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Network Effects of International Shocks and Spillovers

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Network Effects of International Shocks and Spillovers

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Abstract

This paper proposes a method for assessing international spillovers from nominal demand shocks. It quantifies the impact of a shock in one country on all other countries. The paper concludes that the network effects in shock spillovers can be substantial, comparable, and often exceed the initial shock. Individual countries may amplify, absorb, or block spillovers. Most developed countries pass-through shocks, whereas low-income countries and oil exporters tend to block shock spillovers. The method is used to study demand shocks originating from a large and medium country, China and Ukraine respectively.

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Summary

This paper proposes a new method for assessing international spillovers from nominal demand shocks. The method is derived from complex network theory and quantifies the impact of a shock in the country affected by the crisis (called here the "epicenter country") on all other countries. In the first round, the drop in demand at the epicenter affects all its trading partners across the world (the direct spillover effect). In the second round, all affected trading partners propagate the shock to their respective partners (the spill-in effect). Finally, all countries affected by the shock in the first two rounds, radiate the shock back to the epicenter country (the spill-back effect). The method assumes that in the short run the countries affected by the shock cannot take measures to prevent spillovers.

- The strength of shock spillovers can be amplified by network effects, which can be captured and quantified by the method proposed in this paper. The network effects may exceed the initial shock in magnitude.
- The impact from a domestic demand shock can be calculated for any other country, region, and the epicenter country itself; the results can be used for policy recommendations.
- The size of the network effects is generally higher for small open economies and lower for large and relatively closed economies.
- The profile of spillovers depends on the network structure, including the size and location of the epicenter country in the network, the number and economic characteristics of its partners, and the direction and strength of economic flows among them.
- Individual countries may amplify, absorb or block spillovers. About 40 percent of countries block, 40 percent absorb and 20 percent amplify shocks.
- Most developed countries pass through shocks by either amplifying them or absorbing part of their strength. Low-income countries and commodity exporters typically block shocks.
- Countries capable to transmit shocks should bear special responsibility for international economic stability. Economic policies in spillover amplifiers (e.g., US, Switzerland, Italy, Korea, and India) and some spillover absorbers (e.g., Japan, Germany, France) may help attenuate the impact of spillovers from negative demand shocks in large countries.

I. INTRODUCTION

1. **International spillovers reflect the impact of macroeconomic changes, possibly following a policy action, in one country on other countries.** The spillovers are possible because of the integrated nature of the international economy, where any country is linked to other countries across the world by multiple flows captured in its balance of payments. Such patterns reflect the multilayer network properties of balance of payments flows generated in the epicenter country and propagating to its economic partners across the world.

2. **International spillovers originate from a shock at the epicenter country**. Usually, such shocks are driven by an unexpectedly lower GDP growth compared with the baseline projections. The lower than expected growth can reflect domestic developments in the epicenter country, such as a domestic banking crisis, loss of consumer confidence, fiscal contraction, or exogenous developments such as a drop in international prices for the main export commodity, natural disasters, or geopolitical crises. Spillovers may also originate in policy actions taken unilaterally by governments, such as a decision to restrict imports based on political considerations (sanctions) or in retaliation for its trading partners' actions (dumping, export subsidies).

3. **Spillovers operate through several channels.** Any balance of payments flow can be a potential channel of shock transmission, with varying implications for partner countries depending on the channels involved. Trade and financial flows are the most important channels of shock spillovers for most countries. Growth slowdown usually has a negative impact on demand for imports of the affected country with substantial spillovers on its trading partners. From the supply side, such shocks can disrupt global supply chains and would negatively affect production in partner countries. Financial spillovers are also important as cross-border claims of banks and equity holdings have grown recently. Other channels that may be important for some countries include remittances, direct and portfolio investment, tourism, and commodity prices. Countries may amplify, absorb or block spillovers depending on the structures of their economies.

4. **The purpose of the paper is to develop a method for assessment of the network effects in cross-border shock spillovers.** The network effects are defined as second-round effects derived from the network structure of balance of payments flows. Such effects have been largely disregarded in the existing literature on spillovers but can be substantial and at times exceed the initial shock. This paper proposes a method 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 flows, and captures spillovers from the initial shock and the subsequent network effects, including spillin and spillback effects. The method is illustrated by application to spillovers from an import demand shock in a large and medium country (China and Ukraine) through the trade channel.

5. **To model international spillovers on a network, the paper proceeds as follows.** Section II reviews the exiting literature and proposes a network model of economic spillovers. Section III discusses the empirics of spillovers in a network context. Section IV applies the model to spillovers originating from a large and a medium country. Finally, section V presents conclusions and practical recommendations.

II. THE NETWORK ECONOMICS OF SPILLOVERS

A. Literature Review

6. **Models of spillovers on networks have been seen in the existing literature as a variation of the standard cascading model well known from the network theory.** Jackson (2010) bases the discussion of cascade propagation on a simple Bass model for innovations where the speed and timing of adoption depends on the degree of innovativeness by innovators and the degree of imitation among adopters. This initial setup is then supplemented with elements from the percolation theory on networks to model fictions for shock diffusion. Newman (2010) introduces spillovers in the form of epidemics on the networks, mainly in terms of spreads of contagion diseases and computer viruses, and systematically goes over the susceptible-infectious (SI), susceptible-infectious-removed (SIR), and susceptible-infectious-susceptible (SIS) models, their degree approximation and time-dependent properties. In the same vein, Easley and Kleinberg (2010) see the diffusion on a network many as an epidemic process represented by the SIS model and its extensions and knowledge-spreading process as a branching process.

7. **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. However, target countries affected by such a shock are in turn better able to dissipate the impact if they are well integrated into the 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. The theorem states that relative changes in bilateral trade volumes can be estimated on the basis of changes in the GDP of trade partners, as relative changes in GDP translate into changes in bilateral trade volumes. Finally, Fagiolo and others (2014) analyzed spillovers using Leontief input-output matrices connecting industrial sectors in several European countries. They show that the impact of economic shocks strongly depends on the nature of the shock and country size. Shocks that impact the final demand have on average a large but very homogeneous impact. Conversely, if shocks change the input-output structures, the spillovers are large but more heterogeneous.

8. **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 methodology; (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 them; finally (iv) it proposes macroeconomic interpretations of a number of network concepts and metrics.

B. The Economics of Spillovers

9. **The balance of payments can be viewed as a multilayer network.** In line with Kivelä (2014), the trade balance of the current account, that is, a single-layer network can be seen as an elementary layer of a multilayer balance of payments network, which can have any number of dimensions (aspects). Therefore, only one balance of payments layer, the international trade, and payments related only to trade flows are considered in this paper, although its methodology can be extended to other flows in a multilayer balance of payments presentation.

10. **For a multilayer network presentation, bilateral data on each balance of payments flow are needed.** Currently, such data remain scarce and highly incomplete, although attempts to compile bilateral balance of payments are underway, in particular in developed countries. For the current account, only bilateral trade data are available from the United Nations Commodity Trade Statistics Database (UN Comtrade). It contains detailed bilateral exports and imports of goods in terms of value and quantity from 1962 to present for over 200 countries and areas (UN, 2014). For the capital and financial accounts of the balance of payments, the Coordinated Portfolio Investment Survey is the only global survey of portfolio investment holdings that collects information on cross-border holdings of equities and long- and short-term debt securities classified by the economy of residence of the issuer for 74 countries for 2001–2012 in line with the IMF's balance of payments method.

