal spillovers and take into account China's position in the global value chain.

I. INTRODUCTION

1. **Growth in China is expected to continue declining in the medium term from the unprecedentedly high rates in the first decade of the 2000s**. As a result, the risks of a an import shock emanating in China may increase and will be mainly related to the transition to a new consumption-led growth model with less reliance on import-intensive investment. Moreover, excesses in real estate, credit, and investment continue to unwind, with a further moderation in the growth rates of investment, especially in residential real estate. Overall, this has led to the observation that in emerging markets medium-term risks might come from spillovers from a "hard landing" or much slower potential growth in China (IMF, 2015a). This forecast assumes that policy action will be consistent with reducing vulnerabilities from recent rapid credit and investment growth and hence not aim at fully offsetting the underlying moderation in activity.

2. **The purpose of the paper is to assess the impact of the potential slowdown in China's imports on the rest of the world, including through the network effects.** The network effects, defined as higher-round effects generated by the network structure of bilateral balance of payments flows, have been largely disregarded in the existing literature on spillovers but can be substantial and at times exceed the initial shock. This paper is based on a method proposed in Kireyev-Leonidov (2015) for quantifying the network effects, using a nominal demand shock as an example. The method consists of a sequential transformation of the inflow-outflow matrices of bilateral trade flows, and captures spillovers from the initial shock and the subsequent network effects, including spillin and spillback effects.

3. **Only a few earlier studies touch on the issue of international spillovers from economic shocks in a network context**. Cerdeiro and Wirkierman (2008) proposed a linear general interdependence model of the world economy to assess the propagation of an exogenous shock to autonomous expenditures through the channel of international trade. Kali and Reyes (2010) mapped the global trading system as an interdependent complex network to obtain indicators of how well connected a country is to the global trading system. They found that a crisis is amplified if the epicenter country is better integrated into the trade network. Vidon (2011) assessed the impact of a change in US imports as a direct impact on its trading partners and including the knock-on effects by taking into account interconnectedness. Fronczak and Fronczak (2012) proposed a spillover model based on a fluctuation response theorem. Finally, Contreras and Fagiolo 2014 (2014) analyzed spillovers using Leontief input-output matrices connecting industrial sectors in several European countries.

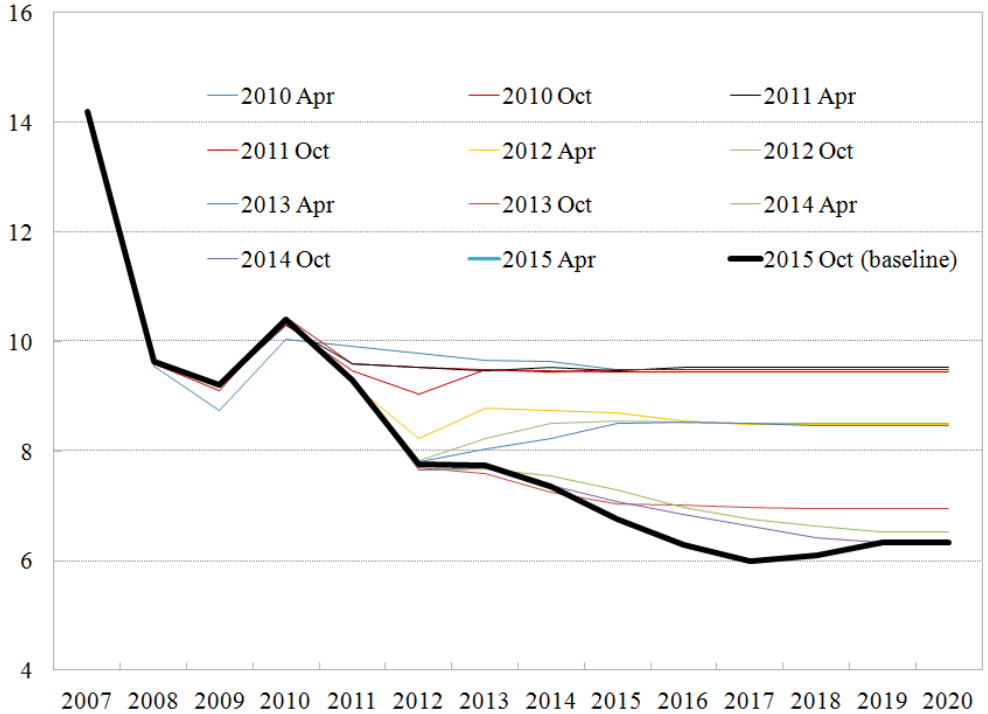
4. **This paper contributes to the existing literature in several areas**: (i) it develops a computable network model of international spillovers that can be used on any bilateral balance of payments flows; (ii) it allows identification and estimation of the network effects of international shock spillovers that can significantly amplify the initial shock and are largely untraceable by existing methodologies; (iii) it proposes the concept and presents estimations of a pass-through coefficient, which allows quantifying shock percolation through individual countries by introducing a quantitative measure of their ability to amplify, absorb, or block shocks; finally (iv) it assesses potential spillovers from China's imports slowdown which contribute to uncertainty and a higher risk of economic vulnerability

5. **To model international spillovers on a network, the paper proceeds as follows.** Section II provides an overview of current policy challenges related to China. Section III adapts the earlier developed network model of economic spillovers to the case of China. Section IV discusses the empirics of spillovers in a network context. Finally, Section V presents conclusions and practical recommendations.

II. POLICY SETTING

6. **China's imports is projected to moderate as a result of a new growth model after unprecedentedly high rates observed since the early 2000s**. China's growth stayed in the range of 10 percent a year through 2010, driven mainly by domestic investment and exports (Figure 1). Since then, growth gradually declined to an average of 8 percent in 2011-14. China's leadership has recently announced a new growth model to rebalance the economy in favor of domestic consumption, including of services, with less reliance on import-intensive investment. As a result, for 2015-16, it targeted even lower growth rates, of 6-7 percent. For 2015, IMF staff continues to see GDP growth of 6½-7 percent as striking the right balance between addressing vulnerabilities and minimizing the risk of too sharp a slowdown/disorderly adjustment (IMF, 2015b).

Figure 1. China: Growth Projections Revisions, 2016-20
(Real GDP growth in percent)



Sources: IMF WEO databases, 2012-15.

7. **The transition to a new growth model is considered favorable for China and the world as the model is more sustainable in the long run.** In the last two decades China graduated from labor-intensive toward more sophisticated export products, increasing domestic value added and reducing import content of its exports. This move up the value chain has contributed to a sharp reduction of China's imports from the main supplier countries, increasing their trade deficits with China. Lower import demand by China driven by the orderly slowdown has already been largely factored into exports and growth forecasts for the rest of the world. Therefore, the near-term slowdown in economic activity in China is broadly viewed as a price worth paying for safer and more sustainable long-term growth.

8. **While China's growth has been moderating broadly in line with projections, the international spillovers from China's imports slowdown already seem larger than previously envisaged.** In September 2015, the WTO revised its previous trade forecast for 2015. The downward revision to Asia on the import side was strong, from 5.1% to 2.6%, partly due to lower Chinese imports which were down 2.2% year-on-year in Q2 (non-seasonally adjusted data). The product composition of China's merchandise imports suggests that some of the slowdown may be related to the country's ongoing transition from investment to consumption led growth. Large year-on-year drops in quantities of imported machinery (-9%) and metals (iron and steel -10%, copper ‑6%) were recorded in customs statistics (WTO, 2015). Driven mainly by reduced projections of import-intensive investment, the lower import demand by China has already spilled over the rest of the world and affected both the volumes of exports of other countries to China and international prices.

9. **The risks of a substantial imports drop in China are open to debate and span a broad spectrum, including real and financial channels**. Two possible risk scenarios were presented in the October 2015 World Economic Outlook (WEO) (IMF, 2015a, Box1) related to structural slowdowns in a number of emerging market economies. In both simulations, investors expect lower growth in the future, because of slower catching up and lower productivity growth, as well as because of lower capital inflows and tighter financial conditions. Hence, they reduce investment expenditure relative to the WEO baseline projections, resulting in weaker domestic demand in emerging market economies. In particular, the sizable decline in investment and growth in China—together with the generalized slowdown across emerging market economies—implies a sizable weakening of commodity prices, particularly those for metals, resulting in a weakening of the terms of trade for commodity exporters. The 2015 IMF staff report for Article IV consultations with China (IMF, 2015b) highlights similar risks of a sharp slowdown relative to the baseline scenario already in 2015-16 and slower medium-term growth (Figure 2).

Figure 2. China: Domestic Risks
(from Global Risk Assessment matrix, October 2015)

Main source of risk	Overall level of concern	
	Likelihood over the next one to five years	Impact and policy response
Sharp slowdown in 2015-16	**Low** Growth falls significantly below target, possibly due to a severe housing downturn or a shock in the shadow banking sector, and absent offsetting stimulus.	**High** Such a shock could trigger a negative feedback loop between real activity, bank asset quality, lending, and local government finances . **Policy response** : If near-term growth were to slow too sharply, then fiscal stimulus should be used in a manner that supports rebalancing and helps protect vulnerable groups.
Medium-term slowdown	**Medium** Insufficient progress with reforms leads to a continued buildup of vulnerabilities, which over the medium term results in a significant growth slowdown.	**High** Main impact would be through continued resource misallocation, leading to significant TFP slowdown and overall potential growth in the medium term. **Policy response** : Advance structural reforms to accelerate the transition towards a more balanced and sustainable growth path.

Source: IMF 2015b, www.imf.org/external/country/chn.

10. **Different assumptions have been used to quantify the risks.** According to one of them, without reforms growth would gradually fall to around 5 percent in 2020, with steeply increasing debt (IMF, 2015b). Another scenario suggests that China might experience four consecutive years of lower growth for a permanent cumulative loss of 12 percent on the level of real GDP after four years, compared to the baseline scenario (Anderson et al., 2015). In all cases, the scenarios are purely illustrative and do not represent the views of IMF staff about the potential growth decline in China. Rather the exercises attempt to highlight the channels of transmission to the rest of the world.

11. **The spillovers have been modeled mainly in the context of global general equilibrium models**. For example, staff simulations based on the Flexible System of Global Models (FSGM) suggest that the impact of such a slowdown on other major economies is relatively minor, while slow progress in reforms or containing vulnerabilities—resulting in much lower income in China over time—would have significant negative spillovers in the medium to long term (IMF, 2015b). Simulations based on the Global Integrated Monetary and Fiscal model (GIMF) model suggest that the impact on commodity prices depends on how the slowdown is perceived: it would be largest if fully unanticipated, which could be interpreted as a substantial revision of expectations regarding growth prospects or, equivalently, a misperception about growth prospects before the slowdown, which led to excessive investment in future supply).The findings from the above-mentioned models suggest that the impact would depend on the exposure of individual countries to China, the size of their external sectors, and the commodity composition of their trade. For example, lower growth in China was found to have non-negligible effects on global real GDP, which permanently declines by more than 1.6 percent with respect to the baseline (Box 1).

Box 1. Spillovers from China's Rebalancing: Selected Earlier Findings

IMF October 2015 WEO (IMF, 2015a). The scenario of possible global repercussions of a generalized slowdown in emerging market and developing economies includes the materialization of a number of risks—a slowdown in investment and growth across emerging market economies, more severe in faster-growing economies such as China and India; lower commodity prices, arising from this slowdown; and higher risk premiums and exchange rate depreciation across emerging market economies. The implications for growth in emerging market economies and developing countries would be sizable, with growth rates 1.5 to 2 percentage points lower after five years. Spillovers onto advanced economies would also be material, with growth about 0.2 to 0.3 percentage point lower after five years, depending on whether risk aversion toward emerging market assets increases, and a sizable deterioration in current account balances, despite the partial offset from lower commodity prices.

People's Republic of China: Staff Report for the 2015 Article IV Consultation (IMF, 2015b): Simulations based on the FSGM model suggest that the impact of a slowdown in China on other major economies is relatively minor, while slow progress in reforms or containing vulnerabilities—resulting in much lower income in China over time—would have significant negative spillovers in the medium to long term. While China's transition is beneficial for the global economy, benefits accruing to individual countries vary at different stages of this process. Estimates based on a structural VAR indicate that the impact of China on global commodity prices has been increasing. Simulations based on the GIMF model suggest that the impact depends on how the slowdown is perceived: it would be largest if fully anticipated, which could be interpreted as a substantial revision of expectations regarding growth prospects (or, equivalently, a misperception about growth prospects before the slowdown, which could have led to excessive investment in future supply).

Anderson et al (2015). In the event of lower potential output in China global real GDP is 1.6 percent lower compared to baseline. Real commodity prices are also lower – oil prices by almost 8 percent. However, the net effect on economic activity on sub-Saharan Africa commodity importers is near zero because of the positive effect of lower global commodity. The overall impact on the commodity exporters is negative, about -0.5 percent of GDP. The China rebalancing scenario has global effects that have an impact on sub-Saharan Africa. The simulations in this paper suggest that these reforms are likely to lead to higher real GDP of more than 25 percent in the medium to long term but at the expense of adverse effects on Chinese economic activity in the short to medium term, with a decline of about 1 percent relative to baseline. During the transition, there is marginally negative impact on global economic activity and commodity prices are likely to be lower than in the baseline. But in the long term, oil prices are roughly 15 percent higher. Consequently, the Chinese reforms benefit the commodity exporters in sub-Saharan Africa by about 1 percent of real GDP, but they would provide little benefit to the commodity importers.

12. **This paper explores the risk from a drop in China's imports that would exceed the baseline projections.** Two parallel forces may trigger this higher drop in imports. On one hand, domestic rebalancing in China implies a transition to more sustained growth path over the medium to long term and s the shift from import-intensive investment to the less import-intensive consumption might reduce the demand for imports by Chinese companies and government. On the other hand, lower demand for exports of final goods assembled in China because of the sluggish growth in most of its key export markets would inevitably reduce China's demand for intermediate imports.

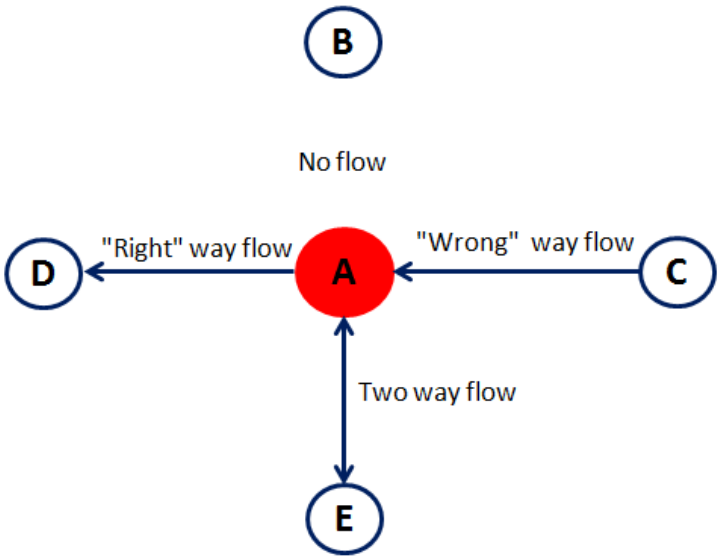
III. TRADE NETWORK ECONOMICS

A. Network Presentation of Spillovers

13. **International trade can be presented in a network form**. Each country would be considered a node and its bilateral trade as links. This trade network can be described as a directed, weighted, incomplete, and asymmetric graph. This graph is directed because the links that represent revenue from exports and payments for imports explicitly denote a flow and its direction from one country to another. The graph is weighted because all links reflect some value of payment that is different for each country and each flow. The graph is incomplete as not all countries of the world are connected with each other through trade. Finally, the graph is asymmetric because for most countries the number of export partners (out-links) differs from the number of import partners (in-links).

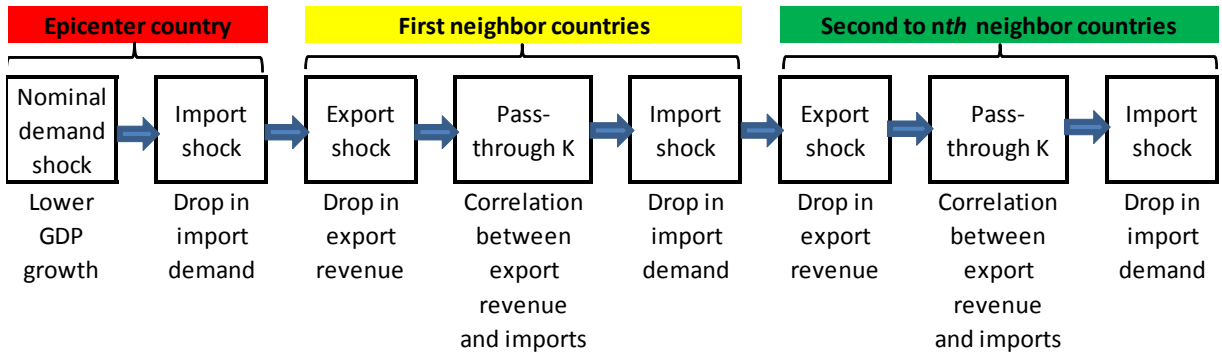
14. **Several elementary types of connections are possible within a trade network**. From the position of the epicenter country *A* affected by the domestic demand shock, there are the following four possible options (Figure 3): (a) If there are no links in any direction and therefore there can be no direct impact from a shock in *A* on *B*, which does not exclude an indirect impact through the spillin effect. (b) There might be a one-way link but in the "wrong" direction for shock spillovers. The epicenter country *A* exports to *C* and gets payments for exported goods shown by the arrow, but *A* does not import from *C* and therefore does not pay for these imports. Therefore, an import demand shock in *A* would not directly affect *C*. Again, spillins are still possible. (c) There can be a one-way link in the "right" direction for shocks spillovers. Country *A* does not export to *D* but *A* imports from *D* and sends payments for imports shown by the arrow. Therefore, there will be a direct impact from an import demand shock in *A* on *D*, as *D* simply would be getting less revenue from its exports. In this case, there is no direct spillback from *D* to *A*, but indirect spillbacks are still possible. (d) There might be two-way links. *A* exports to *E* and gets payments for exported goods shown by the top arrow. In parallel, *A* imports from *E* and sends payments for imports shown by the bottom arrow. In this case, an import demand shock in *A* will affect *E*, its first neighbor; and there will be also an immediate spillback from E to A, because the loss in export revenue in *E* will translate in lower imports from all its trading partners, including *A*.

Figure 3. Import Links in the Trade Network



15. **Two types of shocks emerge in the spillover cascade**. An *import shock* in the epicenter country can be defined as a drop in its import demand driven by any reason. An *export revenue shock* can be defined as a drop in export revenue of its trading partners because of the import demand shock the epicenter country (Figure 4). The two shocks are fundamentally different. An import shock sends an *exit* shock, that is, it sends a signal from the epicenter country to its first neighbors, from its first neighbors to its second, third, and the *n*th neighbors. An export shock is an *entrance* shock, which affects first and other neighbors following and import shock at the epicenter. Once an export shock hits first neighbors, it might pass through to their imports or might die if the country because of its economic structure does not pass through shocks. An export shock for each country will always nonzero, whereas an import shock will be nonzero only for countries where import depends on export revenue, and is zero otherwise.

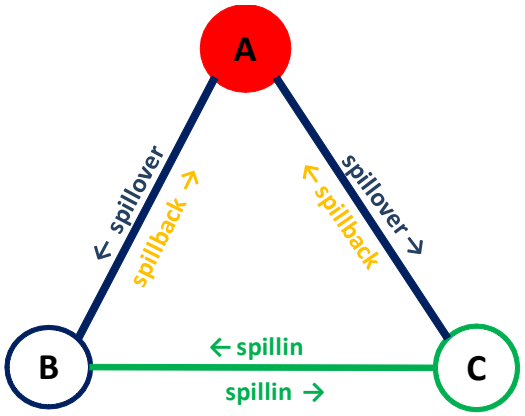
Figure 4. Spillover Cascade



16. **The world trade represented as a network allows modeling the network effects from shocks to individual countries.** The immediate impact is generally well understood. The list of immediate trading partners of each country is known and the distribution of the impact from and import demand shock in the epicenter country can be immediately assessed based on its share in their exports. The higher-round impacts are lesser known and generally poorly understood because of the complexities in the assessment of the network effects in traditional global general equilibrium models.