11. **Most macroeconomic shocks to an individual country spill over to its economic partners through one or several layers of the balance of payments network.** Assume the exchange rate and prices do not adjust quickly. In this simplest case, the shock can be viewed as affecting only the country's nominal imports, as the drop on aggregate demand leads to lower demand for both domestic and imported goods. Although other balance of payments flows may also be affected, assume for a moment that they do not change, at least in the short run. Marginal propensity to import can be calculated for each country as

$$MPM = \Delta \mathrm{M}/\Delta \mathrm{Y} \qquad (1)$$

and would show the extent to which imports are induced by changes in nominal GDP, possibly with a lag of n. Therefore, lower than expected growth or an outright growth collapse driven by any domestic reasons would directly affect the capacity of the affected country to import from the rest of the world.

12. **In most cases, import demand shocks are generated by a difference between the projected and the actual real growth of the affected country.** The projected growth of imports M_t^{proj} depends on the growth rate of GDP (Y^{proj}) and the marginal propensity to import MPM

$$M_{t+1}^{proj} = M_t\left(1 + Y^{proj} * MPM_t\right) \quad (2)$$

Suppose the actual growth of imports was

$$M_{t+1}^{act} = M_t\left(1 + (Y^{proj} - dY) * MPM_t\right) \quad (3)$$

where $dY = (Y^{proj} - Y^{act})$, that is, dY is growth shortfall. Therefore, imports shortfall in nominal terms is

$$M_{t+1}^{act} - M_{t+1}^{proj} = M_t(-dY) * MPM_t) \quad (4)$$

13. **The demand shock can spill over to other countries through the trade channel if imports depend on exports revenue**. A country's i capacity to pay for imports critically depends on its ability to generate sufficient revenue from exports, probably with lags n, that is.

$$M_t^i = f(X_t^i, X_{t-1}^i, \ldots X_{t-n}^i) \quad (5)$$

In this case, export revenue of a country can be viewed as an important budget constraint on its imports.

14. **For the imports to depend on exports, some empirical studies point to the need for a cointegration relationship between *X* and *M*.** It is viewed as a broader precondition for long-run sustainability of a country's trade and current account balances, implying certain synchronicity in their changes (Husted, 1992). In line with Ericsson (2011) cointegration between exports and imports was estimated as

$$\Delta \mathrm{M_t} = \alpha \Delta \mathrm{X_t} + \beta(\mathrm{M_{t-1}} - \gamma \mathrm{X_{t-1}}) + \varepsilon_t \quad (6)$$

where $\alpha\Delta \mathrm{X_t}$ can be interpreted as an immediate impact of the change X in on the change in M and, therefore, α as a short-run elasticity; $\beta(\mathrm{M_{t-1}} - \gamma \mathrm{X_{t-1}})$ can be viewed as a disequilibrium effect, where $(\mathrm{M_{t-1}} - \gamma \mathrm{X_{t-1}})$ as an error-correction term, β as a feedback coefficient, and γas a long-run elasticity. If in a particular country, there is cointegration between imports and exports, and therefore the cointegration vector that inflicts certain synchronicity in import changes driven by changes in export revenue, this country will relay the shock and will create the next shock wave. The short-term elasticity α will indicate the magnitude of the immediate shock transmission, whereas the coefficient γ will point to its potential magnitude in the long run. If there is no cointegration in a country, the initial shock, which hits it, will all be absorbed by the country itself and will not spill over further. Empirically, while *X* and *M* were found cointegrated in the cases of 35 out of 50 countries, including the United States, Australia, and some other developed countries (Arize, 2002), this is not the case in developing countries. Narayan (2005) found that exports and imports are cointegrated only for 6 out of the 22 countries included in the sample.

15. **In addition to cointegration, import dependency on exports revenue can be presented as a simple elasticity of imports to exports revenue and learned from the data**. For small changes in values, the elasticity can be estimated in logarithms or absolute changes in the case if nominal values of the intercept are significant and dominate the log-level parameters. As this is the case in the trade data, an equation

$$\Delta M_{t-n}^i / M_t^i = \alpha_t + \beta_t \, \Delta X_{t-n}^i / X_t^i + \varepsilon_t \quad (7)$$

can be estimated for each country i. Parameter β can be viewed then as a *pass-through coefficient* for shock spillovers through each country.

16. **Exports revenue is only one of many factors affecting import demand**. Exported goods are only part of the goods produced by any economy, while other goods are consumed or invested domestically. Therefore, income obtained by a country through exporting its goods is only a part of the income generated by its economy. Arriving at full import demand would require estimating real demand for imports in the form of $m = f(y, p)$, where, m is the volume of imports, y is real GDP, and p is a vector of relative domestic and foreign prices, including the exchange rate. As it is not the purpose of this paper to estimate the comprehensive import demand equation of each country, it focuses only on the income derived from exports assuming that all other factors driving imports are captured by the constant.

17. **The estimated pass-through coefficients may 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 may 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.

18. **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.

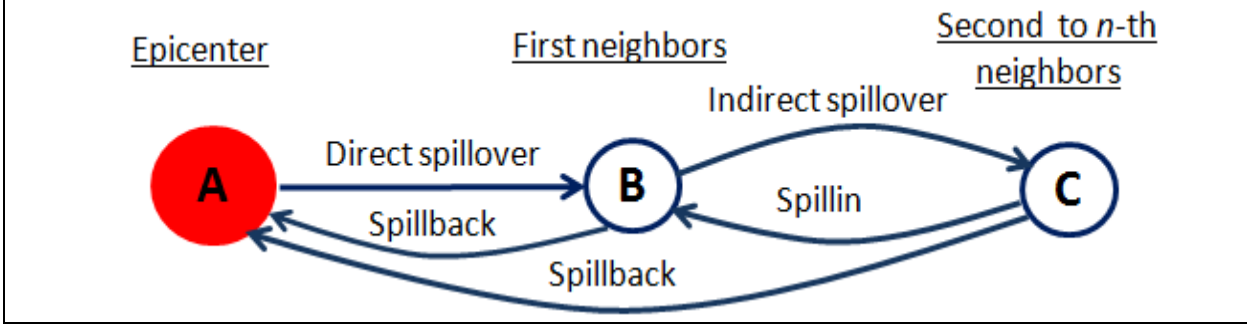
- *Second and sequential rounds*: the variably lower GDP growth rate of the immediate trading partners of the epicenter country will translate in a demand shock for their trading partners, which at this stage is not uniform but rather proportional to the decline in export revenue of each of the immediate 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.

C. Network Representation of Spillovers

19. **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. The network is directed because the links that represent revenue from exports and payments for imports explicitly denote a flow from one country to another. The network is weighted because all links reflect some value of payment that is different for each country and each flow. The network is incomplete as not all countries of the world are connected with each other through trade. Finally, the network is asymmetric because for most countries the number of export partners (out-links) differs from the number of import partners (in-links).

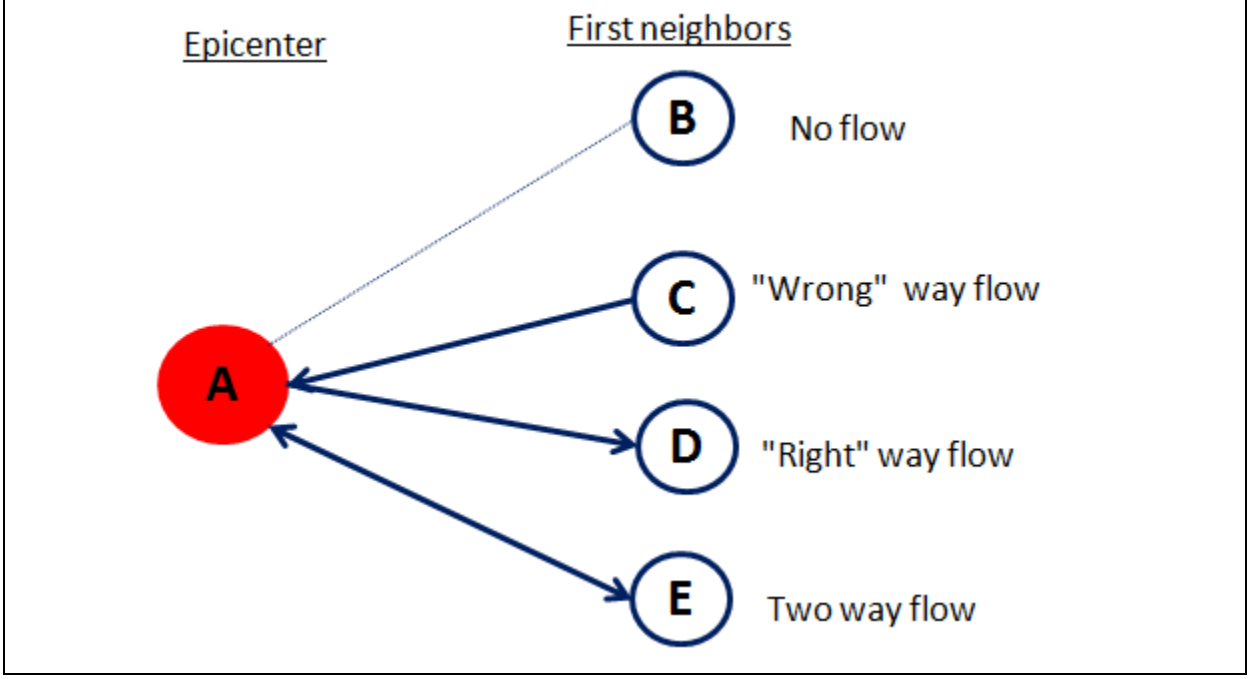
20. **Three types of countries can be identified in an international trade network from the shock spillover perspective**. Assume that that the shock originates in *an epicenter A* (Figure 1), which is the country affected by a domestic demand shock. The epicenter country is surrounded and directly connected to its *first neighbors*, that is, its immediate trading partners. The number of first neighbors is very limited for small developing countries, such as Burundi, Tonga, Guinea-Bissau, Solomon Islands, São Tomé and Príncipe, Comoros, and Vanuatu, which export to and import from not more than 40–50 other countries. Conversely, first neighbors of the world's largest trading nations (China, United States, Germany, Netherlands, Turkey) include virtually all other countries of the world, as each of them trade with165–169 countries. Through its first neighbors, the epicenter country is indirectly connected to *second neighbors*, that is, countries directly connected to its first neighbors. As its second neighbors are in turn connected to some other countries that are their immediate neighbors, the epicenter country will be indirectly connected to its *third neighbors*, and so on. In this setup, a *spillover* effect can be defined as a cascade effect by which the initial shock spills from the epicenter country over its first neighbors and, through first neighbors that pass through the shock to its second to *n*th neighbors. The spillover of the shock between the epicenter and its first neighbors can be called a *direct spillover*. The spillover from the first neighbor to second through the *n*th neighbor could be considered *indirect spillovers*. A *spillback* is then the ricochet impact from any of the neighbors to the epicenter country and a *spillin* effect is the ricochet impact on first neighbors from the second to the *n*th neighbors.

Figure 1. Countries and Effects in the Trade Network



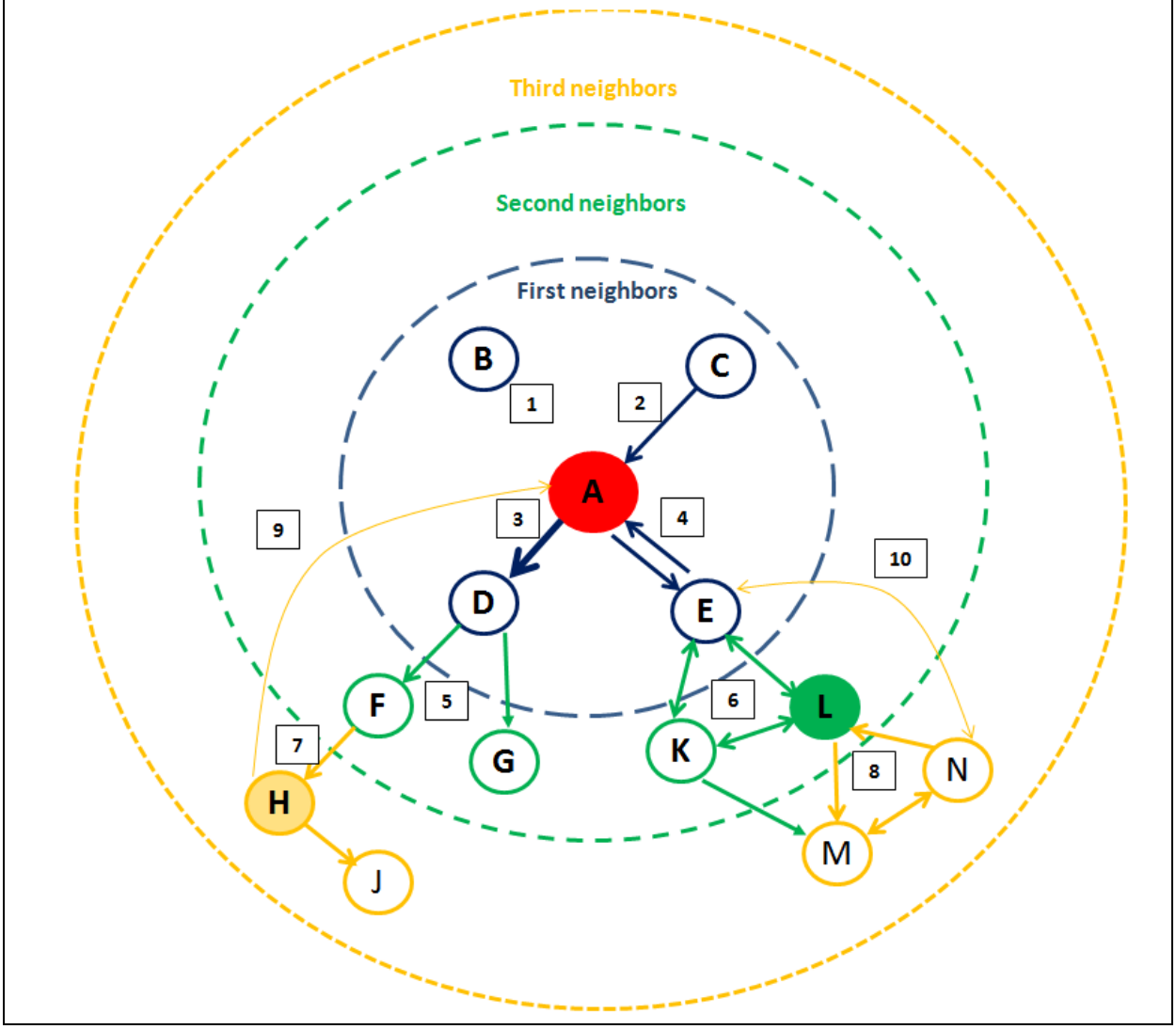
21. **Several elementary types of links are possible within such a network**. From the position of the epicenter, there are the following four possible options (Figure 2): (a) If there are no links in any direction and therefore there can be no direct impact from a shock in *A* on *B*, which does not exclude an indirect impact through the spillin effect. (b) There may 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 may 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*. The strength of the initial spillover of the shock and of the spillback and spillins effect depends on the relative weights of each link.