17. **The network effect of an import demand shock can be decomposed into spillover, spillin, and spillbacks effects.** In a simplified form, the distinction between the three types of network effects can be presented as follow (Figure 5). Suppose that the world consists of three countries. Country *A*, is the epicenter of the shock, is directly connected to countries *B* and *C*. Therefore: *spillovers* are first round impacts from the shock in *A* on *B* and *C*; *spillins* are all higher round effects between *B* and *C* in both directions generated by spillovers; and *spillbacks* are all higher round impacts from *B* and *C* back on *A*.

Figure 5. Spillovers, Spillins, and Spillbacks



B. Network Model of Spillovers

18. **The data on international trade flows are represented by export-import matrices.** An export-matrix is a matrix where rows show exports of a country to all other countries and columns are imports of each country from all other countries. These matrices are $W = \{w_{ij}\}$, such that w_{ij} is a matrix element of matrix W, which stands for exports from country i to country j. For a fixed $i = i_0$, vector $w_{i_0 j}$ is thus the vector of exports of a country i_0, and for a fixed $j = j_0$, vector $w_{i j_0}$ is the vector of imports into country j_0.

19. **A cascade round is a process of transforming the initial import shock in the epicenter country into a secondary shock to its trading partners**. Schematically each round of the cascade consists of two steps:

- The initial import demand shock $(\Delta M_1, \dots, \Delta M_N)$ is proportionally distributed

among exporters to the epicenter country and by definition creates a vector of export shocks to their export revenue

$$(\Delta M_1, \dots, \Delta M_N) \rightarrow (\Delta X_1, \dots, \Delta X_N)$$

- These export shocks create secondary import shocks $(\Delta \widetilde{M}_1, \dots, \Delta \widetilde{M}_N)$

$$(\Delta X_1, \dots, \Delta X_N) \rightarrow (\Delta \widetilde{M}_1, \dots, \Delta \widetilde{M}_N)$$

If additional import shocks need to be included on top of the dynamically generated secondary imports shocks, they can be added to the secondary shocks $(\Delta \widetilde{M}_1, \dots, \Delta \widetilde{M}_N)$.

20. **Export shocks are generated by the following process.** Assume that total imports $\vec{\mathrm{M}} = (\mathrm{M}_1, \dots, \mathrm{M}_\mathrm{N})$ of the epicenter country have dropped by $\vec{\mathrm{M}} - \Delta\vec{\mathrm{M}}$. For each of its components $\mathrm{M_j}$, the negative import demand shock $\Delta\vec{\mathrm{M}}$ by definition translates in losses in export revenue $\{\Delta \mathrm{w_{ij}}\}$ for all countries {i} that export to the epicenter country j.

$$\Delta M_j = \sum_{i=1}^{N} \Delta w_{ij}$$

Assuming that export reduction is proportional to corresponding shares of export from i to j

$$\Delta w_{ij} = \frac{w_{ij}}{\sum_{k=1}^{N} w_{kj}} \Delta M_j \equiv \frac{w_{ij}}{M_j} \Delta M_j$$

This equation corresponds to the transformation $W \rightarrow \widetilde{W}$ of the import-export matrix by which

$$W = \begin{pmatrix} w_{11} & \cdots & w_{1j} & \cdots & w_{1N} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{N1} & \cdots & w_{Nj} & \cdots & w_{NN} \end{pmatrix}$$

turns into

$$\widetilde{W} = W - \Delta W$$

where

$$\Delta W = \begin{pmatrix} \Delta w_{11} & \cdots & \Delta w_{1j} & \cdots & \Delta w_{1N} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \Delta w_{N1} & \cdots & \Delta w_{Nj} & \cdots & \Delta w_{NN} \end{pmatrix}$$

The component of the corresponding drop in the export revenue vector $\Delta\vec{X}$ is thus equal to

$$\Delta X_i = \sum_{j=1}^{N} \Delta w_{ij} \equiv \sum_{j=1}^{N} \frac{w_{ij}}{M_j} \Delta M_j$$

21. **This equation can be presented in two equivalent forms:**

- As a matrix multiplication

$$\Delta\vec{X} = W\frac{\Delta\vec{M}}{\vec{M}}$$

whereby the exports shock $\Delta\vec{X}$ transforms the initial export-import matrix W by changing the relative imports weights $\frac{\Delta\vec{M}}{\vec{M}}$ for all countries.

- Or it can be written in a matrix form

$$\Delta\vec{X} = \Omega\Delta\vec{M}$$

where Ω is a matrix W in which each column is normalized by its sum, so that $\Omega_{ij} = w_{ij}/M_j$.

22. **The pass-through coefficient is estimated as part of an import demand function.** Estimations in real and nominal terms have been considered. In real terms, the pass-through coefficients β_i for each country *i* can be estimated based on the following import demand function

$$ln\left(\frac{m_{i,t+1}}{m_{i,t}}\right) = \alpha_i + \beta_i ln\left(\frac{x_{i,t+1}}{x_{i,t}}\right) + \gamma_i ln\left(\frac{r_{i,t+1}}{r_{i,t}}\right) + \delta_i ln\left(\frac{P^M_{i,t+1}}{eP_{i,t}}\right) + \varepsilon_i$$

This model allows differentiating marginal propensities to import across expenditure categories. In each country *i*, changes in demand for real imports (m_i) depend on changes in exports revenue in real terms (x_i), real domestic income (r_i) defined as the economy's total real income from all sources minus its real income from exports $(y - x)_i$ relative prices defined as a ratio of the index of import prices (P_i^M) to domestic prices (P_i) for each country converted into dollars by using the exchange rate (e), and a country-specific error term (ε_i). This model requires taking the small country assumption as international prices are treated as given for all countries other than China itself and the shock propagation affects only volumes of imports and exports.

Alternatively, the pass-through coefficients can be estimates in nominal terms to take into account of both price and volume effects. The equation is

$$ln\left(\frac{M_{i,t+1}}{M_{i,t}}\right) = \alpha_i + \beta_i ln\left(\frac{X_{i,t+1}}{X_{i,t}}\right) + \gamma_i ln\left(\frac{R_{i,t+1}}{R_{i,t}}\right) + \varepsilon_i$$

whereby changes in nominal imports $M_i$are driven by changes in export revenue X_i, domestic income R_i. The assumption on the spillover dynamics is that for some, but not for all countries, decline in export revenue can lead to a drop in imports, contemporaneously or with a lag. Therefore, the export shock is transmitted only to imports and does not affect directly domestic income. Parameter β_i can be viewed then as a *pass-through coefficient* for shock spillovers through each country (Annex 3).

23. **Secondary import shocks are generated as follows**. In the simplest case, a linear relation can be assumed between export revenue and the ensuing imports, so that the secondary import shock $\Delta\widetilde{\mathrm{M}}_{\mathrm{i}}$ generated by the export revenue shock $\Delta\mathrm{X}_{\mathrm{i}}$ is on average determined by

$$ln\left(\frac{M_i - \Delta\widetilde{M}_i}{M_i}\right) = \beta_i ln\left(\frac{X_i - \Delta X_i}{X_i}\right)$$

or

$$\Delta\widetilde{M}_i = M_i\left(1 - \left(1 - \frac{\Delta X_i}{X_i}\right)^{\beta_i}\right)$$

The newly generated import demand shock $\{\Delta\widetilde{M}_i\}$ becomes a new export revenue shock for the next round of the shock spillover.

24. **The cascade of spillovers can be generated dynamically on quarterly shocks**. Let's assume that the vector of imports drops by some fixed amount $\Delta\overrightarrow{M_0^i}$ each quarter. In this case the cascade proceeds as follows. Let is denote by $\Delta\vec{M}_{In}^{(i)}$ the vector of direct import shocks in a given quarter i and by $\Delta\vec{M}_{Out}^{(i)}$ the network-generated import shock at the end of each quarter. The resulting cascade is:

$$\Delta\vec{M}_{In}^{(1)} \rightarrow \Delta\vec{X}^{(1)} \rightarrow \Delta\vec{M}_{Out}^{(1)}$$
$$\Delta\vec{M}_{Out}^{(1)} + \Delta\vec{M}_0^{(2)} \rightarrow \Delta\vec{X}^{(2)} \rightarrow \Delta\vec{M}_{Out}^{(2)}$$
$$\ldots \rightarrow \cdots$$
$$\Delta\vec{M}_{Out}^{(7)} \rightarrow \Delta\vec{X}^{(8)} \rightarrow \Delta\vec{M}_{Out}^{(8)}$$
$$\ldots \rightarrow \cdots$$

25. **The estimated pass-through coefficients might lead to three cases in shock diffusion**. Individual countries can be (i) *spillover amplifying*; if $\beta > 1$, a change in export revenue of first neighbors would lead to a proportionally larger change in their imports. As a result, the initial shock impulse would expand passing through such countries and its impact on other countries might be stronger than the original shock; (ii) *spillover absorbing,* if $0 < \beta \leq 1$, a change in export revenue would lead to a proportionally smaller change in imports and the shock impulse spilled over from first to second neighbors will be relatively smaller than the original shock; finally, (iii) *spillover blocking*; if $\beta \leq 0$ or not statistically significant irrespective of its value, exports revenue cannot be seen as a constraint for imports and the shock to exports revenue of this country would not have any impact on its imports, which are probably financed from other sources. Countries with this type of the pass-through coefficient would serve as natural barriers to shock spillovers.

26. **In sum, the economics of spillovers from an import demand shock can be presented as follows**:

- *Initialization:* The initial shock to the epicenter country i is the decline in its nominal demand ΔY_i; assuming its marginal propensity to import is unity, this shock translates into a decline in its imports of ΔM_i; this translates to a loss of export revenue for N_i adjacent countries by the same amount. The underlying assumption is that the initial shock redistributes between exporters to the epicenter country proportionally to their shares in its imports. A more detailed balance of payments analysis would certainly modify this assumption.

- *First round*: the loss of export revenue for N_i adjacent countries leads to a decline in their GDP, $Y_i \downarrow = C + I + \mathrm{X_i} \downarrow - \mathrm{M}$; the impact on trading partners' GDPs depends on the share of exports in their GDP; the larger the share, the larger the impact.

- *Pass-through:* countries with $\beta > 1$ will amplify the original shock and spill it over to their trading partners; countries with $0 < \beta \leq 1$ will absorb part of the shock but will still spill it over; countries with $\beta < 0$ or statistically insignificant, will block the shock (Box 2).

- *Second and sequential rounds*: the variably lower GDP growth rate of the immediate trading partners of the epicenter country will translate in a demand shock for their trading partners, which at this stage is not uniform but rather proportional to the decline in export revenue of each of the immediate partners at the first round. Assuming again the marginal propensity to import at unity, imports of the epicenter country's first neighbors from their immediate neighbors should decline in proportion to the change in their export revenue.

Box 2. Shock Amplifiers, Absorbers, and Blockers

Countries can be classified into shock-amplifiers, shock-absorbers, and shock-blockers. Of 185 countries, 148 countries are capable of passing through shocks (Annex 3).

- **Only 51 (28 percent) of them can potentially play the role of shock-amplifiers**. Among them there are such important and well-connected players in international trade as the United States, India, Brazil, Italy, and Switzerland, which pass through shocks with insignificant amplifications of 5–10 percent. However, this group includes a small subgroup of strong shock amplifiers, such as Argentina, Thailand, Korea, Hong Kong SAR, Denmark, Indonesia, and India, some of which are capable of expanding the original shock by 30 percent and more. Shock-offsetting policies in these countries are particularly important to constraining negative shock proliferation.
- **A total of 97 countries (52 percent) are shock-absorbers**. However, even without public policies aimed at reducing the shock, the magnitude of the aftershock for second neighbors will be smaller relative to the original shock. A number of important countries (Italy, Japan, Germany) have the pass-through coefficient very close to unity, suggesting that the pass-through might be almost one-to-one in the absence of shock absorbing policies. Other large countries, such as China, Canada and the UK, should in principle reduce the shock strength for second neighbors.
- **Finally, 37 countries (20 percent) do not pass through shocks at all. These are shock-blockers**. Their pass-through coefficients are statistically insignificant. When a shock reaches one of these countries, it dies out naturally, even without any policy intervention on its behalf. These are mainly small developing countries with little impact on international trade (Bhutan, Chad, Central African Republic, Djibouti, and so forth), where import is financed mainly by public and private capital flows and depends little on export revenue. Some oil producers are also part of this group (Azerbaijan, Qatar, Iran, Iraq, Oman, Venezuela) some of them with a substantial accumulated wealth, which would allow to them to maintain imports irrespective of the level of export revenue. Finally, a number of financial centers do not pass through trade shocks either as their commodity imports are financed substantially by financial services exports. The

distinction between shock amplifiers, absorbers and blockers depends only on each country's economic structure and is unrelated to the structure of the network and to the location of each country in the network.

On aggregate, the network is shock absorbing as the spillovers die down after several rounds.

27. **The spillover process is assumed to continue for several rounds before it dies out.** This version of the proposed algorithm uses contemporaneous import and export data from the same matrix and the pass-through coefficients remain unchanged for each round. The network estimation is dynamic as the shock is applied to sequentially to each quarter in 2016-17 and spillover on 2018-20 also sequentially by quarter. In more general versions, the corresponding matrices can lag, the pass-through coefficients can be updated at each round and recalculated on a bilateral basis, and more generic functional dependencies between import and export can be considered.

28. **The proposed network-based spillover model for China rests of a number of assumptions**. First, the model assumes only partial equilibrium effects from imports slowdowns and does not consider any general equilibrium effects on variables other than trade and GDP; it also assumes that the trade matrix, the pass-through coefficients and the commodity structure of trade remains unchanged in each spillover round. Second, the model does not differentiate between consumption and investment goods in China's imports. The transformation of the Chinese growth model would involve a reduction of growth in exports as investment slows down, providing mitigating effects for global demand. Also, the Chinese households will receive a higher share of income and save less, opening up the possibility of higher imports of luxury goods and foreign services such as tourism. Third, the initial import shock from China is assumed to be distributed proportionately between trade partners. Therefore, all countries with varying export bundles to China are assumed to be uniformly affected conditional only on their total exports to China. This may not be the case if the fall in imports is not distributed proportionally between consumer and investment goods. Fourth, the analysis abstracts from initial and subsequent output gaps, underlying potential growth rates, and self-equilibrating tendencies. In that sense, the paper leaves out some relevant dynamics, even though the simulations are for 5 years ahead. Fifth, the model is presented in nominal terms and does not allow calculating directly the price and volume effects of spillovers. For example, China's volume of oil and iron ore imports were growing in 2015, but the imports revenue decreased due to the declining global commodity prices. Finally, the model does not take into account the role of China in the value-added chain. Given that processing trade accounted for a relatively big ratio in Chinese trade, the raw materials imports by China is bound to decline because of weakening external demand for China's exports.

IV. EMPIRICAL FINDINGS

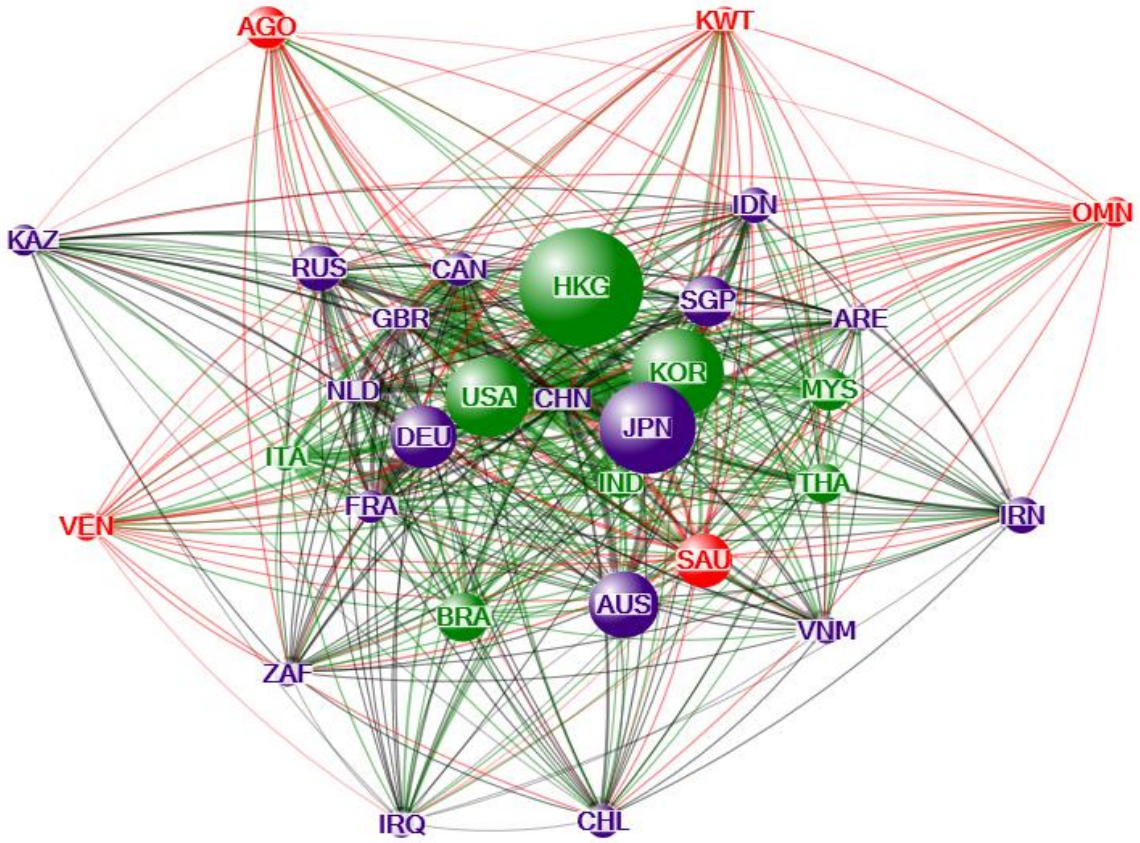
A. China in the World Trade Network

29. **China holds a central place in the world trade network.** It trades with virtually all countries in the world. China's in/out degree is 168/166 out of the maximum of 170, and the value of trade in most directions is very high relative to other countries. The visualization

based on the Fruchterman-Reingold (1991) force-directed layout algorithm shows that the largest trade flows in the world pass through China. This algorithm squarely places China in the middle of the world trade network suggesting that any shock with the epicenter in China would have a major impact on the rest of the world economy.

30. **The network structure of China's main import partners suggests that they include shock amplifiers, shock absorbers, and shock blockers.** An import demand shock originated in China would lead to an immediate drop in export revenue of its partners in the proportion of China's share in their exports (Figure 6). Although virtually all countries around the world will be affected, the main impact will be felt by only 30 countries as almost 90 percent of China's imports are sourced from these countries. However, the role of amplifiers, absorbers, and blockers in the network is not equal. The shock most likely would amplify at each iteration, because all of China's main partners (United States, Hong Kong SAR, Korea, Italy, India) are large spillover amplifiers. Most other partners are spillover absorbers (Japan, Germany, United Kingdom, Netherlands) but even taken together have a smaller share in China's imports. Shock blockers (Argentina, Kuwait, Oman, Saudi Arabia, Vietnam) are very peripheral for China's trade network and most likely will not be able to impede the passing through of the shock to the rest of the trade network.

Figure 6. China's Import Network, 2014

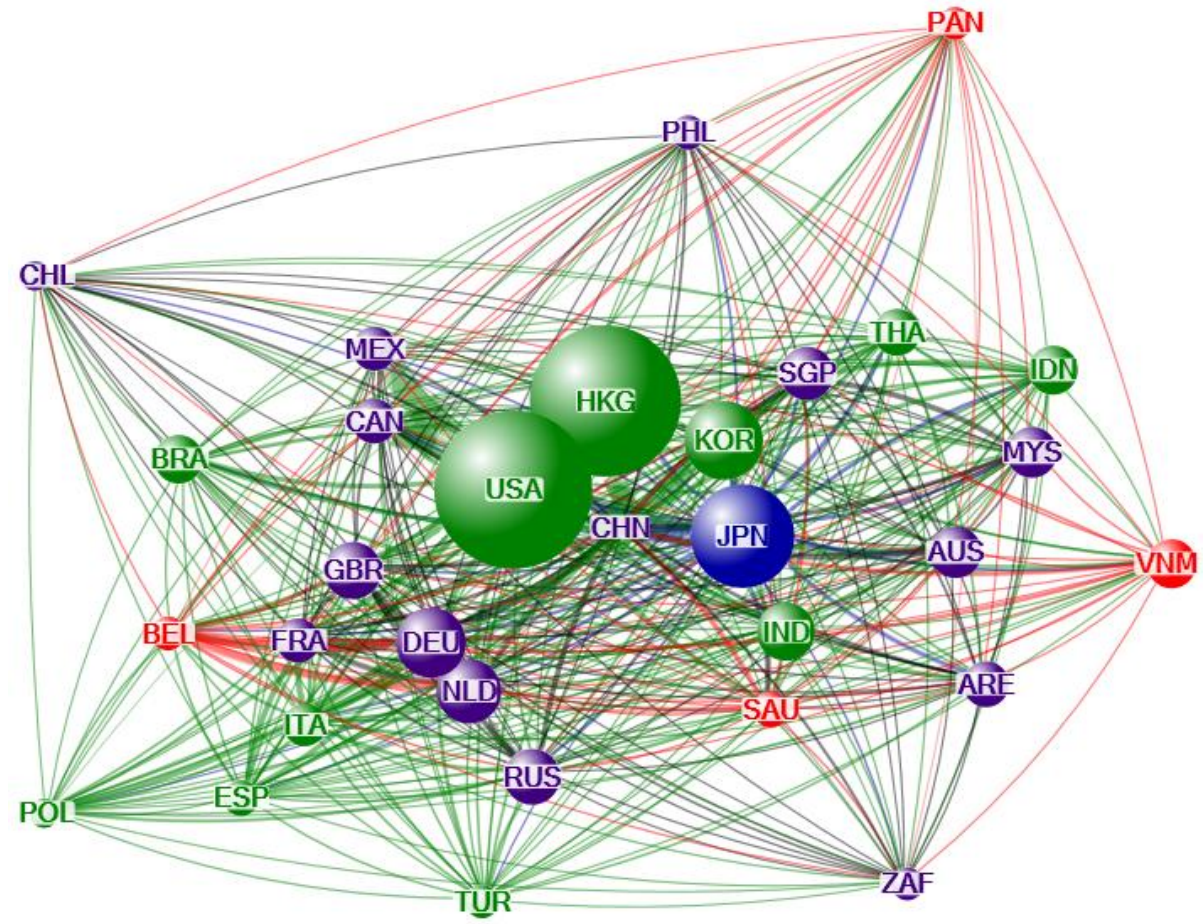


amplifiers absorbers blockers

Note: node areas are proportional to the share of a partner in China's imports; link weights are proportional to the value of trade in each direction.

31. **The network structure of China's main export partners suggests that it differs substantially from the import structure.** Of top 20 China's trading partners, about 30 percent are not same on the export and import side. China exports virtually to every country of the world, but the top 30 countries absorb about 85 percent of China's exports (Figure 7). China is surrounded by large shock amplifiers (United States, Hong Kong, Korea, India). Some other countries absorb shocks (Japan, Germany, the Netherlands, Great Britain), but their importance for China's exports is visibly lower. Finally, shock blockers are clearly very peripheral (Belarus, Panama, Saudi Arabia, Vietnam) in China's export network.

Figure 7. China's Export Network, 2014



amplifiers absorbers blockers

Note: node areas are proportional to the share of a partner in China's imports; link weights are proportional to the value of trade in each direction.

32. **Asymmetries in China's export and import partner network structures have important consequences for shock spillovers**. The value of its trade in most directions is unbalanced, with large trade surpluses with many important countries. Geographically, at least half of China's main export and import partners are not the same. While the United

States, Hong Kong SAR, Japan, and Korea are clearly dominant as both China's main export destination and the source of imports, Singapore, Australia, Malaysia, and Brazil are important destinations for China's exports, but are not included on the list of China's key sources of imports. In the same vein, Saudi Arabia, Russia, Angola, Iran, Oman, Kuwait, and some other countries are important sources for China's imports but not included on the list of its key export destinations.

33. **Once the shock to export revenue hits China's first neighbors, it will easily spill over to their imports**. The reason is that although almost the whole world can be included in China's first neighbors, and many of them should in principle block any further spillovers, there are only five spillover-blockers among China's most important import partners. These are oil producing countries (Saudi Arabia, Kuwait, Angola, Oman, Venezuela) where imports can be financed by accumulated savings, regardless of the drop in current export revenue.

B. Data and Shock Calibration

34. The **dataset is derived from bilateral flows for 1993–2014 and October 2015 World Economic Outlook (WEO) projections for 2015-2020.** The sample includes 170 countries for which the data on bilateral trade flows are available. Of 28,730 possible bidirectional trade flows, 9,029 (about 31 percent) are absent, that is, there is no trade in either direction or there is trade only in one direction. The model is estimated using world trade data for 1993–2014. Given radical changes in the structure of China's trade in the past few years, the paper uses 2013-14 weights for the 2015-20 projections of bilateral trade flows. The import demand shock is applied on top of the projected slowdown of China's imports for 2015-20 already included in the baseline.

35. **This study relies on the UN Comtrade database rather than on the joint OECD – WTO Trade in Value-Added (TiVA) used in recent studies.** The United Nations Commodity Trade Statistics Database (UN Comtrade) (UN,2015) contains annual bilateral imports and exports statistics of about 200 countries or areas from 1962 onwards[2]. The 2015 edition of the TiVA database (WTO/OECD, 2015) includes only 61 economies covering OECD, EU28, G20, most East and South-east Asian economies and a selection of South American countries for 1995, 2000, 2005 and 2008 to 2011.Therefore, while the TiVA database provides important insights on the value added by each country within global production chains, its country coverage and periodicity are not sufficient for a network-based model of spillovers. In addition, the large delays in the TiVA would not allow capturing the deep structural changes in the trade and production structure of China in recent years.

[2] Comtrade has important limitations. Some countries may not report some of its detailed trade or trade statistics for every year in the most recent commodity classification; imports reported by one country may not coincide with exports reported by its trading partner. Differences are due to various factors including valuation (imports CIF, exports FOB), differences in inclusions/ exclusions of particular commodities, timing etc.; almost all countries report as partner country for imports the country of origin, hence, the term 'partner country' in the case of imports does not necessarily imply any direct trading relationship. Bilateral gross trade data is also problematic because it double counts many of the trade flows as part of the global value chain.

36. **To model the spillovers from the shock to China's import annual trade flows were split into four equal quarterly flows.** The shock was assumed to affect China each quarter in 2016-17 in the same amount, i.e., a drop by 10 percent relative to the baseline projections This approach would allow capturing high intrayear correlations between export revenue and import flows observed empirically in most countries. With current data available to trade operators in real time and for customs authorities on a monthly basis, the adjustment of import values to intrayear changes in export proceeds also takes place within the year, probably on a quarterly basis. Therefore, a four-round shock spillover process would seem to reflect a correct intrayear correlation between exports proceeds and import flows for most countries.[3]

37. **The assumption of the size of the import demand shock in China is consistent with the October 2015 WEO scenario of a structural slowdown in emerging economies** (IMF, 2015a). In this scenario, investment growth in emerging markets is assumed to decline annually by about 4 percentage points on average relative to the baseline. Within this general approach, this paper takes an additional assumption in application to China only. The assumption is that China's imports would be 10 percent lower relative to the baseline WEO projections in 2016 and 2017. In this scenario growth in China would be by 1 percentage lower than the baseline and would lead to a drop in its nominal imports by about 2.5 percent of the projected GDP in 2016 and 2017. This assumption was not discussed in the October 2015 WEO, is purely illustrative and does not represent an IMF assessment of potential amplitude of the GDP and import reduction of China if the structural slowdown scenario materializes.

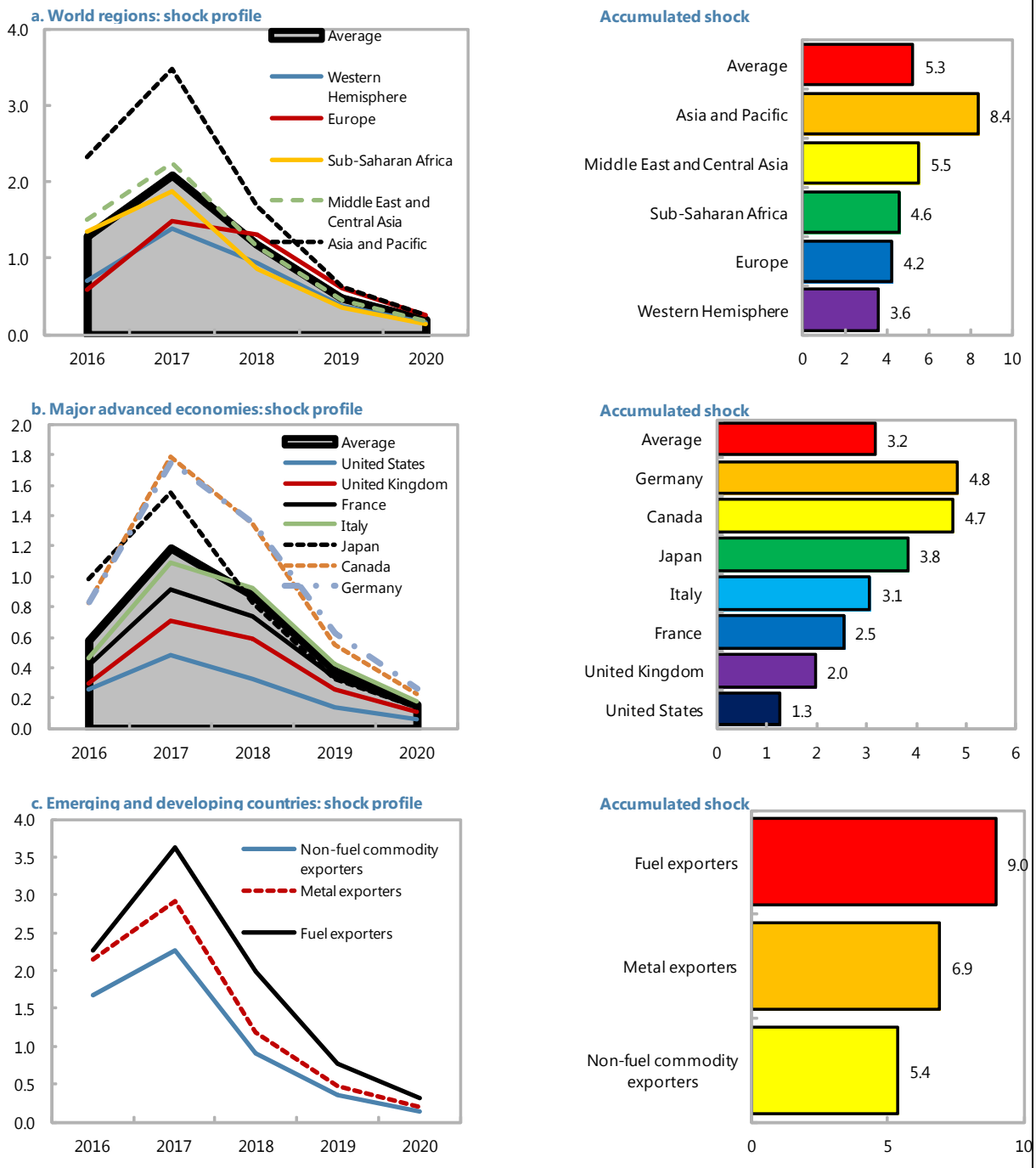
C. Export Shock to China's Trading Partners

38. **The drop of imports by China would immediately spill over to trading partners and translate into an export revenue shock for all of them.** As virtually all countries export to China, all of them would be directly affected at the first round, in proportion to the exposure of their exports to China (Figure 8). Assuming the below the baseline import performance in China continues in 2016-17, the initial impact would be on average a loss of about 1.2 percent of GDP in export revenue in 2016 by all countries, which with network effects would increase to 2.0 percent of GDP in 2017 before abating gradually by 2020 to about 0.2 percent of GDP in 2020.

39. **The spillovers would affect unequally different regions of the world.** Asia and Pacific countries might lose substantially more in export revenue than an average country, about 2.3 percent of GDP in 2016 and 3.5 percent of GDP in 2017, because of their large export exposure to China (Figure 8a). Hong Kong SAR, Singapore, Solomon Islands,

[3] An exporter of steel would know its orders from China at least a quarter ahead. If these orders decline relative to the same period last year, the exporter would reduce its imports of iron ore from third countries scheduled for that quarter.

Figure 8. China: Export Shock Spillovers, 2016-20
(Percent of GDP)



Source: Authors' calculations.

Malaysia, Mongolia, and Vietnam will be among the most affected Asian economies. The accumulated average shock on Asian countries during 2016-20 might exceed 8 percent of their GDP. Middle East and Central Asia would also be affected at above the average rate. Oman, Mauritania, Qatar, and Saudi Arabia would feel the largest reduction of export revenue given their substantial exposure to exports of oil and other primary commodities to China. The cumulative shock might exceed 5 percent of their GDP. The impact on other regions would most likely be below the average.

40. **For major advanced economies, the shock from China's drop of imports most likely would not be significant**. In 2016, the shock to their export revenue would not exceed 0.6 percent of GDP and might double in 2017. The average shock accumulated during the next five years would be about 3 percent of their GDP, well below the world average (Figure 8b). Germany, Canada, and Japan are more exposed to exports to China than other advanced countries, and therefore would likely be affected the most.

41. **Among emerging and developing economies, oil-exporting countries would take most of the hit from the drop in China's imports**. Fuel exporters might lose 2.3 percent of their GDP in export revenue already in 2016 and an additional 3.6 percent of GDP in 2017 (Figure 8c). The cumulative impact during the next five years might reach 9 percent of their GDP. If oil-exporters respond by trying to maintain global sales while reducing prices, the spillin effects could be much larger. Poorly diversified oil-exporting countries, such as Equatorial Guinea, Oman, Brunei Darussalam, and Angola will feel the most the impact from China's imports slowdown. As China is the world's largest metal importer, the impact on metal exporters would also be significant, 2.1 percent of their GDP in 2016 and 2.9 percent of GDP in 2017. The cumulative five-year loss of export revenue in metal exporters might reach 7 percent of their GDP. Mauritania, Mongolia, Zambia and Chile will top the list of countries with the most significant export revenue losses. Finally, the impact on non-fuel commodity exporters will also be sizeable. Their loss of export revenue in 2016-20 might exceed 5 percent of their GDP. Mauritania, Solomon Islands, Sierra Leone, and Mongolia will lose the most.

D. Higher Round Effects of the Import Shock in China

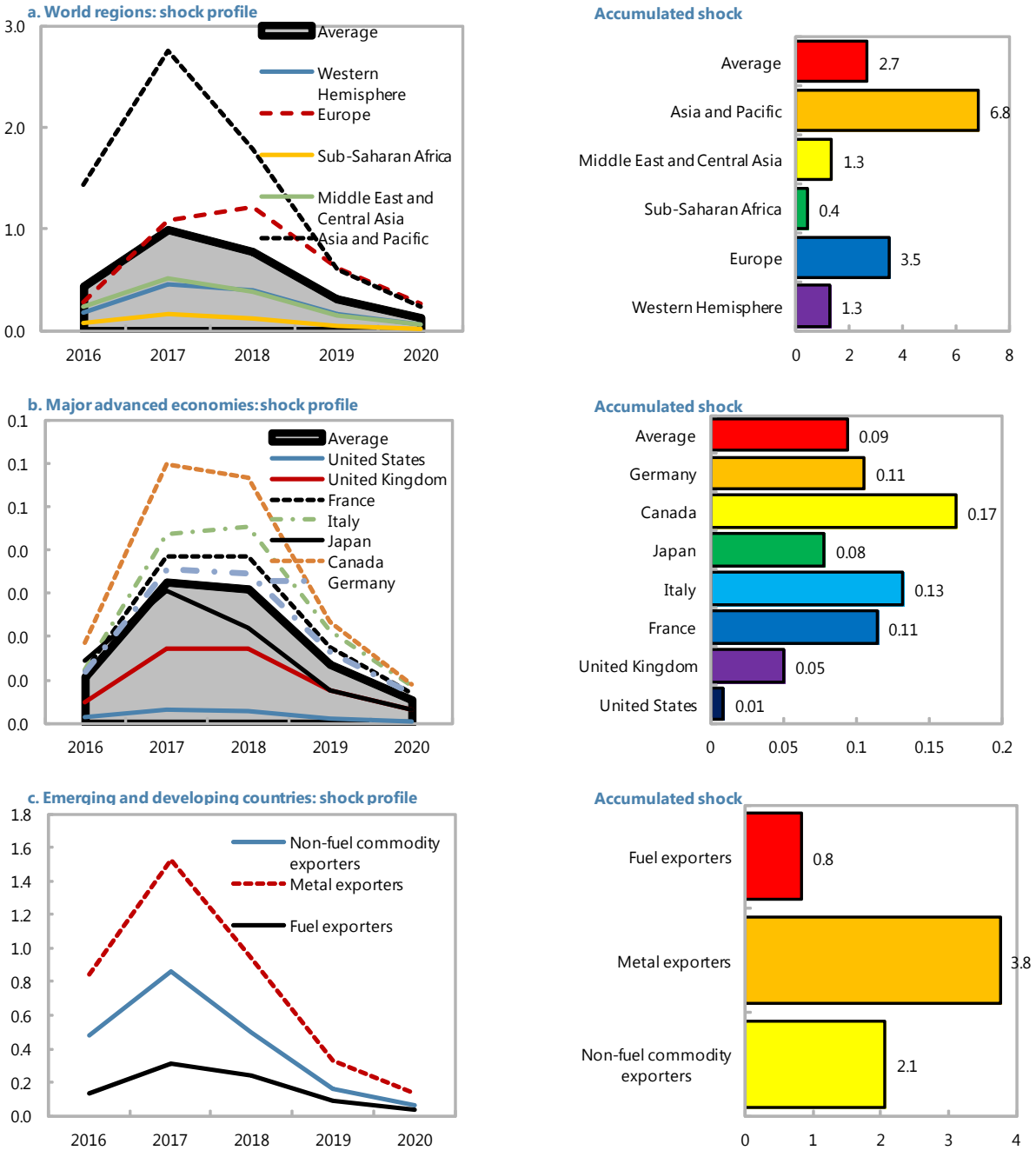
42. **With the above mentioned asymmetries in the network structure of China's trade, the profile of the import shock differs substantially from the export shock**. As many countries either block shocks or substantially reduce their magnitude, the average size of the second-round import shocks is substantially lower than that of the spillover from initial shock to export revenue that provokes it (Figure 9). On average, the 2016 loss of export revenue by all countries would translate to only about 0.4 percent of GDP reduction in the imports financed with this revenue. With the network effects, the drop in imports would increase to 1 percent of GDP in 2017 but would decline thereafter to virtually zero by 2020 when the shock would dissipate altogether. The average import shock during 2016-20 might amount to at most a half of the export shock.

43. **As in the case of the export shock, the secondary import shock provoked by it would spread unequally across different regions.** Second-round effects would be the strongest in Asia and Pacific where countries would pass through to the rest of the world the shock of about 1.4 percent of GDP in 2016 and 2.8 percent of GDP in 2017. The total secondary shock emanating from this region might reach almost 7 percent of GDP in the next five years (Figure 9a). Hong Kong SAR, Singapore, Malaysia, and Mongolia would pass through the shock to the rest of the trade network, and some of them, given their internal economic structure, would even amplify it. Europe might be the second largest region that would reduce its imports following the drop of export revenue and pass through a substantial proportion of the initial drop augmented by network effect to the rest of the world. With Europe strongly involved in international trade, the secondary shock might be very persistent and increase until 2018, reflecting strong network effects, and remain visible to the end of the period. Small European countries (such as Malta, Estonia, Slovak Republic, Ukraine, Ireland, Czech Republic) seem to be capable of passing through the largest portion of the initial shock and some of them can even augment it. The cumulative average secondary import shock from Europe might reach about 3.5 percent of its GDP in 2016-20. The secondary import shock from other regions would most likely be below the average.

44. **In most advanced economies, the drop in export revenue will not lead to significant cuts in imports.** Most of them pass through the shock that would amount to less than 0.05 percent of their GDP (Figure 9b). However, given the relatively large size of their GDP, the secondary import shock emanating from them can be significant for other countries. The largest reduction in imports than can spillover further to the rest of the world could be expected in Canada, Italy, and Germany. Spillovers from the United States and the United Kingdom most likely would be negligible. The overall accumulated secondary import shock passed through by advanced economies should not exceed 0.1 percent of their GDP.

45. **Finally, among emerging and developing economies, metal exporters will pass through the largest share of the export revenue shock to their imports**. Metal exporters, obviously might be the worst hit by the drop in export revenue and will have to reduce their imports from the rest of the world (Figure 9c). This reduction would amount to 0.8 percent of their GDP in 2016 and 1.5 in 2017 to reach the cumulative average drop in their import demand of almost 4 percent by 2020. Mongolia would clearly be the largest source of the secondary import shock among all metal exporters. Non-fuel commodity exporters also would have to trim their imports as a result of the decline in export revenue for a total of about 2 percent of GDP. This drop would be driven by the same countries, plus Solomon Islands. Finally, oil producers will pass through the shock to their export revenue at the margin as most of them have alternative sources for import financing (sovereign funds, capital inflows) and they can maintain their imports at roughly unchanged levels, regardless of the drop in export revenue because of lower demand for their oil from China.