Figure 2. Links in the Trade Network



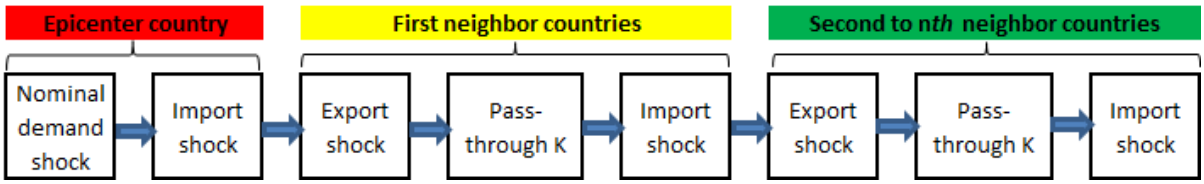
22. **Other than the elementary links, countries through their links in the trade network can be part of most standard network topologies**. Suppose the network consists of countries (*A* ... *Z*). Country *A* is the epicenter of the shock and is surrounded by neighbors as discussed below (Figure 3). When considering the first phase of shock spillovers, country *A* together with its first neighbors *D* and *E* represents a *star* with links 1) to 4), of which only 3) and 4) can spill over shocks. At the subsequent phases of shock spillovers, possible link topologies include 5) a *tree*, when country *D* can spillover the shock to *F* and *G* to which it is linked in one direction, without loops for spillins; 6) a *ring*, when countries *E*, *K*, and *L* are all interlinked in both directions; the spillover and spillins will depend on the relative weight of links and other factors; 7) countries *D*, *F*, *H*, *G* are linked sequentially with no spillins, thus forming a *line*; 8) countries *L*, *M*, and *N* are also linked sequentially, but feedback between *M* and *N* may be viewed as a *mesh*; 9) can be *spillback* from any neighbor, such as *H*, all the way back to the epicenter country *A*; or finally 10) a *spillin* to any other neighbor of lower or higher order, such as from *N* to *E*. Moreover, some countries such as *H* may not pass through shock at all and country *J*, which is at the end of the line, will not be affected. However, irrespective that country *L* does not pass through shocks either, countries *M* and *N*, which are directly linked to it, will be affected anyway, as the shock will reach them through country *K*. Needless to say that the real life topology of the trade network is much more complex than this simple illustration.

Figure 3. A Network Representation of a Macroeconomic Shock



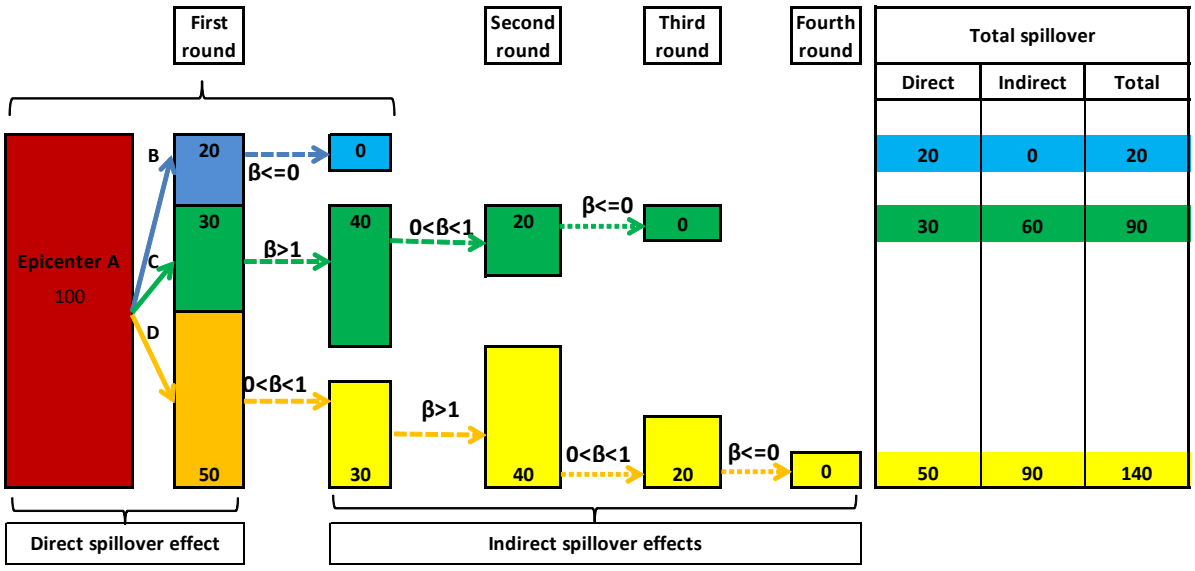
23. **Two types of shocks emerge in the spillover process**. An *import shock* in the epicenter country can be defined as a drop in its import demand driven by any reason. An *export revenue shock* can be defined as a drop in export revenue of the epicenter country's trading partners because of the import demand shock (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 may pass through to their imports or may die if the country because of its economic structure does not pass through shocks. First neighbors will be hit by both the direct shock from the epicenter and spillins from other first neighbors. Therefore, 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. Types of Spillover Shocks



24. **Finally, international shocks will spill from the epicenter over neighbors in several rounds reflecting the network structure of international flows**. Assume that epicenter country *A* has only three first neighbors—*B*, *C*, and *D*. At the *first round*, country *A* is affected by a domestic demand crisis and as a result its imports from its neighbors drop by 100. The immediate spillover effect is trivial as the decline in imports by *A* is translated into a loss of exports revenue by the three neighbors proportionally to the share of *A* in their exports. Suppose that export revenue of *B*, *C*, and *D* drops by 20, 30, and 50, respectively. Country *B* does not pass through shocks and irrespective of the loss of revenue continues to import from other countries at the same rate. There is no secondary spillover effect. Country *C* amplifies the initial shock and its loss of exports revenue of 30 translates into a drop of its imports from all other countries by 40. Country *D* absorbs part of the initial shock, and its loss of export revenue of 50 translates into a drop of its imports from all other countries only by 30. At the *second round*, only countries *C* and *D* spill over the shock further, as the decrease of their imports leads again to a drop in export revenue of their trading partners. Assume that for country *C* the network of trading partners is such that on average they absorb part of the shock and the reduction of their export revenue by 40 leads to the reduction of their imports from country *C* by only 20. For country *D* the situation is different. Because of the specificity of the network of its trading partners, they amplify the secondary shock; and the drop in their export revenue by 30 leads to the decrease of their imports by 40. At the *third round*, the shock dies for country *C* but persists for country *D*, although substantially weakened, at 20. Finally, at the *fourth round*, the shock dies out also for country *D*. As a result of this multistep spillover process, the total spillover effect may be substantially larger than the immediately observed and largely trivial spillover effect, as in most cases it would be supplemented by secondary spillover effects, whose magnitude critically depends on the properties of the international network.

Figure 5. Spillover Rounds



25. **The immediate spillover effect is generally well understood**. The list of immediate trading partners of each country is well known, their MPM can be easily calculated, and the distribution of the impact can be immediately assessed based on the share of the epicenter country in their exports. The secondary spillover effects are lesser known and generally poorly understood because of the complexities in the assessment of the network effects on shock spillovers.

D. A Network Model of Spillovers

26. **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.