Figure 9. China: Import Shock Spillovers, 2016-20
(Percent of 2015 GDP)



Source: Authors' calculations.

E. Network Effects

46. **The direct spillovers from a nominal shock in China would be augmented by the network effects.** As a share of the world's GDP, the total shock would be composed of the initial shock and the network effects. The initial shock represented by the assumed drop in China's imports during 2016-17 would be redistributed among all exporters to China proportionate to their observed weights in China's imports. The network effects would include all secondary shocks radiating from the rest of the trade network, excluding China. The network-based calculations suggest that relative to the GDP of each region of the world the initial shock would amount uniformly to 0.4 percent of their GDP (Figure 10). However, the network effects would differ substantially across regions. The overall network effect might be around 1 percent of GDP by 2017 and would be generated by multiple higher-round effects as the initial shock radiates from the rest of trade network.

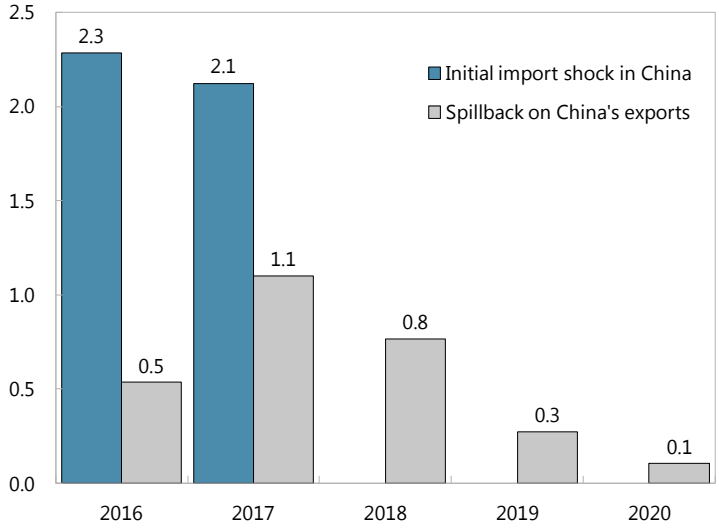
47. **In terms of their respective GDPs, the regions of the world might experience very heterogeneous impacts from the network effects driven by the slowdown in China.** The largest negative network effects might be felt in the Middle East and Central Asia where the network effect might exceed 2.3 percent of GDP by end-2017, in addition to the initial shock of 0.4 percent of GDP. Sub-Saharan Africa could be the second most affected region with a network effect of about 1.8 percent of its GDP because most countries in the region are strongly connected to countries that would be affected by the first round shock. In Asia and Pacific, the network effect would be lower and amount to 1.6 percent of its GDP. In all these regions, the network effect would exceed the initial shock in both 2016 and 2017 expanding its amplitude in both years. The strong network effect in these three regions might reflect high vulnerability of developing countries to shock spillovers from large economies like China, as their individual GDPs are small relative to the size of the potential loss of export revenue from the shock.

48. **The network effect in Europe and Western Hemisphere might have a very different profile.** In both regions, the network effect from the immediate shock would be very small in the first year and would add almost nothing to the overall shock in Western Hemisphere and just 0.2 percent of GDP in Europe in 2016. However, the network effect expands substantially during the second year of the initial shock, to 0.4 and 1 percent of GDP respectively. The insignificance of the network effect in the first year can be explained by the substantial resilience of advanced European economies, the United States, and Canada to the reduction of export revenue driven by the drop in import demand in China. However, the network effect strengthens substantially during the second year of the shock, probably reflecting substantial integration of these countries into international trade flows as demand for their exports drops not only in China but also across the world.

49. **The drop of China's imports from the rest of the world might affect its own exports, the spillback effect.** As China's trading partners lose a portion of their export revenue, those of them capable of passing through the shock have to reduce their imports from all other countries, including China. This fall of imports from China summed across all its trading partners represents the spillback effect (Figure 11). If because of the transition to the new growth model China's imports drop by more than 2 percent of its GDP in 2016 and 2017, the spillback on China's own exports could reach 0.5 percent of GDP already during

2016 and exceed 1 percent of GDP in 2017. As exports are part of GDP, this spillback effect would further reduce China's GDP growth. Even in the absence of further import demand shocks in 2018-20, China would still be feeling the negative spillback effects before they fade out toward the end of the period.

Figure 10. China: Spillback Effect, 2016-20
(Percent of GDP)



Source: Authors' estimates.

50. **The spillin effect can be calculated as the difference between total spillovers, the initial shock, and the spillback to China.** In the shock to China, the total spillover period stretches to 20 quarters, that is, 2016-20, while the initial shock is assumed to persist for 8 quarters, that is, 2016-17. The spillin effect is generated by the import shock. The spillin effect can be measured in terms of its *relative size*, that is, the difference between the overall and the initial shock in percent of GDP of each country. It can also be measured in terms of its *relative strength*, as the ratio of the total spillin to the initial shock.

51. **For a shock radiating from China, the list of affected countries in terms of the size of spillins and their strength are fundamentally different.** On average, the relative size of spillin effect exceeds 6 percent of individual countries' GDP with a much skewed distribution (Figure 12a). Only 9 countries (mainly China's immediate Asian trading partners, such as Honk Kong SAR, Singapore, Thailand, Malaysia, Mongolia, Vietnam, and Korea) generate spillins substantially exceeding the average for the world, with over 80 remaining countries generating relatively low spillins. At the same time, the strength of the spillover effect is relatively high because on average the ratio of the total spillover to the initial shock is 7.6 (Figure 12b) Again, only 14 countries radiate strong spillins, substantially exceeding the average, virtually all of them are small open economies in Europe, such as Bosnia and Herzegovina, Slovak Republic, Croatia, Slovenia, Latvia, and so forth. Finally, the spillback effect on China itself from the rest of the network can also be seen, but it would amount to only 1.5 percent of its GDP. As should be expected, the strength of the spillback effect would be very low.

Figure 11a. China: 2016-20 Spillin Size
(Percent of GDP)

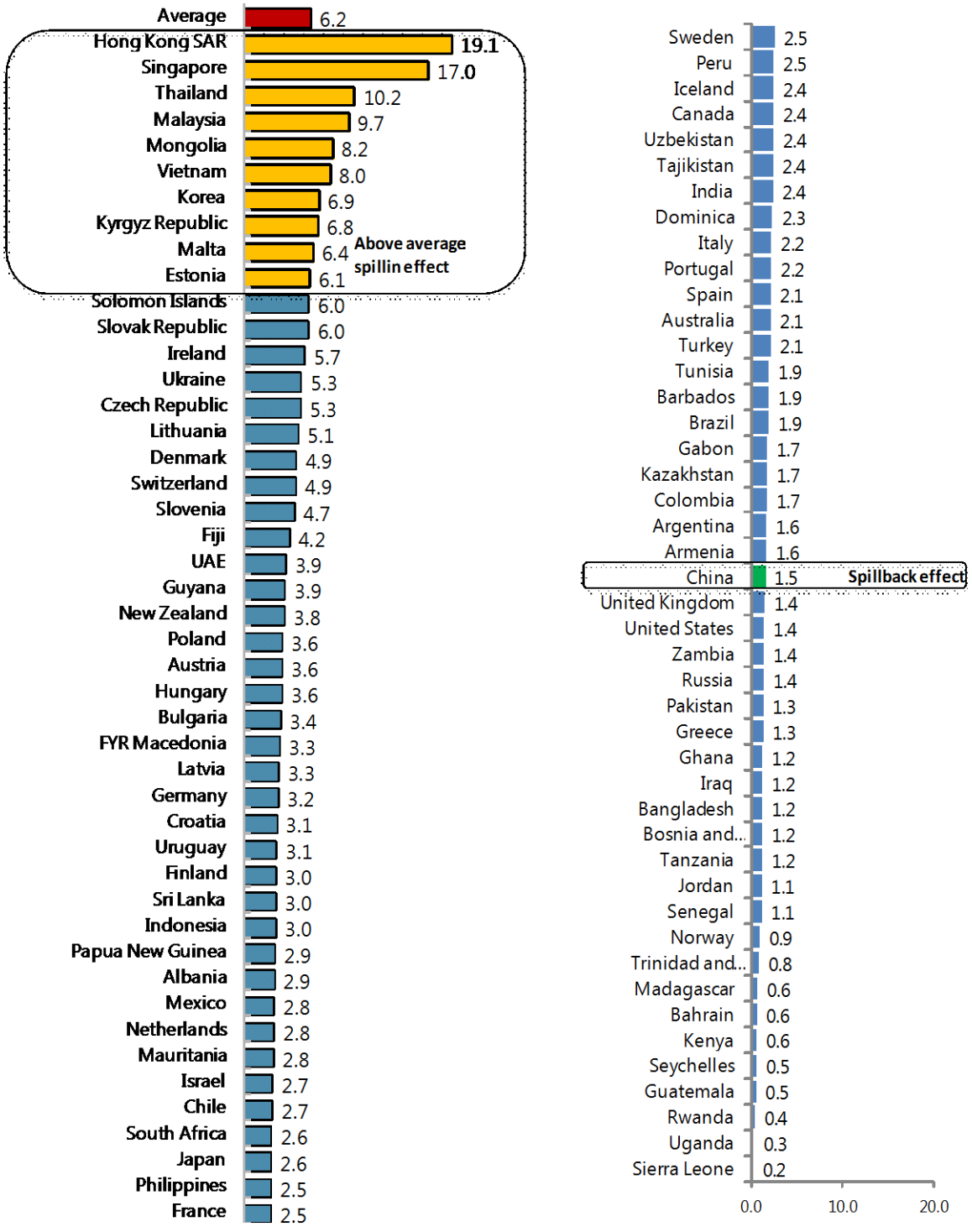
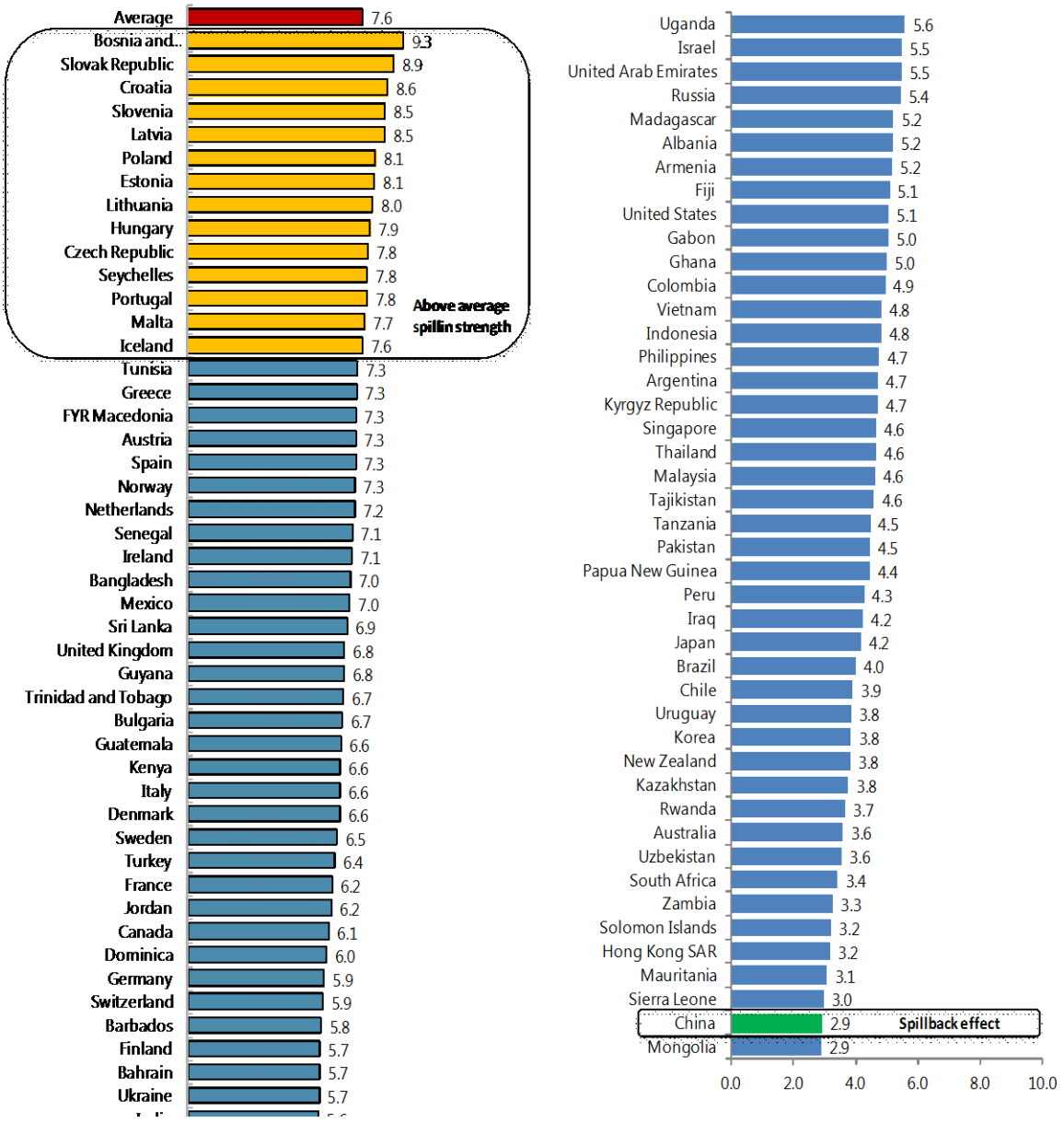


Figure 12b. China: Spillin Strength
(Ratio)



F. Sensitivity Analysis and Robustness checks

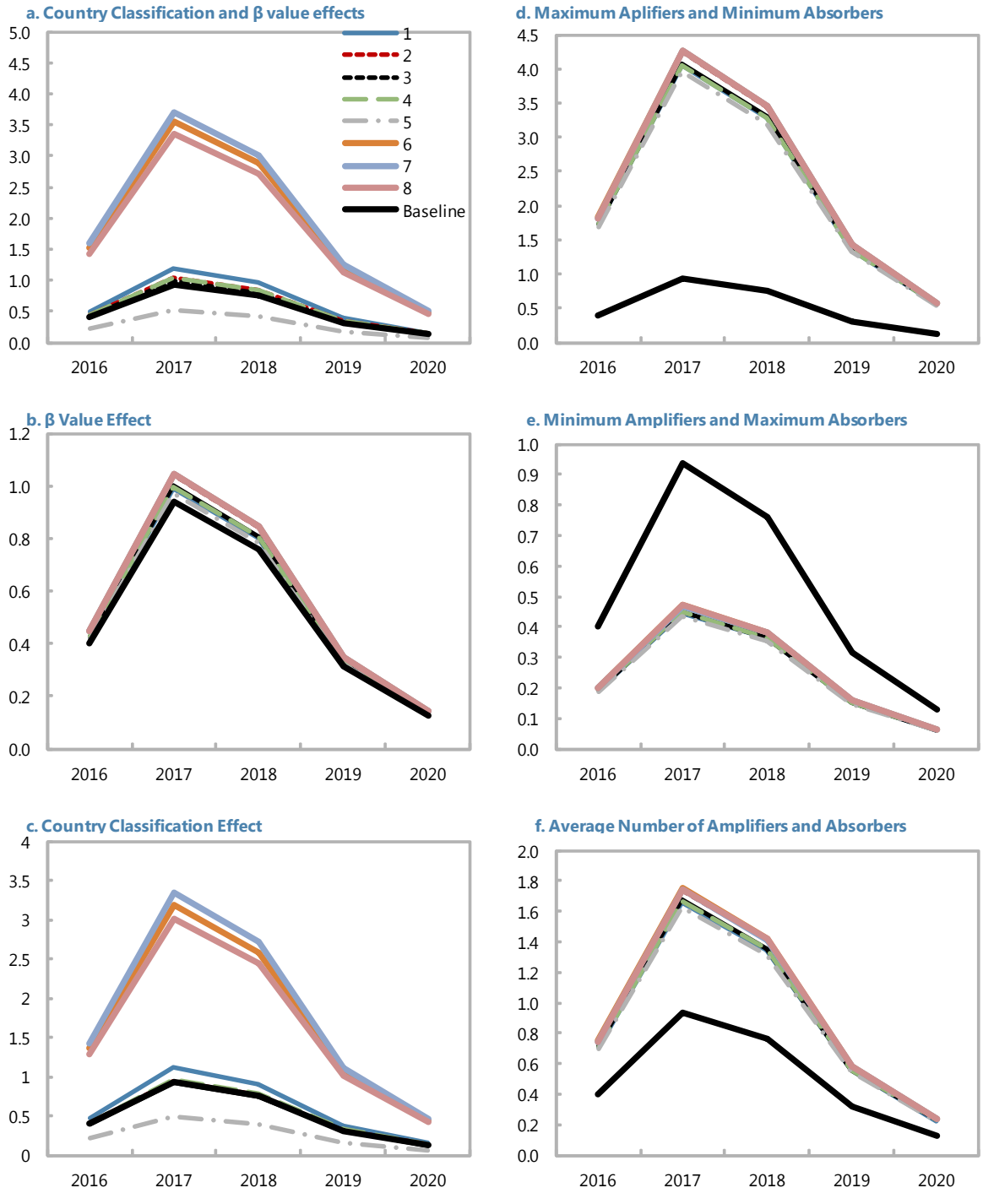
52. **The sensitivity analysis to different specifications suggests that the magnitude of spillovers depends on the policies of countries capable to pass-through shocks**. In nine model specifications in real (1-5) and nominal (6-9) terms, the models in nominal terms were found especially sensitive to the classification of countries as shock amplifiers, absorbers, and blockers (Figure 13a). The values of β coefficients across all model specifications do not

seem to have any significant impact on the magnitude of shock spillovers or their profile as most models depict a shock very close to the baseline (Figure 13b). At the same time, the application of different assumptions regarding the numbers of countries capable to amplify, absorb and block shocks can change the magnitude of spillovers and their time profile (Figure 13c).

53. **Counterfactual experiments have been performed on the classification of countries capable to pass through the shocks**. They suggest that the largest higher round effects under all model specifications can be expected under the extremes assumptions that a total of 103 countries are capable to augment the shock as in models 7 and 8 and only 48 countries would absorb at least part of the shock as in model 1, with all remaining countries assumed shock blockers. Under this extreme assumption, and also assuming that the countries take no policy actions to prevent the pass-through of the shock, the spillovers in 2017 can quadruple relative to the baseline (Figure 13d). In the opposite case scenario, if the model with the minimum number of shock amplifiers (23 as in model 5) and the maximum number of shock absorbers (97 as in model 9) is assumed to be true, the network spillover effect would be roughly half of the 2017 baseline level (Figure 13e). Finally, if the number of shock amplifiers and absorbers is set at the average level across all nine models, i.e. at 56 and 63 respectively, the 2017 spillover would still be about 40 percent higher relative to the baseline (Figure 13f).

54. **Therefore, the current baseline shock presented in this paper should be treated as conservative as its higher round spillovers critically depend on the policy actions taken by China's trading partners in response to the slowdown of Chinese imports**. These policies can either further augment the initial shock or absorb part of its impact before spilling it over to other countries. Compensatory policy measures taken by China's trading partners may shift them from the group of shock amplifiers to the group of shock absorbers and even shock blockers. Such policies would help arrest the proliferation of negative spillovers through the trade network. If China's trading partners take no policy measures, their capacity to pass-through shocks would remain unchanged relative to previous years.

Figure 13. Import Shock Spillovers: Sensitivity Analysis, 2016-20
(Percent of GDP)



Source: Authors' estimates.

V. CONCLUSIONS

55. **A network model of spillovers applied to China allows capturing higher round network effects of spillovers..** The network effects would originate from the feedback process starting from the second round of shock propagation. Their strength would depend on the network structure, including the relative magnitude of the initial shock at the epicenter, the epicenter country's centrality and other network properties, the position of its main trading partners in the network, their domestic economic structure, the relative compounding strength of spillover signals spreading in the same direction, and the offsetting strength of signals spreading in opposite directions. When compounded through different rounds of the shock spillover, the network effect could become comparable and often exceeds the initial shock at the epicenter country.

56. **Compared to other spillover models, the network model allows getting important insights.** The main value added of applying network analysis that cannot be address with other existing tools, e.g., GVARs, FSGM, General Equilibrium DSGE models, consists in direct quantification of higher-round effects. The inferences rely on the analysis of observable directional flows, rather than on correlations between as in most other models. Moreover, the direction of causality is also directly captured from the data compared to other models where is its established probabilistically based on econometric techniques. Overall, the network modules could be seen as complimentary for GE models.

57. **The projected drop of imports by China might lead to spillovers across the world through the trade channel.** China's growth at a bound 1 percentage point below the baseline in 2016-17, leading to a drop of in demand for imports by about 10 percent each would lead to a loss of about 1.2 percent GDP of export revenue in 2016 for all countries, which with network effects may increase to 2.0 percent of GDP in 2017 before abating gradually by 2020 to about 0.2 percent of GDP in 2020. The network effects substantially augment the initial shock. Such effects consist of direct spillovers of the nominal shock in China; the spillin effects, when all affected trading partners propagate the shock to each other; and the spillback effect from all countries on China itself. While the assumed nominal shock amounts to about 0.4 percent of the world's GDP in 2016 and 1.1 percent of GDP in 2017, the induced spillover and spillin effects can more than double the magnitude of the initial shock. The spillback effect on China would amount to 0.5 and 1.1 percent of its GDP in each of these years.

58. **The impact on individual regions would be heterogeneous**. Asia and Pacific would be affected the most, followed by the Middle East and Central Asia because of their relatively higher exposure to trade with China. The impact on sub-Saharan Africa would be less visible because of its still relatively low trade with China. The spillover on Europe would be moderate because of its substantial economic size, and the impact on the Western Hemisphere would be marginal. Metal exporters might be hit the hardest by the spillovers from China, which is the largest metal importer in the world, followed by non-fuel primary commodity exporters. The impact on fuel exporters most likely would be marginal. Among individual countries, the strongest negative spillovers in terms of the impact on their GDP would be expected in Hong Kong SAR, Singapore, Mauritania, Republic of Congo, Mongolia, and Solomon Islands.

59. **The model has several limitations and its conclusions should be interpreted with caution.** First, the analysis is partial equilibrium and abstracts from the possible endogenous responses of exchange rates and policy variables in the face of a slowdown in China, it does not incorporate the usual mitigating or amplification channels through financial markets, exchange rates, commodity prices, etc., which should be modeled separately. Second, the model is not based on trade in value added that would allow capturing both direct and indirect trade linkages in complicated global supply chain networks, but rather at this stage spillovers are illustrated based on a more comprehensive Comtrade database of bilateral trade flows. Upstream and downstream productions are closely linked, across sectors, and within China, but also cross-country-sectors, and within other countries and final products should be treated very differently from raw material inputs. Third, the model is applied to the data in nominal terms and therefore does not allow distinguish explicitly between price and volume effects in spillovers. The findings and implications may not necessarily remain the same regardless of whether the reduced nominal exports to China stem from a fall volumes or prices. Finally, the network model does not allow capturing the potentially different impact of processing imports vs. non-processing imports.

60. **China and its trading partners are facing the challenge of offsetting possible spillovers from its imports slowdown**. Main policy recommendations to China include avoiding a sharp growth slowdown, reducing vulnerabilities from excess leverage after a credit and investment boom, and strengthening the role of market forces in the economy (IMF, 2015a). Modest policy support may be needed to China's partners, in particular those most exposed to trade with China. China further progress in implementing structural reforms would be critical for private consumption to pick up some of the slack from slowing investment growth (IMF 2015b). The core of the reforms would be to give market mechanisms a broader role in the economy, eliminate distortions, and strengthen institutions.

VI. REFERENCES

Acemoglu, D., A. Ozdaglar, and A. Tahbaz-Salehi, 2013, "The Network Origins of Large Economic Downturns," *NBER Working Paper* No. 19230.

Acemoglu, D., U. Akcigit, W. Kerr, W. , 2015. "Networks and the Macroeconomy: An Empirical Exploration," *NBER Chapters*.

Acemoglu, D., V. Carvalho, A. Ozdaglar, and A. Tahbaz-Salehi, 2012, "The Network Origins of Aggregate Fluctuations," *Econometrica*, 80: 1977–2016.

Anderson D., J. Canales Kriljenko, P. Drummond, P. Espaillat, and D. Muir, 2015, "Spillovers from China onto Sub-Saharan Africa: Insights from the Flexible System of Global Models (FSGM)," *IMF Working Paper*, 15/221.

Bandelj N. and M. Mahutga, 2013, "Structures of globalization: Evidence from the worldwide network of bilateral investment treaties (1959–2009)," *International Journal of Comparative Sociology*, April 2013; 54: 95-123.

Bems R., R. Johnson, Y. Li, 2013, "The Great Trade Collapse," *Annual Review of Economics* 5(2): 375-400.

Bems, R., R. Johnson, and Kei-Mu Yi, 2010, "Demand Spillovers and the Collapse of Trade in the Global Recession," *IMF Economic Review* 58(2): 295-326.

Borgatti S., M. Everett, J. Johnson, 2013, *Analyzing Social Networks*, SAGE Publications, 296 p.

Centola, D. and M. Macy, 2007, "Complex Contagions and the Weakness of Long Ties," *American Journal of Sociology*, 113(3): 702–34, http://sdl.soc.cornell.edu/mwm/WLT_AJS.pdf

Cerdeiro, D., and Wirkierman, A., 2008, "International Trade Transmission Channel of a Local Crisis: a Simple Model," *Económica*, 54, 87-119 .

Clark R. and J.Beckfield, 2009, "A New Trichotomous Measure of World-system Position Using the International Trade Network," *International Journal of Comparative Sociology*, February 2009; 50 (1): 5-38.

Contreras, M. and Fagiolo, G., 2014, "Propagation of Economic Shocks in Input-Output Networks: A Cross-Country Analysis." *Physical Review E*, 90(6), 062812.

De Benedictis L, S. Nenci, G. Santoni, L.Tajoli, C. Vicarelli, 2013, "Network Analysis of World Trade Using the BACI-CEPII Database," *CEPII Working Paper*, No.24.

Easly D., J. Kleinberg, 2010, *Networks, Crowds and Markets*, Cambridge University Press, 727 p.

Fracasso A. and S. Schiavo, 2009, "Global Imbalances, Exchange Rates Adjustment and the Crisis: Implications from Network Analysis," *Journal of Policy Modeling* 31(5): 601-19.

Fronczak A. and P. Fronczak, 2012, "Statistical Mechanics of the International Trade Network," Physical review E 85, arXiv:1104.2606v2.

Hausmann, R. and C. Hidalgo, 2011, "The Network Structure of Economic Output," *Journal of Economic Growth*, 16 (4), 309–42, http://www.chidalgo.com/Papers/HausmannHidalgoJOEG_2011.pdf

International Monetary Fund, 2010, "Do Financial Crises Have Lasting Effects on Trade?" Chapter 4, *World Economic Outlook* (Washington, DC: International Monetary Fund).

International Monetary Fund, 2014, *Spillover Report*, www.imf.org.

International Monetary Fund, 2015a, *Adjusting to Lower Commodity Prices*, World Economic Outlook, October, Washington DC, IMF, www.imf.org/external/pubs/ft/weo/2015/02.

International Monetary Fund, 2015b, People's Republic of China: Staff Report for the 2015 Article IV Consultation, Country Report No. 15/234, www.imf.org/external/country/chn.

International Monetary Fund, 2015c, *Dealing with the Gathering Clouds*, Regional Economic Outlook, Sub-Saharan Africa, October, http://www.imf.org/external/pubs/ft/reo/2015/afr

Jackson M., 2010, *Social and Economic Networks*, Princeton University Press, 504 p.

Kali R. and J. Rayes, 2010, "Financial Contagion on the International Trade Network," *Economic Inquiry*, 48(4): 1072–1101.

Kick E., Davis B., 2001, "World-System Structure and Change. An Analysis of Global Networks and Economic Growth across Two Time Periods." *American Behavioral Scientist*, 44(10): 1561-1578.

Kireyev A. and A. Leonidov, 2015. "Network Effects of International Shocks and Spillovers," *IMF Working Papers* 15/149, International Monetary Fund.

Mahutga, M., 2006, "The Persistence of Structural Inequality? A Network Analysis of International Trade," 1965-2000, *Social Forces*, 84(4):1863-1889.

Mastrandrea R., T. Squartini, G. Fagiolo, D. Garlaschelli, 2014, "Intensive and extensive biases in economic networks: reconstructing the world trade multiplex," arXiv:1402.4171

Morin, M. and C. Schwellnus, 2014, "An Update of the OECD International Trade

Equations", OECD Economics Department Working Papers, No. 1129, OECD Publishing. http://dx.doi.org/10.1787/5jz2bxbkrxmv-en

Reyes V., 2013, "The structure of globalized travel: A relational country-pair analysis," *International Journal of Comparative Sociology,* April 2013; 54(2): 144-170.

Reyes, J., Wooster, R. and Shirrell, S., 2014, "Regional Trade Agreements and the Pattern of Trade: A Networks Approach." *World Economy,* doi: 10.1111/twec.12121.

Riccaboni R. and S.Schiavo, 2014, "Stochastic Trade Networks," *Journal of Complex Networks,* May; 3: 1-15.

Rhee C. , 2015, "Managing Economic Transition. iMF Direct Global Economy Forum," Blog post, http://blog-imfdirect.imf.org/2015/10/05/managing-chinas-economic-transition.

Serrano A., M. Boguna, A.Vespignani, 2007, "Patterns of Dominant Flows in the World Trade Web," *Journal of Economic Interaction and Coordination,* 2(2): 111-124.

Sgrignoli, P., 2014, "The World Trade Web: A Multiple-Network Perspective," Papers arXiv:1409.3799.

Morin, M. and Schwellnus, C., 2014. "An Update of the OECD International Trade Equations," *OECD Working Paper* No.1129.

Tokarick, S., 2010, "A method for calculating export supply and import demand elasticities," IMF Working Paper 10/180: 1-40.

United Nations, 2015, "Commodity Trade Statistics Database (UN Comtrade)" http://comtrade.un.org/db/help/uReadMeFirst.aspx.

Vidon E. , 2011, "US Trade Spillovers: Typical Response to US Activity" in *The United States Spillover Report*, IMF Country Report No. 11/203.

World Trade Organization, 2015, "Falling Import Demand, Lower Commodity Prices Push Down Trade Growth Prospects" PRESS/752, https://www.wto.org/english/news_e/pres15_e .

World Trade Organization/OECD, 2015, "Measuring Trade in Value Added: An OECD-WTO joint initiative" http://www.oecd.org/sti/ind .

Annex 1. Export Shock by Region

(Percent of GDP)

Country	2016	2017	2018	2019	2020	Average
Sub-Saharan Africa	**1.36**	**1.87**	**0.86**	**0.35**	**0.14**	**0.92**
Republic of Congo	11.44	12.05	3.87	1.66	0.74	5.95
Equatorial Guinea	6.11	9.80	5.33	2.29	0.98	4.90
Angola	6.40	8.12	2.82	1.15	0.47	3.79
Sierra Leone	5.73	6.52	1.54	0.59	0.24	2.92
Gabon	2.40	4.17	2.55	0.98	0.40	2.10
South Africa	2.67	3.57	1.36	0.55	0.23	1.68
Zambia	2.47	3.01	0.91	0.34	0.13	1.37
Liberia	1.75	2.57	1.28	0.54	0.22	1.27
The Gambia	1.98	2.41	0.77	0.31	0.12	1.12
Guinea	0.70	1.56	1.21	0.51	0.19	0.83
DRC	1.30	1.59	0.49	0.19	0.08	0.73
Seychelles	0.43	1.23	1.14	0.51	0.21	0.70
Chad	0.60	1.25	0.95	0.37	0.15	0.66
Zimbabwe	1.06	1.41	0.53	0.21	0.09	0.66
Madagascar	0.62	1.13	0.73	0.30	0.12	0.58
Mozambique	0.75	1.16	0.62	0.24	0.09	0.57
Côte d'Ivoire	0.45	1.02	0.80	0.33	0.13	0.55
Nigeria	0.42	0.99	0.80	0.33	0.14	0.54
Guinea-Bissau	0.51	1.02	0.72	0.29	0.12	0.53
Togo	0.64	0.97	0.50	0.20	0.08	0.48
Ghana	0.51	0.85	0.53	0.23	0.09	0.44
Mauritius	0.27	0.68	0.59	0.26	0.10	0.38
Malawi	0.35	0.72	0.52	0.21	0.09	0.38
Cameroon	0.35	0.65	0.45	0.20	0.08	0.35
Benin	0.52	0.69	0.28	0.11	0.04	0.33
Tanzania	0.31	0.50	0.27	0.11	0.04	0.25
CAR	0.44	0.52	0.17	0.06	0.02	0.24
Burkina Faso	0.34	0.45	0.18	0.07	0.03	0.21
Mali	0.28	0.38	0.16	0.06	0.02	0.18
Senegal	0.13	0.32	0.26	0.11	0.04	0.17
Rwanda	0.26	0.35	0.14	0.05	0.02	0.16
Comoros	0.10	0.29	0.26	0.11	0.04	0.16
Kenya	0.10	0.22	0.17	0.07	0.03	0.11
Uganda	0.10	0.19	0.13	0.05	0.02	0.10
Niger	0.12	0.20	0.11	0.04	0.02	0.10
Ethiopia	0.11	0.16	0.08	0.03	0.01	0.08
Cape Verde	0.03	0.11	0.12	0.06	0.02	0.07
Burundi	0.08	0.14	0.08	0.03	0.01	0.07
São Tomé and Príncipe	0.01	0.04	0.04	0.02	0.01	0.02

Country	2016	2017	2018	2019	2020	Average
Asia and Pacific	**2.32**	**3.48**	**1.67**	**0.62**	**0.25**	**1.67**
Hong Kong SAR	16.77	21.01	6.76	2.68	1.09	9.66
Singapore	6.72	11.28	6.37	2.34	0.95	5.53
Solomon Islands	6.24	7.59	2.30	0.87	0.35	3.47
Brunei Darussalam	3.43	7.01	4.68	1.50	0.58	3.44
Malaysia	3.33	5.32	2.88	1.02	0.40	2.59
Mongolia	4.91	5.68	1.34	0.52	0.20	2.53
Vietnam	2.72	4.61	2.67	1.03	0.41	2.29
Thailand	2.63	4.48	2.56	0.97	0.40	2.21
Korea	2.64	3.72	1.63	0.63	0.25	1.77
Papua New Guinea	1.82	3.08	1.72	0.61	0.25	1.50
Cambodia	1.20	2.57	1.91	0.76	0.30	1.35
Vanuatu	1.09	2.50	1.89	0.69	0.28	1.29
Lao PDR	1.89	2.70	1.22	0.45	0.18	1.29
Australia	1.83	2.52	1.02	0.39	0.16	1.18
New Zealand	1.46	2.21	1.06	0.40	0.17	1.06
Indonesia	1.01	1.70	0.99	0.37	0.15	0.84
Japan	0.98	1.55	0.83	0.33	0.14	0.76
Myanmar	1.05	1.57	0.77	0.28	0.11	0.76
Philippines	0.85	1.38	0.75	0.27	0.10	0.67
China	0.54	1.10	0.77	0.28	0.11	0.56
Fiji	0.60	1.08	0.66	0.24	0.10	0.54
India	0.33	0.62	0.41	0.16	0.06	0.32
Bangladesh	0.20	0.47	0.38	0.16	0.06	0.26
Sri Lanka	0.21	0.48	0.38	0.15	0.06	0.25
Maldives	0.16	0.41	0.35	0.14	0.06	0.22
Samoa	0.20	0.41	0.28	0.10	0.04	0.21
Tonga	0.11	0.21	0.15	0.05	0.02	0.11
Nepal	0.09	0.20	0.16	0.06	0.03	0.11

Country	2016	2017	2018	2019	2020	Average
Europe	**0.59**	**1.48**	**1.31**	**0.61**	**0.25**	**0.85**
Belgium	1.34	3.52	3.20	1.48	0.62	2.03
Czech Republic	1.02	2.93	2.90	1.45	0.63	1.79
Netherlands	1.11	2.88	2.60	1.21	0.51	1.66
Hungary	0.98	2.75	2.65	1.27	0.54	1.64
Slovak Republic	0.84	2.68	2.75	1.34	0.56	1.63
Slovenia	0.77	2.35	2.38	1.16	0.49	1.43
Ukraine	1.17	2.22	1.56	0.67	0.27	1.18
Estonia	0.69	1.97	1.87	0.87	0.36	1.15
Lithuania	0.63	1.87	1.87	0.90	0.37	1.13
Bulgaria	0.79	1.86	1.58	0.73	0.30	1.05
Austria	0.67	1.71	1.55	0.73	0.31	0.99
Germany	0.83	1.75	1.36	0.62	0.26	0.96
Russia	1.05	1.85	1.20	0.50	0.20	0.96
Ireland	0.67	1.68	1.46	0.64	0.26	0.94
Switzerland	0.79	1.71	1.33	0.58	0.25	0.93
Belarus	0.66	1.60	1.38	0.61	0.25	0.90
Latvia	0.48	1.41	1.39	0.66	0.27	0.84
Norway	0.55	1.42	1.29	0.60	0.25	0.82
Denmark	0.64	1.47	1.20	0.54	0.23	0.82
Finland	0.66	1.37	1.05	0.47	0.20	0.75
Sweden	0.55	1.29	1.08	0.50	0.21	0.73
Poland	0.44	1.23	1.17	0.54	0.22	0.72
FYR of Macedonia	0.50	1.21	1.06	0.50	0.21	0.69
Israel	0.59	1.22	0.89	0.37	0.16	0.64
Italy	0.46	1.09	0.92	0.42	0.18	0.61
Portugal	0.34	0.95	0.90	0.43	0.18	0.56
Luxembourg	0.37	0.97	0.88	0.40	0.17	0.56
France	0.41	0.92	0.74	0.33	0.14	0.51
Iceland	0.30	0.83	0.79	0.38	0.17	0.50
Bosnia and Herzegovina	0.23	0.79	0.84	0.42	0.17	0.49
Moldova	0.32	0.85	0.77	0.35	0.14	0.49
Albania	0.51	0.92	0.61	0.27	0.11	0.48
Spain	0.32	0.82	0.73	0.34	0.14	0.47
Malta	0.27	0.73	0.67	0.30	0.12	0.42
United Kingdom	0.30	0.71	0.60	0.26	0.11	0.39
Croatia	0.20	0.61	0.61	0.30	0.12	0.37
Turkey	0.28	0.64	0.52	0.23	0.09	0.35
Greece	0.19	0.50	0.44	0.20	0.09	0.28
Cyprus	0.12	0.27	0.22	0.10	0.04	0.15

Country	2016	2017	2018	2019	2020	Average
Middle East and Central A	**1.50**	**2.25**	**1.15**	**0.45**	**0.18**	**1.11**
Oman	7.53	9.93	3.80	1.47	0.62	4.67
Mauritania	6.88	8.24	2.41	0.97	0.40	3.78
Kuwait	3.27	5.74	3.48	1.30	0.53	2.87
Qatar	2.67	4.89	3.06	1.11	0.45	2.44
Saudi Arabia	2.64	4.32	2.41	0.92	0.38	2.13
UAE	2.11	4.05	2.67	0.99	0.40	2.05
Iraq	2.69	3.98	2.03	0.78	0.31	1.96
Turkmenistan	3.18	3.48	0.85	0.32	0.12	1.59
Kazakhstan	1.96	2.60	1.12	0.46	0.18	1.26
Republic of Yemen	1.82	2.45	1.08	0.41	0.17	1.19
Azerbaijan	0.60	1.58	1.43	0.58	0.24	0.89
Iran	1.32	1.77	0.70	0.27	0.11	0.84
Tunisia	0.44	1.24	1.18	0.54	0.22	0.72
Algeria	0.56	1.26	1.02	0.46	0.19	0.70
Bahrain	0.65	1.34	0.96	0.37	0.15	0.69
Morocco	0.29	0.73	0.63	0.28	0.11	0.41
Kyrgyz Republic	0.46	0.76	0.43	0.16	0.07	0.38
Uzbekistan	0.58	0.77	0.30	0.12	0.05	0.37
Sudan	0.52	0.66	0.25	0.09	0.04	0.31
Jordan	0.24	0.55	0.42	0.17	0.07	0.29
Georgia	0.21	0.47	0.37	0.16	0.06	0.25
Tajikistan	0.29	0.47	0.28	0.12	0.05	0.24
Pakistan	0.30	0.48	0.27	0.11	0.04	0.24
Armenia	0.23	0.44	0.31	0.14	0.06	0.24
Egypt	0.21	0.40	0.28	0.12	0.05	0.21
Lebanon	0.10	0.21	0.16	0.06	0.03	0.11
Afghanistan	0.06	0.14	0.12	0.05	0.02	0.08
Djibouti	0.06	0.13	0.10	0.04	0.02	0.07