27. **A cascade step is a process of transforming the initial import demand shock at the epicenter country into an export revenue shock for its first neighbors**. Schematically, each round of the spillover cascade consists of two steps: (i) the initial import demand shock $(\Delta M_1, \dots, \Delta M_N)$ is distributed proportionally among exporters to the epicenter country and by definition creates a vector of shocks to their export revenue $(\Delta X_1, \dots, \Delta X_N)$, that is,

$$(\Delta M_1, \dots, \Delta M_N) \to (\Delta X_1, \dots, \Delta X_N) \qquad (8)$$

(ii) the shock to export revenue creates reduced their demand for imports and creates a cascade of import shocks in first neighbors $(\Delta \widetilde{M}_1, \dots, \Delta \widetilde{M}_N)$, that is,

$$(\Delta X_1, \dots, \Delta X_N) \to (\Delta \widetilde{M}_1, \dots, \Delta \widetilde{M}_N) \tag{9}$$

28. **Import shocks are generated by the following mechanism**. Assume that total imports $\vec{M} = (M_1, \dots, M_N)$ of the epicenter country have dropped by $\Delta\vec{M}$, that is, in value terms it dropped to $\vec{M} - \Delta\vec{M}$.[2] A negative import demand shock $\Delta\vec{M}$ in the epicenter country by definition translates in losses in export revenue $\{\Delta w_{ij}\}$ for all countries $\{i\}$ that export to the epicenter country j.

$$\Delta M_j = \sum_{i=1}^{N} \Delta w_{ij} \tag{10}$$

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

$$\Delta w_{ij} = \frac{w_{ij}}{\sum_{k=1}^{N} w_{kj}} \Delta M_j \equiv w_{ij} \frac{\Delta M_j}{M_j} \tag{11}$$

The first round therefore generates a transformation of the export-import matrix $W \to \widetilde{W}$, where

$$W = \begin{pmatrix} w_{11} & \cdots & w_{1j} & \cdots & w_{1N} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{N1} & \cdots & w_{Nj} & \cdots & w_{NN} \end{pmatrix} \tag{12}$$

turns into

$$\widetilde{W} = W - \Delta W \tag{13}$$

where

$$\Delta W = \begin{pmatrix} \Delta w_{11} & \cdots & \Delta w_{1j} & \cdots & \Delta w_{1N} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \Delta w_{N1} & \cdots & \Delta w_{Nj} & \cdots & \Delta w_{NN} \end{pmatrix} \tag{14}$$

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

$$\Delta X_i = \sum_{j=1}^{N} \Delta w_{ij} \equiv \sum_{j=1}^{N} \frac{w_{ij}}{M_j} \Delta M_j \tag{15}$$

The equation can be presented in two equivalent forms:

- As a matrix multiplication

$$\Delta\vec{X} = W \frac{\Delta\vec{M}}{\vec{M}} \tag{16}$$

[2] The original shock can be set as percent r of a country's GDP ($\Delta\vec{M} = rY$) and the final impact can be calculated also in percent of GDP. But for the calculation of the spillover within the cascade, the shock should be measured directly in dollars to ensure additivity of spillover effects for each affected country.

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 using eq. 15, it can be written in a matrix form

$$\Delta\vec{X} = \Omega\Delta\vec{M} \tag{17}$$

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

29. **The key 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**. In the simplest case, a linear relation can be assumed between export revenue and the ensuing imports, so that the import shock $\Delta\widetilde{M}_i$ generated by the export revenue shock ΔX_i is on average determined by

$$\frac{\Delta\widetilde{M}_i}{M_i} = \alpha_i + \beta_i\left(\frac{\Delta X_i}{X_i}\right) + \varepsilon_i \tag{18}$$

or

$$\Delta\widetilde{M}_i = M_i\left(1 - \left(1 - \frac{\Delta X_i}{X_i}\right)^{\beta_i}\right) \tag{19}$$

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

30. **The spillover process can be summarized as follows (**see Box 1 for a numerical example):

- An import demand shock at the epicenter country reduces export revenue of its first neighbor

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

- The overall drop of export revenue is proportional to the relative share of each affected country in the epicenter countries' imports

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

- The drop in their export revenue leads to a secondary import shock

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

- The redistribution of the shock transforms the initial export-import matrix

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

- The drop of exports revenue leads to a drop in imports at the second round

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

Box 1. Shock Spillover - Example

Assume that the world consists of three countries A, B, and C. Their bilateral trade is

	A	B	C
A	0	30	50
B	10	0	60
C	20	40	0

with exports (X) shown in rows and imports (M) in columns. Therefore, exports by A to B is $X_{AB} = 30$ and the total exports by A is $X_A = 0 + 30 + 50 = 80$. Similarly, imports by A from B is $M_{AB} = 10$ and the total imports by A is $M_A = 0 + 10 + 20 = 30$.

In a matrix notation, bilateral trade can be represented as an export-import matrix (W)

$$W = \begin{pmatrix} 0 & 30 & 50 \\ 10 & 0 & 60 \\ 20 & 40 & 0 \end{pmatrix}$$

Assume now that A is affected by a demand shock and its imports from the rest of the world drops by 10 percent, i.e. by 1 from B and by 2 from C:

$$\begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 2 & 0 & 0 \end{pmatrix}$$

Therefore, the total import shock in A is $\Delta M_A = 0 + 1 + 2 = 3$ (the sum of the first column) Because there is no import shock in B and C, $\Delta M_B = 0$ and $\Delta M_C = 0$ (sums of the second and third columns), and the overall import shock is $(3 \quad 0 \quad 0)$.

This import shock leads to the following transformation of the export-import matrix

$$\widetilde{W} = \begin{pmatrix} 0 & 30 & 50 \\ 10 & 0 & 60 \\ 20 & 40 & 0 \end{pmatrix} - \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 2 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 30 & 50 \\ 9 & 0 & 60 \\ 18 & 40 & 0 \end{pmatrix}$$

and the loss of export revenue by first neighbors is

$$\begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 2 & 0 & 0 \end{pmatrix}$$

where the export revenue loss for B is $\Delta X_B = 1 + 0 + 0 = 1$ (the sum across the second row) and for C is $\Delta X_C = 2 + 0 + 0 = 2$ (the sum across the third raw).

Assume now that A is a shock blocker and does not to pass through shocks at all, B is a shock absorber and passes through only 0.5 of the initial shock, and C is a shock amplifier with a pass-through coefficient of 1.5.

Because B and C lost part of their export revenue, they have to reduce imports from other countries and thus generate secondary import shocks:

$$\Delta M_B = M_B\left(1-\left(1-\frac{\Delta X_B}{X_B}\right)^{0.5}\right) = (30+40)\left(1-\left(1-\frac{1}{10+60}\right)^{0.5}\right) \approx 0.5$$

$$\Delta M_C = M_C\left(1-\left(1-\frac{\Delta X_C}{X_C}\right)^{1.5}\right) = (50+60)\left(1-\left(1-\frac{2}{20+40}\right)^{1.5}\right) \approx 5.5$$

Therefore, the newly generated import shocks are $\Delta M_B \approx 0.5$ and $\Delta M_C \approx 5.5$.

A complete first round consists of a transformation of the export-import matrix

$$\begin{pmatrix} 0 & 30 & 50 \\ 10 & 0 & 60 \\ 20 & 40 & 0 \end{pmatrix} \rightarrow \begin{pmatrix} 0 & 30 & 50 \\ 9 & 0 & 60 \\ 18 & 40 & 0 \end{pmatrix}$$

and a pass through of a shock to export revenue to imports: the initial total import shock in A of $\Delta M = (3 \quad 0 \quad 0)$ is transformed into an export revenue shock for B of $\Delta X_B = 1$ and for C of $\Delta X_C = 2$ or $\begin{pmatrix} 0 \\ 1 \\ 2 \end{pmatrix}$, and further into and import shock for B of $\Delta M_B = 0.5$ because it absorbs part of the shock and for C of $\Delta M_C = 1.5$ because it amplifies the shock:

$$(3 \quad 0 \quad 0) \rightarrow \begin{pmatrix} 0 \\ 1 \\ 2 \end{pmatrix} \rightarrow (0 \quad 0.5 \quad 5.5)$$

The second round would be an application of the newly generated import shock $(0 \quad 0.5 \quad 5.5)$ to the transformed export-import matrix $\begin{pmatrix} 0 & 30 & 50 \\ 9 & 0 & 60 \\ 18 & 40 & 0 \end{pmatrix}$.

The subsequent rounds of shock spillovers are similar and continue until the shock becomes insignificant, usually after four rounds.

31. **The spillover process continues for several rounds before it dies out.** This version of the proposed algorithm uses contemporaneous import and export data from the same matrix. In more general versions, the corresponding matrices can lag, and more generic functional dependencies between import and export can be considered.