Country	2016	2017	2018	2019	2020	Average
Western Hemisphere	**0.71**	**1.38**	**0.95**	**0.38**	**0.15**	**0.72**
Venezuela	2.71	4.45	2.55	0.99	0.40	2.22
Costa Rica	2.61	4.34	2.50	0.99	0.40	2.17
Trinidad and Tobago	1.25	3.00	2.41	0.96	0.39	1.60
Chile	2.10	3.08	1.42	0.56	0.23	1.48
Bolivia	1.08	2.18	1.49	0.55	0.22	1.10
Mexico	0.75	1.81	1.48	0.60	0.24	0.98
Canada	0.83	1.79	1.35	0.55	0.22	0.95
Guyana	0.65	1.68	1.46	0.62	0.25	0.93
Nicaragua	0.68	1.70	1.43	0.59	0.24	0.93
Honduras	0.72	1.69	1.37	0.58	0.24	0.92
Paraguay	0.73	1.63	1.26	0.50	0.21	0.87
Peru	1.13	1.73	0.89	0.36	0.14	0.85
Dominica	0.64	1.51	1.17	0.44	0.18	0.79
Uruguay	1.02	1.48	0.67	0.27	0.11	0.71
Ecuador	0.57	1.30	1.02	0.42	0.18	0.70
Colombia	0.67	1.11	0.67	0.26	0.10	0.56
Brazil	0.73	1.09	0.53	0.21	0.09	0.53
Belize	0.35	0.90	0.77	0.34	0.14	0.50
Argentina	0.44	0.81	0.52	0.21	0.09	0.41
The Bahamas	0.24	0.67	0.61	0.26	0.11	0.38
Haiti	0.24	0.60	0.50	0.20	0.08	0.32
Dominican Republic	0.25	0.57	0.45	0.19	0.08	0.30
Guatemala	0.24	0.56	0.45	0.18	0.07	0.30
United States	0.26	0.49	0.32	0.13	0.06	0.25
St. Kitts and Nevis	0.16	0.44	0.39	0.16	0.07	0.24
Barbados	0.11	0.23	0.18	0.08	0.03	0.12
St. Vincent and the Grenadines	0.06	0.19	0.20	0.09	0.04	0.11
Grenada	0.06	0.17	0.15	0.06	0.02	0.10
St. Lucia	0.06	0.17	0.15	0.06	0.03	0.09
Panama	0.04	0.08	0.05	0.02	0.01	0.04

Annex 2. Import Shock by Region

(Percent of GDP)

Country	2016	2017	2018	2019	2020	Average
Sub-Saharan Africa	**0.07**	**0.16**	**0.12**	**0.04**	**0.02**	**0.08**
South Africa	0.89	1.58	0.91	0.30	0.12	0.76
Gabon	0.32	0.83	0.69	0.27	0.11	0.44
Zambia	0.55	0.91	0.47	0.14	0.05	0.42
Ghana	0.24	0.58	0.48	0.20	0.08	0.32
Tanzania	0.27	0.60	0.45	0.17	0.07	0.31
Senegal	0.12	0.45	0.48	0.22	0.09	0.27
Madagascar	0.11	0.29	0.26	0.11	0.04	0.16
Kenya	0.07	0.23	0.23	0.10	0.04	0.13
Seychelles	0.04	0.20	0.23	0.11	0.04	0.12
Rwanda	0.11	0.22	0.13	0.04	0.02	0.10
Uganda	0.05	0.13	0.12	0.05	0.02	0.07
Sierra Leone	0.08	0.12	0.05	0.01	0.01	0.06
São Tomé and Príncipe	0.00	0.00	0.00	0.00	0.00	0.00
Burundi	0.00	0.00	0.00	0.00	0.00	0.00
Cape Verde	0.00	0.00	0.00	0.00	0.00	0.00
Ethiopia	0.00	0.00	0.00	0.00	0.00	0.00
Niger	0.00	0.00	0.00	0.00	0.00	0.00
Comoros	0.00	0.00	0.00	0.00	0.00	0.00
Mali	0.00	0.00	0.00	0.00	0.00	0.00
Burkina Faso	0.00	0.00	0.00	0.00	0.00	0.00
CAR	0.00	0.00	0.00	0.00	0.00	0.00
Benin	0.00	0.00	0.00	0.00	0.00	0.00
Cameroon	0.00	0.00	0.00	0.00	0.00	0.00
Malawi	0.00	0.00	0.00	0.00	0.00	0.00
Mauritius	0.00	0.00	0.00	0.00	0.00	0.00
Togo	0.00	0.00	0.00	0.00	0.00	0.00
Guinea-Bissau	0.00	0.00	0.00	0.00	0.00	0.00
Nigeria	0.00	0.00	0.00	0.00	0.00	0.00
Côte d'Ivoire	0.00	0.00	0.00	0.00	0.00	0.00
Mozambique	0.00	0.00	0.00	0.00	0.00	0.00
Zimbabwe	0.00	0.00	0.00	0.00	0.00	0.00
Chad	0.00	0.00	0.00	0.00	0.00	0.00
DRC	0.00	0.00	0.00	0.00	0.00	0.00
Guinea	0.00	0.00	0.00	0.00	0.00	0.00
The Gambia	0.00	0.00	0.00	0.00	0.00	0.00
Liberia	0.00	0.00	0.00	0.00	0.00	0.00
Angola	0.00	0.00	0.00	0.00	0.00	0.00
Equatorial Guinea	0.00	0.00	0.00	0.00	0.00	0.00
Republic of Congo	0.00	0.00	0.00	0.00	0.00	0.00

Country	2016	2017	2018	2019	2020	Average
Europe	**0.29**	**1.09**	**1.22**	**0.61**	**0.26**	**0.69**
Malta	0.52	2.32	2.69	1.33	0.55	1.48
Estonia	0.46	2.12	2.56	1.34	0.56	1.41
Slovak Republic	0.36	1.92	2.51	1.39	0.59	1.36
Ukraine	0.86	2.35	2.14	0.97	0.40	1.34
Ireland	0.52	2.12	2.37	1.15	0.48	1.33
Czech Republic	0.39	1.77	2.19	1.18	0.51	1.21
Switzerland	0.63	2.02	2.00	0.90	0.38	1.18
Lithuania	0.37	1.78	2.14	1.10	0.44	1.17
Denmark	0.54	1.89	2.01	0.98	0.42	1.17
Slovenia	0.30	1.52	1.95	1.07	0.46	1.06
Austria	0.32	1.27	1.47	0.77	0.33	0.83
Poland	0.27	1.23	1.50	0.79	0.34	0.82
Bulgaria	0.37	1.29	1.42	0.72	0.30	0.82
Hungary	0.27	1.22	1.48	0.79	0.34	0.82
FYR of Macedonia	0.32	1.20	1.38	0.72	0.31	0.78
Germany	0.41	1.28	1.29	0.63	0.27	0.78
Latvia	0.22	1.08	1.36	0.74	0.31	0.74
Finland	0.42	1.25	1.22	0.56	0.23	0.74
Albania	0.51	1.27	1.12	0.51	0.22	0.73
Croatia	0.20	1.00	1.30	0.71	0.31	0.70
Israel	0.39	1.18	1.11	0.46	0.19	0.66
Netherlands	0.25	1.03	1.19	0.60	0.25	0.66
France	0.30	1.00	1.04	0.49	0.21	0.61
Sweden	0.27	0.96	1.02	0.50	0.21	0.59
Iceland	0.20	0.85	1.01	0.53	0.23	0.56
Italy	0.23	0.84	0.91	0.44	0.19	0.52
Portugal	0.17	0.75	0.91	0.49	0.21	0.51
Turkey	0.24	0.83	0.87	0.40	0.17	0.50
Spain	0.19	0.76	0.88	0.45	0.19	0.49
Russia	0.24	0.62	0.55	0.24	0.09	0.35
United Kingdom	0.15	0.56	0.60	0.28	0.11	0.34
Greece	0.11	0.45	0.52	0.27	0.11	0.29
Bosnia and Herzegovina	0.06	0.37	0.49	0.27	0.11	0.26
Norway	0.08	0.32	0.36	0.18	0.08	0.20
Cyprus	0.00	0.00	0.00	0.00	0.00	0.00
Moldova	0.00	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.00	0.00	0.00	0.00	0.00	0.00
Belarus	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.00	0.00	0.00	0.00	0.00	0.00

Country	2016	2017	2018	2019	2020	Average
Western Hemisphere	**0.17**	**0.46**	**0.40**	**0.16**	**0.06**	**0.25**
Guyana	0.37	1.56	1.66	0.73	0.28	0.92
Uruguay	0.86	1.71	1.13	0.40	0.17	0.85
Chile	0.73	1.49	1.01	0.36	0.15	0.75
Mexico	0.27	1.11	1.22	0.55	0.23	0.67
Peru	0.60	1.30	0.94	0.35	0.14	0.67
Canada	0.30	1.01	1.01	0.44	0.18	0.59
Dominica	0.27	1.04	0.97	0.37	0.15	0.56
Brazil	0.49	1.01	0.70	0.26	0.10	0.51
Barbados	0.25	0.80	0.79	0.36	0.14	0.47
Colombia	0.36	0.85	0.68	0.26	0.10	0.45
Argentina	0.31	0.79	0.65	0.25	0.10	0.42
United States	0.24	0.64	0.56	0.23	0.09	0.35
Trinidad and Tobago	0.09	0.34	0.36	0.15	0.06	0.20
Guatemala	0.05	0.20	0.21	0.09	0.04	0.12
Panama	0.00	0.00	0.00	0.00	0.00	0.00
St. Lucia	0.00	0.00	0.00	0.00	0.00	0.00
Grenada	0.00	0.00	0.00	0.00	0.00	0.00
St. Vincent and the Grenadines	0.00	0.00	0.00	0.00	0.00	0.00
St. Kitts and Nevis	0.00	0.00	0.00	0.00	0.00	0.00
Dominican Republic	0.00	0.00	0.00	0.00	0.00	0.00
Haiti	0.00	0.00	0.00	0.00	0.00	0.00
The Bahamas	0.00	0.00	0.00	0.00	0.00	0.00
Belize	0.00	0.00	0.00	0.00	0.00	0.00
Ecuador	0.00	0.00	0.00	0.00	0.00	0.00
Paraguay	0.00	0.00	0.00	0.00	0.00	0.00
Honduras	0.00	0.00	0.00	0.00	0.00	0.00
Nicaragua	0.00	0.00	0.00	0.00	0.00	0.00
Bolivia	0.00	0.00	0.00	0.00	0.00	0.00
Costa Rica	0.00	0.00	0.00	0.00	0.00	0.00
Venezuela	0.00	0.00	0.00	0.00	0.00	0.00

Country	2016	2017	2018	2019	2020	Average
Asia and Pacific	**1.43**	**2.76**	**1.79**	**0.60**	**0.24**	**1.36**
Hong Kong SAR	15.68	25.59	13.20	4.02	1.60	12.02
Singapore	3.53	8.68	6.78	2.40	0.97	4.47
Mongolia	4.06	6.02	2.63	0.69	0.26	2.73
Thailand	2.06	5.09	4.03	1.50	0.62	2.66
Malaysia	2.25	5.23	3.89	1.34	0.51	2.65
Vietnam	1.58	3.96	3.20	1.21	0.48	2.09
Korea	2.03	3.98	2.58	0.89	0.36	1.97
Solomon Islands	2.43	4.09	2.07	0.57	0.22	1.88
Fiji	0.73	2.01	1.72	0.65	0.27	1.07
New Zealand	1.07	2.18	1.43	0.47	0.18	1.07
Indonesia	0.60	1.49	1.19	0.44	0.18	0.78
Papua New Guinea	0.65	1.55	1.17	0.39	0.15	0.78
Sri Lanka	0.32	1.20	1.26	0.56	0.23	0.72
Philippines	0.56	1.35	1.02	0.36	0.14	0.69
Japan	0.61	1.33	0.98	0.35	0.14	0.68
Australia	0.66	1.24	0.76	0.24	0.10	0.60
India	0.37	1.08	0.98	0.39	0.16	0.59
China	0.77	0.66	0.62	0.24	0.09	0.48
Bangladesh	0.12	0.46	0.49	0.23	0.09	0.28
Nepal	0.00	0.00	0.00	0.00	0.00	0.00
Tonga	0.00	0.00	0.00	0.00	0.00	0.00
Samoa	0.00	0.00	0.00	0.00	0.00	0.00
Maldives	0.00	0.00	0.00	0.00	0.00	0.00
Myanmar	0.00	0.00	0.00	0.00	0.00	0.00
Lao PDR	0.00	0.00	0.00	0.00	0.00	0.00
Vanuatu	0.00	0.00	0.00	0.00	0.00	0.00
Cambodia	0.00	0.00	0.00	0.00	0.00	0.00
Brunei Darussalam	0.00	0.00	0.00	0.00	0.00	0.00

Country	2016	2017	2018	2019	2020	Average
Middle East and Central Asia	**0.23**	**0.51**	**0.38**	**0.15**	**0.06**	**0.27**
Kyrgyz Republic	1.50	3.52	2.70	0.95	0.38	1.81
United Arab Emirates	0.62	1.82	1.62	0.62	0.25	0.99
Mauritania	1.22	1.90	0.93	0.26	0.10	0.88
Uzbekistan	0.80	1.43	0.85	0.29	0.12	0.70
Tajikistan	0.54	1.16	0.91	0.39	0.16	0.63
Kazakhstan	0.58	1.01	0.62	0.23	0.09	0.51
Tunisia	0.16	0.71	0.83	0.40	0.16	0.45
Armenia	0.27	0.72	0.65	0.28	0.11	0.41
Pakistan	0.30	0.65	0.49	0.19	0.08	0.34
Iraq	0.33	0.65	0.45	0.16	0.07	0.33
Jordan	0.14	0.49	0.48	0.20	0.08	0.28
Bahrain	0.08	0.26	0.24	0.10	0.04	0.14
Djibouti	0.00	0.00	0.00	0.00	0.00	0.00
Afghanistan	0.00	0.00	0.00	0.00	0.00	0.00
Lebanon	0.00	0.00	0.00	0.00	0.00	0.00
Egypt	0.00	0.00	0.00	0.00	0.00	0.00
Georgia	0.00	0.00	0.00	0.00	0.00	0.00
Sudan	0.00	0.00	0.00	0.00	0.00	0.00
Morocco	0.00	0.00	0.00	0.00	0.00	0.00
Algeria	0.00	0.00	0.00	0.00	0.00	0.00
Islamic Republic of Iran	0.00	0.00	0.00	0.00	0.00	0.00
Azerbaijan	0.00	0.00	0.00	0.00	0.00	0.00
Republic of Yemen	0.00	0.00	0.00	0.00	0.00	0.00
Turkmenistan	0.00	0.00	0.00	0.00	0.00	0.00
Saudi Arabia	0.00	0.00	0.00	0.00	0.00	0.00
Qatar	0.00	0.00	0.00	0.00	0.00	0.00
Kuwait	0.00	0.00	0.00	0.00	0.00	0.00
Oman	0.00	0.00	0.00	0.00	0.00	0.00

Annex 3. Pass-Through Coefficients: Estimation and Limitations

61. **The pass-through coefficients β_i for each country *i* can be estimated based on the following import demand function**

$$ln\left(\frac{m_{i,t+1}}{m_{i,t}}\right) = \alpha_i + \beta_i ln\left(\frac{x_{i,t+1}}{x_{i,t}}\right) + \gamma_i ln\left(\frac{r_{i,t+1}}{r_{i,t}}\right) + \delta_i ln\left(\frac{P^M_{i,t+1}}{eP_{i,t}}\right) + \varepsilon_i$$

This model allows differentiating marginal propensities to import across expenditure categories. In each country *i*, changes in demand for real imports (m_i) depend on changes in exports revenue in real terms (x_i), real domestic income (r_i) defined as the economy's total real income from all sources minus its real income from exports $(x - y)_i$, relative prices defined as a ratio of the index of import prices (P_i^M) to domestic prices $(P_i)$for each country, the nominal effective exchange rate (e_i), and a country-specific error term (ε_i). This model requires taking the small country assumption as international prices are treated as given for all countries other than China itself and the shock propagation affects only volumes of imports and exports.

62. **Alternatively, the pass-through coefficients can be estimates in nominal terms to take into account of both price and volume effects.** The equation is

$$ln\left(\frac{M_{i,t+1}}{M_{i,t}}\right) = \alpha_i + \beta_i ln\left(\frac{X_{i,t+1}}{X_{i,t}}\right) + \gamma_i ln\left(\frac{R_{i,t+1}}{R_{i,t}}\right) + \varepsilon_i$$

whereby changes in nominal imports $M_i$are driven by changes in export revenue X_i, domestic income R_i. Since all variables are defined in nominal terms, this specification does not allow distinguishing between the price and volume effects. However, at the same time, this specification does not require taking the small country assumption as any shock can affect both prices and quantities or modeling relative prices and the exchange rates separately, which makes it more parsimonious. Both specifications of the import demand functions broadly follows Tokarick (2010), Morin and Schwellnus (2014), and IMF (2015a). The estimations are based on the database underlying the October 2015 WEO chapter "Exchange Rates and Trade Flows: Disconnected?" (IMF, 2015a). Coefficient β_i can be interpreted as a pass-through coefficient from export revenue to the ensuring imports as it would indicate by how much imports of each country would change if its export revenue changes by one percent.

63. **Several pooled OLS regressions were estimated to form a preliminary impression of an appropriate functional form for the estimation of the pass-through coefficients**. Twelve specifications of the model were considered – six in real terms and six in nominal terms (Figure 14). In real terms, model 1 includes an intercept, all explanatory variables, trend and no lags of independent variables. Model 2 drops the trend as it was not statistically significant in the previous specification. Model 3 also drops relative prices, as they are not significant either in the previous two specifications. Model 4 adds one lag to the export revenue variable in addition to the previous specification. Model 5 takes both key explanatory variables – export and domestics revenue – with one lag. Model 6 evaluates the impact on import from export revenue with one lag and the contemporaneous value on domestic revenue. Finally, in nominal terms, models 7-12 follow broadly a similar specification pattern.

Figure 14. Average Import Demand: Pooled OLS Estimations

Dependent Variable: DLM	In real terms						In nominal terms					
	1	2	3	4	5	6	7	8	9	10	11	12
C	0.0269	0.0313	0.0308	0.0312	0.0581	0.0596	0.0166	0.0234	0.0234	0.0211	0.0648	0.0626
t-stat	*6.2732*	*12.5743*	*13.1392*	*12.3949*	*22.1336*	*22.9566*	*4.3555*	*10.0237*	*10.0237*	*8.5509*	*12.0345*	*11.8440*
DLX	0.4903	0.4895	0.4901	0.4550			0.7618	0.7637	0.7637	0.7746		
t-stat	*31.7320*	*31.7049*	*31.8123*	*29.1317*			*51.1729*	*51.3534*	*51.3534*	*50.4581*		
DLX(-1)				0.0661	0.0760	0.0636				0.0489	0.2203	-0.2234
t-stat				*4.2785*	*4.3929*	*3.7825*				*4.2454*	*11.1510*	*10.1772*
DLR	0.0986	0.0986	0.0997	0.0387		0.0024	0.3141	0.3155		0.3721		-0.2234
t-stat	*7.0047*	*7.0061*	*7.1393*	*2.6341*		*0.1531*	*19.1824*	*19.2710*		*20.8672*		*-12.8650*
DLR(-1)					0.0486						0.1386	
t-stat					*2.9519*						*6.4570*	
DLP	-0.1459	-0.1454	-0.1451	-0.1338	-0.1476	-0.1477						
t-stat	*-9.9685*	*-9.9344*	*-9.9222*	*-8.9417*	*-8.8141*	*-8.8067*						
DLE	-0.0031	-0.0052										
t-stat	*-0.3567*	*-0.6089*										
Tr	0.0004						0.0007				0.0011	0.0012
t-stat	*1.2492*						*2.2461*				*2.4133*	*2.6881*
D1	-0.0349	-0.0328	-0.0327	-0.0343	-0.0672	-0.0660	-0.0221	-0.0184	-0.0184	-0.0269	-0.0979	-0.0748
t-stat	*-4.9120*	*-4.7513*	*-4.7369*	*-4.9798*	*-8.8485*	*-8.6810*	*-3.2638*	*-2.8002*	*-2.8002*	*-4.1214*	*-11.1389*	*-8.6578*
R-squared	0.2584	0.2581	0.2580	0.2420	0.0491	0.0466	0.4427	0.4420	0.4420	0.4566	0.0535	0.0839
F-statistic	203	244	304	213	43	41	771	1,025	1,025	776	52	85
Akaike info criterion	-1.4255	-1.4256	-1.4261	-1.4450	-1.2188	-1.2162	-1.4263	-1.4255	-1.4255	-1.4720	-0.9171	-0.9497
Schwarz criterion	-1.4132	-1.4150	-1.4173	-1.4340	-1.2097	-1.2071	-1.4182	-1.4232	-1.4232	-1.4690	-0.9142	-0.9468
Periods included	21	21	21	20	20	20	21	21	21	20	20	20
Cross-sections included	167	167	167	167	167	167	185	185	185	185	185	185
Total panel observations	3,507	3,507	3,507	3,340	3,340	3,340	3,885	3,885	3,885	3,700	3,700	3,700

Source: Authors' estimates.