III. DATA, PASS-THROUGH COEFFICIENTS, AND SHOCK CALIBRATION

A. Data

32. The **dataset is derived from COMTRADE bilateral flows for 1993–2013.** There are 184 countries (nodes) and bilateral trade flows among them (weighted directional links) in the original. Because of data deficiencies, the following 14 countries were excluded from the analysis—ATG, BTN, BWA, ERI, KIR, LSO, MNE, NAM, SRB, SWZ, TLS, TUV, TWN, UVK (Annex 1). Overall, these are small countries with the share in the world imports not exceeding 2 percent. For some other important countries, estimation periods were constrained by data availability. For example, bilateral trade data for Belgium and Luxembourg are not available for 1993–96 and for South Africa for 1993–97. Therefore, the whole sample contains 170 countries. Of 28,730 possible bidirectional trade flows, 9,029

(about 31 percent) are absent, that is, there is no trade in either direction or one of the directions. The estimation period covers 1993–2013. Restricting the estimation period would allow capturing better bilateral trade of new countries that emerged in place of the former Soviet Union, Yugoslavia, and Czechoslovakia in the early 1990s. The data on exports and imports for each of the countries included in this study were aggregated into adjacency matrices, a mathematical representation of a weighted graph that helps identify the nodes (countries) and links (trade flows) among them.

B. Pass-Through Coefficients

33. **The pass-through coefficients for each country were estimated on a panel with fixed effects.** The panel included 170 countries with the data for nominal values of exports and imports for 1993–2013. Eq. (7) was estimated on contemporaneous changes in nominal values of exports and imports. A log-linear specification of the model would be preferable, but the nominal values of the intercept α in many cases become dominant and overshadow β if taken as a log. Three specification of this model were considered: model 1 with an intercept and no lags, model 2 with no intercept and no lags; and model 3 with an intercept and one lag, with exports lagged one year relative to imports to check an assumption that imports may react to changes in export revenue with a lag.

34. **The model with an intercept and no lags seems superior to others**. Model 3 with one lag of the independent variable clearly drops out as it has very low overall fit compared to other models, relatively large standard errors and most coefficients are statistically insignificant. Only in eight cases the lagged pass-through coefficient was statistically significant suggesting on average the values of import react contemporaneously to changes in export revenues (Figure 6). Models 1 and 2, with and without the intercept α and lagged dependent variable correspondingly, both have substantially better overall fit, smaller standard errors, and most coefficients are statistically significant at the 5 percent level. Moreover, both models produce an almost identical list of countries with β>1. The fundamental difference between these models is in the number of statistically insignificant β with $p(\beta) > 0.05$, the number of countries with statistically significant β<1, and the significance of α in model 1 in 44 cases. Moreover, in model 1 coefficients α and β are simultaneously statistically significant in 13 cases. Statistical significance of the intercept α cannot be ignored as it captures all determinants that may affect imports, in addition to the country's export revenue. Because building a full econometric model of the determinants driving nominal imports for each country is beyond the scope of this paper, a reduced [JD1]model 1 in which imports depend contemporarily mainly on exports revenue and all other factors captured by α were selected for the estimation of pass-through coefficients.[3]

[3] 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.

Figure 6. Pass-Through Coefficients: Model Selection, 1993-2013

$\Delta M^i_{t-w}/M^i_t = \alpha_i + \beta_i \Delta X^i_{t-w}/X^i_t + \varepsilon_i$	Model 1 Intercept and no lags	Model 2 No intercept and no lags	Model 3 Intercept and one lag
Obs.	170	170	170
α	0.072	...	0.089
sd(α)	0.048	...	0.049
t-stat(α)	1.450	...	1.952
p(α)	0.263	...	0.132
No. p(α)>0.05	126		101
No. p(α)<0.05	44	...	69
β	0.470	0.576	0.058
sd(β)	0.176	0.153	0.221
t-stat(β)	3.194	4.524	0.323
p(β)	0.185	0.112	0.549
R^2	0.326	0.418	0.049
se	0.185	0.165	0.188
No. p(β)>0.05	75	49	162
No. p(β)<0.05	95	121	8
β=<1	69	92	8
β>1	25	29	0

*/ Average statistics for model selection; 170 country-specific coefficients were estimated.

35. **As a robustness check for the pass-through coefficients, a cointegration relationship between imports and exports was also estimated**. Assuming both exports and imports are not stationary in log levels, a cointegration relationship was assessed between imports and exports (Eq. 6). Based on this approach, in 134 countries, imports seem cointegrated with exports; and the country list overlaps with those in the regressions with and without the intercept.

36. **Based on the calculated pass-through coefficients, all countries can be classified into shock-amplifiers, shock-absorbers, and shock-blockers**. Model 1 suggests that of 170 countries, 95 countries are capable of passing through shocks (Figure 7). Only 29 of them (17 percent of the total) 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 (Annex 2). 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 70 countries (41 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 (France, Japan, Germany) have the pass-through coefficient very close to unity, suggesting that the pass-through may 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 by at least a third. Finally, 71 countries (42 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 (Benin, Chad, Central African Republic, Dominica, 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 (Qatar, Iran, Nigeria) 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 (Cyprus, Luxembourg) 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.

Figure 7. Pass-Through Coefficients: Country Classification, 1993-2013

	Amplifiers	Absorbers	Blockers
No. of countries	29	70	71
Percent of total	17	41	42
Pass-through coefficient			
Max	1.68	0.99	…
Min	1.01	0.14	…
Mean	1.16	0.62	…
Median	1.08	0.66	…
Group averages			
GDP per capita (US$, PPP, 2011)	24,248	20,482	11,386
Standard error	2,631	2,145	2,372
Openness (trade in % of GDP, 2013)	101	94	94
Standard error	15	6	6
Doing business rating (2013)	53	80	122
Standard error	8	6	5

37. **Additional analysis allows identifying typical features of a spillover amplifier, absorber and blocker**. The group of *spillover amplifiers* consists mainly of developed countries with the PPP-based GDP per capita of about US$ 24,000. They are characterized by substantial openness to international trade with the ratio of exports plus imports to GDP exceeding 100 percent and relatively solid business environment with the average Doing Business rating of 53. With some exceptions, these are major international trading nations

that are well integrated into the international economic system. They amplify shocks most likely because the private sector may overreact to export revenue shortfall by reducing imports more than needed driven by precautionary considerations. The group of *spillover absorbers* is statistically very close to the group of spillover amplifiers and sometimes is indistinguishable from it at the 95 percent confidence level. These countries also pass through shocks but absorb part of their strength. However, their average per capita GDP and openness to trade are somewhat lower, and their business environment is on average worse than that of shock amplifiers. One possible interpretation is that weaker macroeconomic policies, less openness and more pronounced deficiencies in doing business put natural brakes on the capacity of these countries to transmit shocks. Finally, the group of *spillover blockers* really stands out, both statistically and substantively. These are mainly middle and low-income countries and some oil exporters. Although their openness on average is comparable to shock absorbers, their per capita income is substantially lower and their business environment is on average much worse. These countries block spillovers most likely because their imports are largely delinked from export revenue, as they finance a substantial part of their imports either from sovereign funds or donor resources.

C. Shock Calibration

38. **The demand shocks are calibrated in percent of the epicenter country's imports based on historical precedents**. The examples of demand shocks are taken from the 2014 IMF Spillover Report[4] and the October 2014 World Economic Outlook.[5] Two import demand shocks are considered by way of illustration: lower than projected GDP growth in a large emerging economy (China) and a geopolitical shock in a medium-size country (Ukraine).

39. **The shocks are calibrated to mimic an average observed nominal imports drop in the epicenter countries**. In 1993–2013, all countries experienced episodes of imports decline, most of which were driven by drops in their domestic demand (Figure 8). Obviously, the great trade collapse of 2009 following the world financial crisis, led to the most pronounced drop in imports in most countries when imports declined by 20–30 percent in most countries. In low-income countries, imports have been highly volatile.

[4] http://www.imf.org/external/pp/longres.aspx?id=4881

[5] http://www.imf.org/external/pubs/ft/weo/2014/02.

Figure 8. Nominal Import Shocks, 1993-2013

	Year	Imports drop (%)	Average
USA	2001	-6.7	-16.8
	2009	-26.8	
China	1993	-2.7	-6.4
	1997	-0.5	
	2001	-2.0	
	2009	-16.5	
	2012	-10.2	
Germany	1993	-6.2	-7.9
	1996	-6.2	
	2001	-0.1	
	2009	-22.7	
	2012	-4.3	
France	1993	-14.3	-11.7
	2001	-14.3	
	2001	-1.6	
	2009	-20.7	
	2012	-7.6	
Italy	1993	-20.7	-11.8
	1996	-1.5	
	2001	-1.9	
	2009	-30.0	
	2012	-11.4	
	2013	-5.6	

	Year	Imports drop (%)	Average
Guinea	1993	-14.6	-9.5
	1994	-7.9	
	1998	-4.6	
	2000	-3.8	
	2009	-16.6	
Liberia	1993	-6.8	-18.4
	1995	-6.4	
	1996	-32.6	
	1999	-39.1	
	2001	-18.1	
	2003	-15.3	
	2012	-19.0	
	2013	-9.6	
Sierra Leone	1995	-5.4	-11.3
	1997	-12.0	
	1998	-18.6	
	2004	-14.5	
	2006	-10.4	
	2009	-4.7	
	2013	-13.2	

40. **For the purpose of illustration, individual shocks were set uniformly to a 10 percent drop of nominal imports in 2012.** To mitigate the impact of extreme events, average 1993–2013 import demand shocks hover around 10 percent and were applied to China (where it amounted to 1.7 percent of its 2012 GDP) and Ukraine (4.7 percent of its 2013 GDP). The sample shocks are applied to the 2012 trade data, because this was one of recent years where economic slowdown in many countries actually led to significant declines in imports and for which full bilateral trade data were available.

41. **Finally, for modeling purposes annual trade flows were split into four equal quarterly flows.** The shock was assumed to affect the epicenter country in the first quarter and spill over its trading partners during the remaining three quarters. 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 correctly intrayear correlation between exports proceeds and import flows for most countries.

IV. APPLICATION TO GLOBAL SHOCK SPILLOVERS

A. Shock in a Large Country (China)

42. **Significant growth slowdown in China represents yet another potential shock with major international spillovers.** In the short term activity may be affected by unwinding of accommodative policies, accelerated reforms, a sharp downturn in property prices, financial instability, and/or another domestic or external shock. In the medium term, growth may fall significantly below the targeted level, with the slowdown caused investment that may continue to outstrip external and domestic demand, leading to a further buildup of excess capacity and increased misallocation of resources. Eventually, this would sharply reduce returns on investment and cause bankruptcies and large financial losses, which would hamper employment and lower growth substantially as growth convergence stalls.

43. **China 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. China is central in the international trade network. The visualization based on the Fruchterman-Reingold (1991) force-directed layout algorithm shows that the largest trade flows of the world pass through China (Figures 9a and 9b). The algorithm uses export and import values to determine the attractive forces between countries. The larger the trade flow, the stronger is the attractive force between the countries it links, assuming strength of the repulsive force of 10 with 100 iterations per layout. The node areas are made proportional to the share of a partner in China's exports and imports and link widths are proportional to the value of trade in each direction. This algorithm squarely places China in the middle of the world trade network suggesting that any shock with the epicenter in China would have major impact on the rest of the world economy.

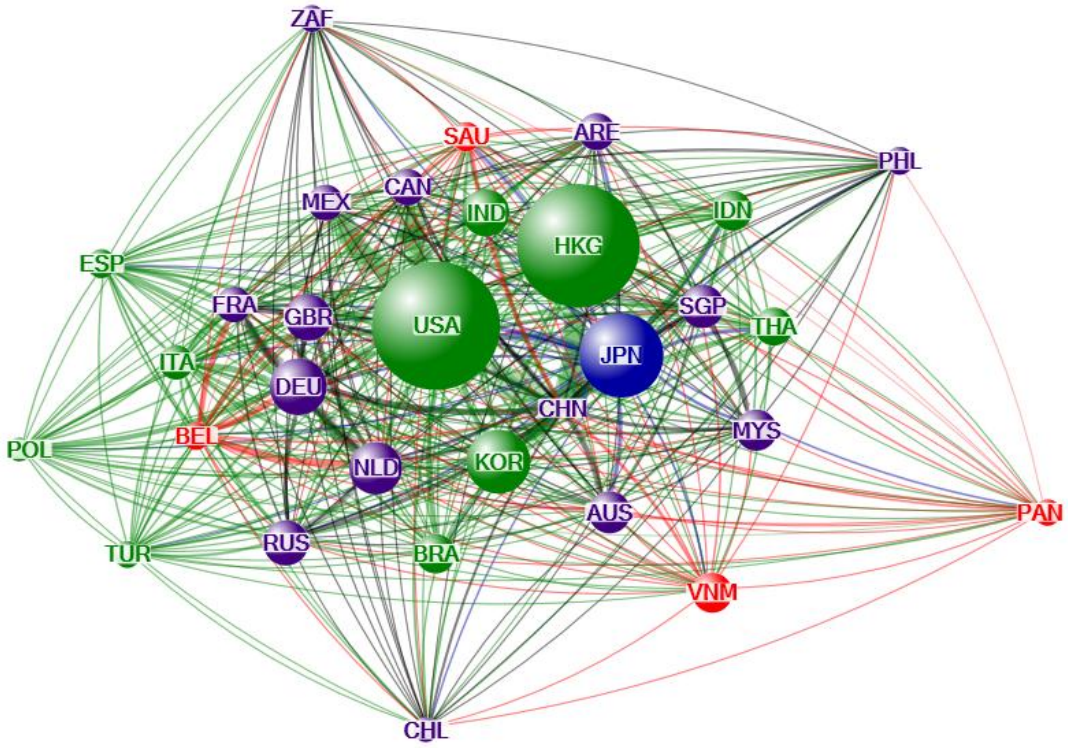
44. **The network structure of China's trade is unbalanced**. The value of its trade in most directions is unbalanced, with large trade surpluses with many important countries. Geographically, at least half of China's main export and import partners are not the same. While the United States, Hong Kong 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.

45. **Asymmetries in China's export and import partner network structures have important consequences for shock spillovers**. As 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. 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 smaller share in China's imports.