64. **Pooled models with no lags of dependent variables outperform models with lags.** The coefficient of determination of the former models is around 0.25 in real terms and 0.45 in nominal terms, which drops to 0.05, once lags are included. Both Akaike and Schwarz information criteria clearly select models with no lags over models with lags in both real and nominal terms. The pass-through coefficient on *DLX* remains virtually unchanged and statistically significant irrespective of specifications, at around 0.45 in real terms and about 0.76 in nominal terms, suggesting that on average for all countries a decline in export volume by 10 percent would translate into a decline in their imports volume by about 4.5 percent and a similar decline in export value would lead to a 7.6 percent decline in the value of their imports.

65. **As the next step, import demand functions were estimated for each country individually.** Obviously, the best specification for each country would be unique and would reflect its country-specific characteristics. However, establishing the specific forms of the import demand function for each country requires substantial country-level research and is beyond the scope of this paper. To estimate the elasticity of imports to export revenue, which is the pass-through coefficient in the spillover model, a uniform function specification was found based on the following procedure. First, 20 different specifications of the import demand function were estimated for each country, 10 in real and 10 in nominal terms (Figure 15). In each case, 5 equations were estimates on the contemporary values of explanatory variables and 5 on their lagged values.

Figure 15. Import Demand: Averages for Individual OLS Estimations

	In real terms				In nominal terms		
	Model	R2	AIC		Model	R2	AIC
No lags	1 dlm = c + dlx + dlr + dlp +dle + d1	0.6608	-2.3675	1	dlm = c + dlx + dlr+tr+d1	0.6828	-2.1173
	2 dlm = c + dlx + dlr + dlp +dle	0.6315	-2.3719	2	dlm = c + dlx + dlr+tr	0.6608	-2.1359
	3 dlm = c + dlx + dlr + dlp	0.5898	-2.3622	3	dlm = c + dlx + dlr	0.6476	-2.1925
	4 dlm = c + dlx + dlr	0.5037	-2.2510	4	dlm = c + dlx + dlr+d1	0.6700	-2.1722
	5 dlm = c + dlx	0.3982	-2.1632	5	dlm = c + dlx	0.5314	-1.9840
	Average	0.5568	-2.3031		Average	0.6385	-2.1204
With lags	6 dlm = c + dlx(-1)+ dlr + dlp +dle + d1	0.5055	-1.8554	6	dlm = c + dlx(-1)+ dlr+tr+d1	0.3150	-1.0647
	7 dlm = c + dlx(-1)+ dlr(-1)+dlp +dle + d1	0.4491	-1.7395	7	dlm = c + dlx(-1)+ dlr(-1)+tr+d1	0.2292	-0.9082
	8 dlm = c + dlx+ dlr(-1)+dlp +dle + d1	0.6101	-2.2553	8	dlm = c + dlx+ dlr(-1)+tr+d1	0.6006	-1.8752
	9 dlm = c + dlx+ dlr(-1)+dlp +dle	0.5761	-2.2575	9	dlm = c + dlx(-1)+ dlr+tr	0.2568	-1.0704
	10 dlm = c + dlx+ dlr(-1)+dlp	0.5293	-2.2341	10	dlm = c + dlx(-1)+ dlr	0.2254	-1.1187
	Average	0.5340	-2.0684		Average	0.3254	-1.2074
	Max/min	0.6608	-2.3719		Max/min	0.6828	-2.1925
	Number of countries	167			Number of countries	185	

Source: Authors' estimates.

66. **The models in nominal terms and no lags seems superior to other specifications**. The overall average fit of models in nominal terms is 0.64 compared to 0.56 for real models, although the average Akaike information criterion is a little less favorable. Both the models in real and nominal terms lose their explanatory power and the average coefficient of determination drops substantially, once lags of any dependent variables are introduced, to 0.53 and 0.33 in real and nominal terms, respectively. The only exception is model 6 with the contemporaneous value of either real or nominal export revenue, which strongly suggests that the pass-through from the change in export revenue to imports is on average contemporaneous. Finally, the model in nominal terms covers 185 countries compared to 167 countries in real terms reflecting data limitations on individual countries.

67. **As the next step, import demand equations were estimates for each country with available data, both in real and nominal terms**. The model building approach was based on a backward selection. Under this approach, a model was fitted with all the variables of interest following the initial screen. Then the least significant variable is dropped, so long as it is not significant at the 95 percent critical level. The successively re-fitting of the reduced models continues until all remaining variables are statistically significant. The process has been applied to the data with no lags of dependent variables. Models 1 and 6 are the broadest models in real and nominal terms, respectively, with all independent variables included. Models 5 and 9 are the narrowest possible models with only one independent variable left, exports revenue in real and nominal terms (Figures 16 and 17).

Figure 16. Pass-Through Coefficients: Country Level OLS Estimations

Countries	Models in real terms							Models in nominal terms						Ratios				
	1	2	3	4	5	St. Dev.	Average	6	7	8	9	St. Dev.	Average	1/6	2/7	3/8	4/9	Average
Afghanistan	0.7858	0.7841	0.7940	0.7424	0.7760	0.0201	0.7765	1.2538	1.2095	1.1106	0.7282	0.2392	1.0755	1.5956	1.5425	1.3987	0.9809	1.3852
Albania	0.4856	0.4902	0.5748	0.5706	0.5436	0.0429	0.5330	0.6351	0.6359	0.6128	0.5615	0.0349	0.6113	1.3079	1.2972	1.0661	0.9841	1.1470
Algeria								0.5317		0.4993		0.0229	0.5155					
Angola	0.7771	0.7869		0.6863		0.0555	0.7501	0.4924	0.4663	0.4612	0.3238	0.0760	0.4359	0.6336	0.5926		0.4718	0.5812
Antigua and Barbuda	0.9787	1.0429	1.0339	1.0216	1.1775	0.0749	1.0509	1.3389	1.4905	1.4687	0.9438	0.2534	1.3105	1.3680	1.4292	1.4205	0.9238	1.2470
Argentina	0.8758	0.8966	0.9679	0.9403		0.0417	0.9202	1.4050	1.4406	1.4064	1.4826	0.0366	1.4337	1.6042	1.6067	1.4530	1.5767	1.5581
Armenia	0.6458	0.4839	0.4402	0.5263	0.4794	0.0792	0.5151	0.9224	0.8360	0.8128		0.0578	0.8571	1.4283	1.7276	1.8464	0.0000	1.6638
Australia		0.8664					0.8664	1.0039	1.0197	1.0179	0.8181	0.0981	0.9649		1.1769			1.1137
Austria	0.7137	0.8042	0.7814	0.7791	0.7887	0.0348	0.7734	1.0735	1.0760	1.0760	1.0291	0.0231	1.0637	1.5041	1.3380	1.3770	1.3209	1.3753
Azerbaijan																		
Bahamas, The										1.0221	0.5233	0.3527	0.7727					
Bahrain					0.8875		0.8875	1.3505	1.3598	1.3362	0.7642	0.2925	1.2027					1.3551
Bangladesh				1.6218	0.8033	0.5788	1.2126	1.7319	1.6706	1.5845	1.1892	0.2442	1.5441				0.7333	1.2734
Barbados	1.4380	1.4396	1.4292	1.4513	0.7676	0.3006	1.3051			0.9173	0.8873	0.0212	0.9023			0.6418	0.6114	0.6913
Belarus	0.8762	0.8697	0.8970	0.8921	0.7829	0.0465	0.8636	0.9080	0.8896	0.8943	0.8773	0.0127	0.8923	1.0363	1.0229	0.9970	0.9834	1.0333
Belgium	0.9673	0.8954	0.9369	0.9490	0.9833	0.0335	0.9464	1.0924	1.0754	1.0744	1.0948	0.0108	1.0843	1.1293	1.2010	1.1468	1.1536	1.1457
Belize				0.7410	0.6950	0.0325	0.7180	1.8602	1.6520	1.6419	0.8602	0.4406	1.5036				1.1609	2.0941
Benin	1.0567	1.1068	1.1045	1.1278	0.4592	0.2873	0.9710	1.2324	1.2356	1.2267	0.8250	0.2033	1.1299	1.1663	1.1164	1.1106	0.7315	1.1637
Bhutan																		
Bolivia	1.2000	1.2569	1.2760	1.2779	0.5344	0.3228	1.1090	1.4307	1.3897	1.3220	0.5290	0.4283	1.1679	1.1923	1.1057	1.0361	0.4140	1.0530
Bosnia and Herzegovina								1.0599	1.0688	1.0670	0.5962	0.2345	0.9480					
Botswana								0.8136	0.7208	0.7223		0.0532	0.7522					
Brazil								1.1316	1.1372	1.1403	1.0899	0.0235	1.1248					
Brunei Darussalam								0.5720	0.5405	0.5702	0.4218	0.0710	0.5261					
Bulgaria				1.2264	0.7650	0.3263	0.9957	0.9334	0.9737	0.9786	0.9748	0.0213	0.9651				0.7948	0.9693
Burkina Faso	0.6088	0.6141	0.6007	0.8614	0.5562	0.1213	0.6482	1.1089	1.1063	1.0785	0.6619	0.2184	0.9889	1.8215	1.8015	1.7954	0.7684	1.5255
Burundi											0.5092		0.5092					
Cabo Verde	0.7519	0.7507	0.7376	0.7611		0.0097	0.7503	1.2793	1.2846	1.2951	0.5424	0.3720	1.1004	1.7014	1.7112	1.7558	0.7127	1.4665
Cambodia	0.6887	0.7023	0.7028	0.7360	0.7092	0.0174	0.7078	1.0812	1.0811	1.0515	0.7105	0.1809	0.9811	1.5699	1.5394	1.4962	0.9654	1.3861
Cameroon	0.4542			0.5037	0.4502	0.0298	0.4694	1.0849	1.0601	1.0255	0.7285	0.1660	0.9748	2.3886			1.4463	2.0767
Canada	1.2097	0.9356	0.9512	0.8966	0.7867	0.1557	0.9560	0.9563	0.9345	0.9354	0.7701	0.0866	0.8991	0.7905	0.9988	0.9834	0.8589	0.9405
Central African Republic								1.0274	1.0289	1.0234		0.0028	1.0266					
Chad								1.0969	1.0917	0.9939		0.0580	1.0608					
Chile				1.2977	1.1691	0.0909	1.2334	1.1047	1.1181	1.1167	0.8068	0.1533	1.0366				0.6217	0.8404
China					0.3747		0.3747	0.6030	0.8410	0.8591	0.9074	0.1360	0.8026					2.1420
Colombia								1.0273	1.0465	1.0556	0.8441	0.1002	0.9934					
Comoros	0.4504						0.4504	0.7315	0.7282	0.7844	0.4258	0.1632	0.6675	1.6241				1.4820
Congo, Democratic Republic of the				0.9525	0.8989	0.0379	0.9257	0.8525	0.7953	0.7983	0.8944	0.0475	0.8351				0.9390	0.9022
Congo, Republic of																		
Costa Rica	1.0517	1.2253	1.2126	1.0636	0.6304	0.2411	1.0367	1.1683	1.2359	1.2293	0.8615	0.1775	1.1238	1.1109	1.0087	1.0138	0.8100	1.0839
Cote d'Ivoire	1.8168	1.8106	1.7222			0.0529	1.7832	1.0214	0.9954	0.9909	0.7837	0.1103	0.9479	0.5622	0.5498	0.5754		0.5315
Croatia	0.6655	0.7785	1.1586	1.1518	0.9294	0.2203	0.9368	0.9821	1.0182	1.0634	0.9145	0.0629	0.9946	1.4757	1.3079	0.9178	0.7940	1.0617
Cyprus				1.3727	1.2167	0.1103	1.2947	1.3043	1.2823	1.3013	1.2613	0.0199	1.2873				0.9188	0.9943
Czech Republic	0.8417	0.9011	0.9063	0.9065	0.8645	0.0294	0.8840	0.9900	0.9959	0.9959	0.9554	0.0195	0.9843	1.1762	1.1052	1.0989	1.0539	1.1134
Denmark	0.9805	0.9355	0.9196	1.1134	1.0853	0.0879	1.0069	1.0988	1.1124	1.1206	1.0964	0.0115	1.1071	1.1207	1.1891	1.2186	0.9847	1.0995
Djibouti	1.2538						1.2538	3.1100		2.0591		0.7431	2.5846	2.4805				2.0614
Dominica									1.2219	1.2820	0.4024	0.4914	0.9688					
Dominican Republic				0.7936			0.7936	1.8151	1.5749	1.5747	1.1271	0.2872	1.5230				1.4202	1.9190
Ecuador			1.0712				1.0712	1.5687	1.5847	1.5562	0.6667	0.4517	1.3441			1.4528		1.2547
Egypt								1.2155	1.1989	1.1925	0.7131	0.2448	1.0800					
El Salvador	1.0952	1.3230	1.2637	1.2681	0.9464	0.1557	1.1793	1.4327	1.5877	1.3490	1.0277	0.2361	1.3493	1.3082	1.2001	1.0675	0.8104	1.1442
Equatorial Guinea				0.6113	0.5550	0.0398	0.5832										0.0000	0.0000
Eritrea	0.2835	0.2976	0.2969			0.0079	0.2927	1.2386	1.2057	1.1296		0.0559	1.1913	4.3690	4.0514	3.8046		4.0705
Estonia	0.9891	1.2217	1.2395	1.2232	1.1436	0.1043	1.1634	1.1094	1.1988	1.1815	1.1492	0.0393	1.1597	1.1216	0.9813	0.9532	0.9395	0.9968
Ethiopia								0.7953	0.7765	0.7198		0.0393	0.7639					
Fiji								1.1487	1.1668	1.1609	0.8306	0.1643	1.0768					
Finland	0.7481	0.7236	0.7219	0.8084	0.8164	0.0458	0.7637	1.0404	1.0325	1.0095	0.9665	0.0332	1.0122	1.3907	1.4269	1.3984	1.1956	1.3255
France	0.8556	0.8015	0.8349	0.8717	0.9002	0.0373	0.8528	1.0837	1.0772	1.0759	1.0729	0.0046	1.0774	1.2666	1.3440	1.2887	1.2308	1.2634
Gabon	0.7668						0.7668	0.3511	0.3455	0.3717		0.0138	0.3561	0.4579				0.4644
Gambia, The	0.9813	0.9932	0.9867	0.9845	0.8900	0.0433	0.9671	1.3570	1.3703	1.3763	1.0194	0.1744	1.2808	1.3829	1.3797	1.3949	1.0354	1.3243
Georgia								1.1581	1.1916	1.1926	1.1137	0.0372	1.1640					
Germany	0.7857	0.7614	0.7348	0.7722	0.7354	0.0225	0.7579	0.9881	0.9693	0.9710	0.9778	0.0085	0.9766	1.2576	1.2730	1.3214	1.2663	1.2885
Ghana	1.0690	1.0057	1.1084		0.6784	0.1959	0.9654	0.9354	0.9394	0.9375	0.7772	0.0801	0.8974	0.8750	0.9341	0.8458		0.9296
Greece	0.7046	0.7518	0.7528	0.7750	0.7757	0.0289	0.7520	1.1285	1.1353	1.2010	0.9011	0.1311	1.0915	1.6016	1.5101	1.5954	1.1627	1.4515
Grenada								1.8087	1.9581	1.7345		0.1139	1.8338					
Guatemala				1.1089	0.8926	0.1529	1.0008	1.1307	1.2943	1.2915	0.6102	0.3235	1.0817				0.5503	1.0809
Guinea	1.6061	1.6928	1.2133	1.1986	0.8561	0.3398	1.3134	1.3941	1.4010	1.4399	1.0437	0.1851	1.3197	0.8680	0.8276	1.1868	0.8708	1.0048
Guinea-Bissau	0.4383	0.4379	0.4226	0.4019	0.4217	0.0149	0.4245	0.5608	0.5637	0.5746	0.3105	0.1281	0.5024	1.2795	1.2873	1.3597	0.7726	1.1836
Guyana								0.9025	0.8961	0.8933	0.8143	0.0417	0.8766					
Haiti	0.6856	0.6270				0.0414	0.6563	1.1298	1.1223	1.1600	0.9884	0.0762	1.1001	1.6479	1.7900			1.6763
Honduras			0.6328	0.7071	0.6677	0.0372	0.6692	0.9598	0.9034	0.9058	0.8737	0.0359	0.9107			1.4314	1.2356	1.3608
Hong Kong SAR					0.9925		0.9925	1.2393	1.2068	1.2066	1.1178	0.0522	1.1926					1.2016
Hungary					0.7848		0.7848	0.9535	0.9904	0.9871	0.7712	0.1042	0.9256					1.1793
Iceland								0.8685	0.9075	0.9063	1.2085	0.1582	0.9727					
India	1.0368	0.9779	0.9704	0.7274	0.7599	0.1405	0.8945	1.3135	1.2545	1.2539	1.0814	0.1003	1.2258	1.2669	1.2829	1.2921	1.4867	1.3704
Indonesia	1.5510	1.5483	1.5236	1.4248	1.2820	0.1150	1.4659	1.2593	1.2645	1.2613	1.2610	0.0022	1.2615	0.8119	0.8167	0.8278	0.8850	0.8606
Iran			0.9017	0.7861		0.0817	0.8439	0.6993	0.6981	0.6913		0.0043	0.6962			0.7667	0.0000	0.8250
Iraq								0.4816	0.5020	0.6077		0.0677	0.5304					
Ireland	1.0712	1.1154	1.1285	1.1196	1.1222	0.0230	1.1114	1.0738	1.1392	1.1143	1.1122	0.0270	1.1099	1.0024	1.0213	0.9874	0.9934	0.9986
Israel	0.7057	0.7515	0.7670	0.7548	0.7519	0.0235	0.7462	1.1251	1.1125	1.1093	1.0312	0.0428	1.0945	1.5943	1.4804	1.4463	1.3662	1.4668
Italy	1.0115	0.8412	0.7889	0.7203	0.7610	0.1134	0.8246	0.9522	0.9367	0.9669	0.9916	0.0234	0.9619	0.9414	1.1135	1.2256	1.3766	1.1665
Jamaica								1.4305	1.4427	1.4109	1.0901	0.1695	1.3436					
Japan				0.4118	0.5245	0.0797	0.4682	1.0308	1.0236	1.0209	0.9498	0.0379	1.0063				2.3065	2.1495
Jordan	1.1795	1.0928	1.0346			0.0729	1.1023				0.7752		0.7752					0.7033
Kazakhstan				0.9391	0.8572	0.0579	0.8982	0.6341	0.6692	0.6630	0.5884	0.0368	0.6387				0.6266	0.7111
Kenya								1.4391	1.4249	1.3922	1.0794	0.1708	1.3339					
Kiribati					0.2551		0.2551	0.8217	0.8225	0.8123	0.3294	0.2448	0.6965					2.7302
Korea	1.2768	1.2226	1.0776	1.0189	0.9082	0.1501	1.1008	1.5762	1.4752	1.4781	1.2770	0.1255	1.4516	1.2345	1.2066	1.3717	1.2533	1.3187
Kosovo			0.0000	0.2688	0.2480	0.1495	0.1723	0.8802	0.8805	0.9099		0.0171	0.8902				0.0000	5.1676
Kuwait			0.5072	0.5096		0.0017	0.5084	0.6192	0.6400	0.6582	0.2046	0.2179	0.5305			1.2977	0.4015	1.0435
Kyrgyz Republic				0.8899	0.9039	0.0099	0.8969	1.1581	1.1518	1.1272	1.0069	0.0707	1.1110				1.1315	1.2387
Lao P.D.R.								0.9777	0.9700	0.9877	0.6223	0.1782	0.8894					
Latvia				1.2682	1.3055	0.0264	1.2869	1.2532	1.3785	1.4038	1.2113	0.0939	1.3117				0.9551	1.0193
Lebanon	0.8553	0.8865	0.7736		0.4512	0.1994	0.7417	1.6375	1.3265	1.3076	0.4974	0.4873	1.1923	1.9145	1.4963	1.6903		1.6076
Lesotho								1.0491	1.0101	1.0062	0.5227	0.2503	0.8970					
Liberia											1.3258		1.3258					
Libya	0.4870	0.4756	0.6631	0.6630	0.6309	0.0947	0.5839	0.4418	0.4437	0.4596	0.3947	0.0280	0.4350	0.9072	0.9329	0.6931	0.5953	0.7449

Legened Amlifiers | Absorbers | Blockers | No data

Figure 17. Pass-Through Coefficients: Country Level OLS Estimations (cont.)

Countries	Models in real terms							Models in nominal terms						Ratios				
	1	2	3	4	5	St. Dev.	Average	6	7	8	9	St. Dev.	Average	1/6	2/7	3/8	4/9	Average
Lithuania				1.2039	1.1124	0.0647	1.1582	1.2470	1.3019	1.2947	1.1253	0.0817	1.2422				0.9347	1.0726
Luxembourg					1.0311		1.0311	0.9539	0.9580	0.9581	1.0058	0.0246	0.9690					0.9397
Macedonia, FYR				0.6957	0.8000	0.0738	0.7479	0.9798	0.9600	0.9659	0.8100	0.0797	0.9289				1.1643	1.2421
Madagascar	0.7101	0.6989	0.7318	0.7066	0.5778	0.0612	0.6850	1.0227	1.0101	1.0016	0.7672	0.1224	0.9504	1.4402	1.4453	1.3687	1.0858	1.3874
Malawi																		
Malaysia	1.1941	1.1791	1.1555	1.3215	1.2340	0.0651	1.2168	1.2077	1.2307	1.2274	1.1536	0.0356	1.2049	1.0114	1.0438	1.0622	0.8729	0.9901
Maldives	0.3883	0.4369	0.4392	0.4273	0.3447	0.0405	0.4073				0.4170		0.4170				0.9759	1.0239
Mali								0.9223	0.9207	0.9304		0.0052	0.9245					
Malta								1.0037	1.0113	1.0132	0.9985	0.0068	1.0067					
Mauritania																		
Mauritius				1.0882	0.5642	0.3705	0.8262	0.7477	0.8001	0.8098	0.7551	0.0313	0.7782				0.6939	0.9419
Mexico	1.0672	0.9540	0.9681	0.9598	0.8497	0.0771	0.9598	1.1698	1.1447	1.1586	0.8196	0.1694	1.0732	1.0961	1.1999	1.1968	0.8539	1.1182
Micronesia																		
Moldova	0.7000	0.7874	0.9433	1.0020	0.9334	0.1250	0.8732	1.2655	1.2676	1.2588	1.0051	0.1295	1.1993	1.8079	1.6099	1.3345	1.0031	1.3734
Mongolia	0.9223	0.9184	0.9966	0.9653	0.9355	0.0330	0.9476	1.1062	1.0741	1.0629	0.7572	0.1630	1.0001	1.1994	1.1695	1.0665	0.7844	1.0554
Montenegro, Rep. of				1.5714	1.1686	0.2848	1.3700	1.6694	1.6006	1.5603	1.0712	0.2732	1.4754				0.6817	2.6923
Morocco	0.8925	0.8281	0.8134	0.8471	0.9092	0.0413	0.8581	1.1496	1.1591	1.1606	1.0754	0.0408	1.1362	1.2881	1.3997	1.4269	1.2695	1.3241
Mozambique								1.1159	1.0827	0.9711	0.6717	0.2022	0.9604					
Myanmar								0.8296	0.8333	1.0890	0.8747	0.1233	0.9067					
Namibia					0.8111		0.8111	0.7673	0.7152	0.7604	0.7621	0.0242	0.7513					0.9262
Nepal				0.5647	0.4544	0.0780	0.5096	1.1166	1.1079	1.1401	0.4933	0.3144	0.9645				0.8736	1.8928
Netherlands	1.1010	1.0970	1.0953	1.0535	0.9979	0.0441	1.0689	0.9116	0.9089	0.9157	0.9422	0.0153	0.9196	0.8280	0.8285	0.8360	0.8944	0.8603
New Zealand								1.1408	1.1683	1.1678	1.1675	0.0135	1.1611					
Nicaragua				1.0395	1.0258	0.0097	1.0327	1.6089	1.6168	1.3754	0.6546	0.4536	1.3139				0.6297	1.2724
Niger								0.6461	0.7065	0.7124	0.6893	0.0300	0.6886					
Nigeria								0.4177	0.4217	0.4150	0.4197	0.0029	0.4185					
Norway								1.0501	1.0953	1.0950	0.5293	0.2762	0.9424					
Oman								0.8866	0.8774	0.9147		0.0194	0.8929					
Pakistan	0.9839	0.9000	0.7086	0.6969		0.1424	0.8224	1.6990	1.6932	1.6774	1.0903	0.2999	1.5400	1.7268	1.8813	2.3672	1.5645	1.8727
Palau				0.5647	0.4451	0.0846	0.5049		0.9763	1.0007	0.8781	0.0649	0.9517				1.5550	1.8849
Panama	0.6494	0.6490	0.7685	0.8453	0.8293	0.0949	0.7483	2.0545	2.0487	1.9333	0.6253	0.6957	1.6655	3.1637	3.1567	2.5157	0.7397	2.2256
Papua New Guinea				1.1692	0.7901	0.2681	0.9797	1.1881	1.1879	0.9639	0.5794	0.2871	0.9798				0.4956	1.0002
Paraguay				0.9689	0.9506	0.0129	0.9598	1.3611	1.3581	1.3409	1.1699	0.0922	1.3075				1.2075	1.3623
Peru				0.9440			0.9440	1.6107	1.5982	1.5877	0.8476	0.3758	1.4111				0.8979	1.4948
Philippines	1.1033	1.0303	1.0063	0.9133	0.6944	0.1580	0.9495	1.2085	1.2057	1.1807	0.7901	0.2045	1.0963	1.0954	1.1702	1.1733	0.8651	1.1545
Poland	1.4528	1.5066	1.1906	1.2047	0.9889	0.2115	1.2687	1.1897	1.2146	1.2086	0.9772	0.1140	1.1475	0.8189	0.8062	1.0151	0.8112	0.9045
Portugal	1.1859	1.1056	0.9460	0.8715	0.8184	0.1558	0.9855	1.0269	1.0243	1.0646	0.9309	0.0569	1.0117	0.8659	0.9265	1.1254	1.0682	1.0266
Qatar								0.5548	0.5986	0.6101		0.0292	0.5878					
Romania	0.7592	1.1093	1.0162	0.8734	0.8446	0.1404	0.9206	1.2688	1.3132	1.3183	1.1535	0.0766	1.2635	1.6712	1.1838	1.2972	1.3207	1.3725
Russia					1.8701		1.8701	0.9002	0.9253	0.9173	0.9213	0.0110	0.9160					0.4898
Rwanda																		
Samoa																		
San Marino					0.8693		0.8693											
Sao Tome and Principe										0.4047			0.4047					
Saudi Arabia	1.6475	1.7092	1.7048	1.3116		0.1899	1.5933			0.9408	0.4174	0.3701	0.6791			0.5519	0.3182	0.4262
Senegal	0.8068	0.8863	0.8851	1.0439	0.6284	0.1509	0.8501	1.2279	1.2467	1.2461	1.1778	0.0324	1.2246	1.5219	1.4066	1.4079	1.1283	1.4406
Serbia				0.8499	0.7417	0.0765	0.7958	1.1325	1.1557	1.1306	1.0603	0.0413	1.1198				1.2476	1.4071
Seychelles				0.6477	0.6026	0.0319	0.6252	0.9935					0.9935					1.5892
Sierra Leone																		
Singapore					1.1207		1.1207	1.0304	1.0218	1.0306	1.0699	0.0215	1.0382					0.9264
Slovak Republic	0.6977	0.7984	0.7047	0.7741	0.7365	0.0436	0.7423	1.0602	1.0502	1.0509	0.9096	0.0722	1.0177	1.5196	1.3154	1.4913	1.1750	1.3711
Slovenia	1.0826	1.1499	1.1419	1.0983	0.9618	0.0755	1.0869	1.1763	1.1835	1.1959	1.1397	0.0242	1.1739	1.0866	1.0292	1.0473	1.0377	1.0800
Solomon Islands								1.2823	1.2807	1.3153	0.6325	0.3305	1.1277					
South Africa	1.4074	1.4892	1.4555	1.3301	1.1010	0.1549	1.3566	1.0997	1.1243	1.1246	1.1169	0.0117	1.1164	0.7814	0.7550	0.7727	0.8397	0.8229
Spain	1.0184	1.2774	1.2152	1.1554	1.1831	0.0961	1.1699	1.1427	1.2217	1.2439	1.2239	0.0447	1.2081	1.1221	0.9564	1.0236	1.0593	1.0326
Sri Lanka	1.0096	0.9761	0.9785	0.9259	0.8831	0.0500	0.9546	1.7403	1.7377	1.7171	1.4786	0.1270	1.6684	1.7238	1.7802	1.7548	1.5969	1.7477
St. Kitts and Nevis								1.1403	1.0146	0.9959		0.0785	1.0503					
St. Lucia								1.5495	1.6658	1.6682		0.0678	1.6279					
St. Vincent and the Grenadines								1.3838	1.3820	1.3604		0.0130	1.3754					
Sudan																		
Suriname								0.6718	0.6732	0.6583	0.5820	0.0434	0.6463					
Swaziland	0.6807	0.6749	0.6611	0.7343	0.5428	0.0705	0.6588	0.8699	0.8673	0.8726	0.7407	0.0647	0.8376	1.2779	1.2851	1.3199	1.0087	1.2715
Sweden	1.0321	0.9499	0.9455	0.9426	0.9495	0.0382	0.9639	0.9511	0.9506	0.9539	0.9552	0.0022	0.9527	0.9215	1.0007	1.0089	1.0134	0.9884
Switzerland				0.3930	0.7021	0.2186	0.5476	1.0150	1.0097	1.0030	1.0033	0.0057	1.0078				2.5529	1.8405
Syria									0.6934	0.6941	0.6053	0.0511	0.6643					
Taiwan Province of China				1.1470	1.1157	0.0221	1.1314	1.1196	1.1080	1.1088	1.2221	0.0552	1.1396				1.0655	1.0073
Tajikistan								0.7821	0.7905	0.8100	0.5648	0.1153	0.7369					
Tanzania			0.7737	0.7266		0.0333	0.7502											
Thailand	1.8846	1.8476	1.8039	1.8561	1.2623	0.2635	1.7309	1.6076	1.6011	1.6009	1.5645	0.0196	1.5935	0.8530	0.8666	0.8875	0.8429	0.9206
Togo			0.6871	0.9505	0.8460	0.1326	0.8279	1.1809	1.1619	1.1451	0.9680	0.0984	1.1140			1.6666	1.0184	1.3456
Tonga	0.2677	0.2587	0.2582	0.2561	0.2561	0.0048	0.2594	0.9476	0.9777	0.9496	0.3148	0.3220	0.7974	3.5398	3.7793	3.6778	1.2292	3.0746
Trinidad and Tobago											0.4572		0.4572					
Tunisia				0.8032	0.8773	0.0524	0.8403	0.8971	0.8931	0.8626	0.9155	0.0219	0.8921				1.1398	1.0617
Turkey								1.4366	1.4627	1.4644	1.3084	0.0742	1.4180					
Turkmenistan								0.4319					0.4319					
Uganda								1.0011	1.0128	1.0120	0.4993	0.2547	0.8813					
Ukraine	1.0331	1.0497	0.9786	1.1334	1.0223	0.0568	1.0434	1.1664	1.1744	1.1722	1.1137	0.0288	1.1567	1.1290	1.1188	1.1978	0.9826	1.1085
United Arab Emirates	0.7287	0.9247	1.0627	1.0604	1.0049	0.1390	0.9563	0.6747	0.6952	0.6639	0.6079	0.0373	0.6604	0.9259	0.7518	0.6247	0.5733	0.6906
United Kingdom	0.8967	0.9535	0.9601	0.8656	0.8647	0.0463	0.9081	0.9677	1.0250	1.0373	0.9757	0.0348	1.0014	1.0792	1.0750	1.0804	1.1272	1.1027
United States	0.6380	0.6386	0.6104	0.6714	0.9288	0.1311	0.6974	2.5034	2.6600	2.6931	1.1208	0.7536	2.2443	3.9238	4.1654	4.4120	1.6693	3.2179
Uruguay	0.8302	0.8245	0.8181	0.8796	1.1073	0.1228	0.8919	1.3166	1.3093	1.2996	1.2489	0.0306	1.2936	1.5859	1.5880	1.5886	1.4198	1.4503
Uzbekistan								1.0818	1.0846	1.1156	0.9750	0.0614	1.0643					
Vanuatu				0.8331	0.8195	0.0096	0.8263	1.0765	1.0838	1.0781	0.5991	0.2402	0.9594				0.7191	1.1610
Venezuela	0.6044	0.8220	0.6195	0.6811	1.3926	0.3293	0.8239	0.8763	0.8805	0.8427		0.0207	0.8665	1.4499	1.0712	1.3603		1.0517
Vietnam				0.9569	0.9507	0.0044	0.9538	1.2851	1.2327	1.2303	1.0374	0.1090	1.1964				1.0841	1.2543
Yemen	0.8530	0.8456	0.5097	0.5159		0.1943	0.6811				0.4453		0.4453				0.8632	0.6538
Zambia								0.7861	0.8080	0.8228	0.6059	0.1010	0.7557					
Zimbabwe								0.9121	0.9777	0.9896		0.0417	0.9598					

Total count	1	2	3	4	5	Average	6	7	8	9	Average	1.4074	1.3641	1.3474	0.9759	1.3125
B>1	30	26	27	37	23	1.2314	102	103	103	51	1.2455					
B<1	48	49	52	68	83	0.7593	57	55	61	97	0.7914					
B=0	89	92	88	62	61		26	27	21	37						

Legened Amlifiers | Absorbers | Blockers | No data

Source: Authors' estimates.

68. **The models allow identifying shock amplifiers, absorbers and blockers**. With only statistically significant β_i shown in Figures 3 and 4, countries with $\beta_i > 1$ can be treated as shock amplifiers, countries with $\beta_i < 1$ as shock absorbers where $\beta_i, < 0$ or statistically insignificant as shock blockers. While there is substantial heterogeneity among models in the assessment of the numerical values of β_i, on average across all countries the models in real and nominal terms produce very close β_i equal to 1.22 and 1.24 for shock amplifiers and 0.75 and 0.79 for shock absorbers. Moreover, the pass-through coefficients are relatively robust to model specifications, in particular in the case of China's key trading partners (Figure 18). For example, the pass-through coefficients for the United States are very robust to model specification and stay within the 0.64-0.67 range for most models in real terms and at 2.5-2.7 for models in nominal terms. Finally, the pass-through coefficients in nominal terms are on average about 30 percent higher than in real terms, the difference reflecting the price effects.

Figure 18. Pass-Through Coefficients: Top 10 China's Export and Import Partners

Export parnters	Models in real terms						Models in nominal terms				
	1	2	3	4	5	Average	6	7	8	9	Average
United States	0.6380	0.6386	0.6104	0.6714	0.9288	0.6974	2.5034	2.6600	2.6931	1.1208	2.2443
Hong Kong SAR					0.9925	0.9925	1.2393	1.2068	1.2066	1.1178	1.1926
Japan				0.4118	0.5245	0.4682	1.0308	1.0236	1.0209	0.9498	1.0063
Korea	1.2768	1.2226	1.0776	1.0189	0.9082	1.1008	1.5762	1.4752	1.4781	1.2770	1.4516
Germany	0.7857	0.7614	0.7348	0.7722	0.7354	0.7579	0.9881	0.9693	0.9710	0.9778	0.9766
Netherlands	1.1010	1.0970	1.0953	1.0535	0.9979	1.0689	0.9116	0.9089	0.9157	0.9422	0.9196
India	1.0368	0.9779	0.9704	0.7274	0.7599	0.8945	1.3135	1.2545	1.2539	1.0814	1.2258
United Kingdom	0.8967	0.9535	0.9601	0.8656	0.8647	0.9081	0.9677	1.0250	1.0373	0.9757	1.0014
Russia					1.8701	1.8701	0.9002	0.9253	0.9173	0.9213	0.9160
Singapore					1.1207	1.1207	1.0304	1.0218	1.0306	1.0699	1.0382
Australia		0.8664				0.8664	1.0039	1.0197	1.0179	0.8181	0.9649

Import partners	Models in real terms						Models in nominal terms				
	1	2	3	4	5	Average	6	7	8	9	Average
Hong Kong SAR					0.9925	0.9925	1.2393	1.2068	1.2066	1.1178	1.1926
Japan				0.4118	0.5245	0.4682	1.0308	1.0236	1.0209	0.9498	1.0063
Korea	1.2768	1.2226	1.0776	1.0189	0.9082	1.1008	1.5762	1.4752	1.4781	1.2770	1.4516
United States	0.6380	0.6386	0.6104	0.6714	0.9288	0.6974	2.5034	2.6600	2.6931	1.1208	2.2443
Australia		0.8664				0.8664	1.0039	1.0197	1.0179	0.8181	0.9649
Germany	0.7857	0.7614	0.7348	0.7722	0.7354	0.7579	0.9881	0.9693	0.9710	0.9778	0.9766
Saudi Arabia	1.6475	1.7092	1.7048	1.3116		1.5933			0.9408	0.4174	0.6791
Singapore					1.1207	1.1207	1.0304	1.0218	1.0306	1.0699	1.0382
Brazil							1.1316	1.1372	1.1403	1.0899	1.1248
Russia					1.8701	1.8701	0.9002	0.9253	0.9173	0.9213	0.9160
Argentina	0.8758	0.8966	0.9679	0.9403		0.9202	1.4050	1.4406	1.4064	1.4826	1.4337

Source: Authors' estimates.

69. **Any of the sets of the pass-through coefficients discussed above can be in principle used to estimate the spillover effects**. The selection of the set of coefficients for the spillover model has to take into account data and its possible interpretation. The fact the pass-through coefficients in real terms are available only for 167 countries compared to 185 countries in nominal terms, argues for the use of nominal models. However, the models in nominal terms does not allow distinguishing between price and volume effects in spillovers, both of which can be important, in particular in the case of large countries like China, which may argue for the selection of a model in real terms. At the same time, the small country

assumption which has to be applied in the case of a real model may be too restrictive and would underestimate possible price effects, which would be captured by nominal model. Finally, with the average pass-through coefficients very similar between the real and nominal models, the main difference between them are in the number of shock amplifies and shock blockers. The nominal model suggests that more countries would amplify shock and fewer block them compared with the real model, while the number of shock absorbers is broadly in the same range in both models. Therefore, a real model may underestimate the strength of spillovers as it includes only volume effects and restricts shock spillovers by a relatively large number of shock blockers, while a nominal model may overestimate the spillovers, as it captures the unspecified price effects, which lead to large pass-through coefficients for some significant countries.

70. **The pass-through coefficients from a nominal model, which are on average closest to the real model, were selected for the calculations in this paper.** Because building a full econometric model of the determinants driving nominal imports for each country is beyond the scope of this paper, a reduced model 9, in which imports depend contemporarily on exports revenue and all other factors captured by α, were selected for the estimation of pass-through coefficients.[4] According to this approach, 51 countries would amplify the shock with an average pass-through coefficient of 1.15. Further, 97 countries would absorb part of the shock with an average pass-through coefficient of 0.71, and finally 37 countries would block the incoming shock altogether. The average margin of error in the estimation of the magnitude of spillovers by this approach would be +/- 15 percent.

[4] In estimating the pass-through coefficients from exports to imports, only trade data is included and an assumption is made that the exchange rates and prices do not adjust quickly. Given that annual data are used in the estimation, such assumption may lead to biases in the pass-through coefficients. Also, an economy's status as shock amplifier, absorber, and blocker may depend on its participation in the global supply chain.