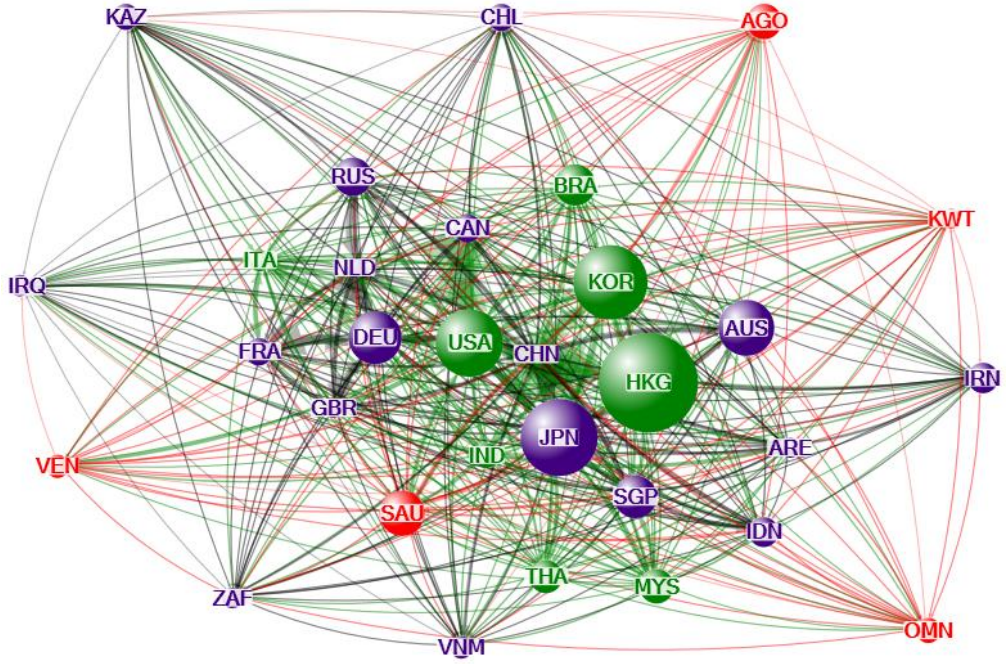
Figure 9. China: Main Export and Import Partners, 2012

(Node areas are proportional to the share of a partner in China's exports and imports; link weights are proportional to the value of trade in each direction)

a. **Exports.** *Top 30 countries absorb about 85 percent of China's exports.*



b. **Imports.** *Almost 90 percent of China's import is sourced from only 30 countries.*



amplifiers absorbers blockers

46. **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 79 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, at least in the short run, imports can be financed by accumulated saving, irrespective of the collapse in current export revenue.

47. **Given this network structure, the spillovers from a nominal shock would affect China's trading partners in several rounds**. The shock is represented by a drop of China's imports by 10 percent (4.3 percent of its GDP in 2012) as a consequence of a drop in nominal demand in China. If expressed as a share of GDP of affected countries, this shock will be felt by countries that export to China, some of which are not included on the list of its main trading partners (Figure 10a). Considering only the 30 countries where the impact from the nominal shock in China would be the largest, the first round *direct spillover* effects would amount on average to 3.6 percent of their GDP. The largest impact (in percent of GDP) would be on such economies as Hong Kong SAR of 22.6, Mongolia of 8.7, and Solomon Islands of 8.6, given their large exposure to exports to China.

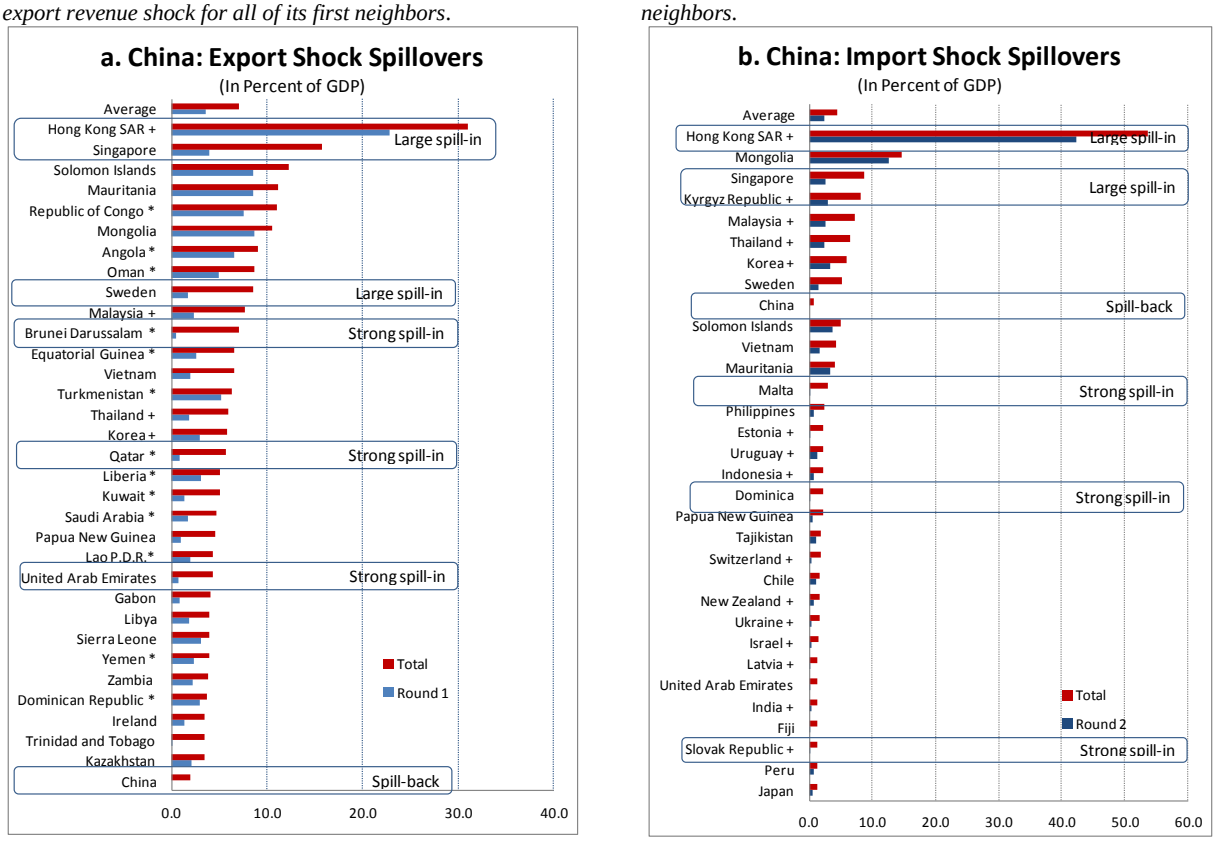
48. **Taking into account the four rounds of shock spillovers, the negative impact on export revenue of affected China's partners could be substantially higher.** On average, the *indirect spillovers* between countries other than China itself driven by the nominal shock in China, would add an additional 3.5 percent of GDP loss to all its trading partners. Therefore, the total impact would be about 7.1 percent of GDP on average for all countries. The largest total direct and indirect spillover would still be on the economies of Hong Kong SAR, Singapore, and Solomon Islands. None of the largest economies of the world are on the list of countries most affected by a shock in China through direct and indirect spillovers as, irrespective of their relatively high exposure to exports to China; the 10 percent drop in import demand by China is minor as a share of their GDP.

49. **The difference between the total spillover after four rounds and the direct spillover after the first round can be considered a *spillin* effect, i.e., a ricochet impact on first neighbors from the second to the *n*th neighbors.** In the case of China, on average the absolute size of spillin effect amounts to 3.5percent of GDP. The absolute amount of the spillin effect is the largest (in percent of GDP) for the economy of Singapore (11.9), Hong Kong SAR (8.2), and Sweden (6.8). However, the strength of the spillover effect (the ratio of the total spillover to the spillover at the first round) is the highest for small open economies, such as Trinidad and Tobago (29.5), Brunei Darussalam (14.9), United Arab Emirates, and Qatar (6.6). There is a visible *spillback* effect, that is, the ricochet impact from trading partners on China itself, of about 0.2 percent of GDP. The spillback effect suggests that a drop of import demand by China by 4.3 percent of GDP will be exacerbated by further 0.2 percent of GDP, once the shock passes through the network of China's trading partners across the world and ultimately hits China itself.

Figure 10. Spillovers From a Nominal Shock in China
(In Percent of GDP)

The drop of imports by China immediately translates into an export revenue shock for all of its first neighbors.

Lower revenue from exports lead to lower imports by first neighbors.



+ amplifiers; - absorbers; * blockers.

50. **The loss of export revenue by China's first neighbors leads to an import shock for their trading partners**. This import shock becomes nontrivial only starting from the second round, as the first round is represented just by the drop of China's own imports (Figure 10b). Countries that block spillovers will not pass through the shock further. As the pass-through effect for such countries is zero, they are not included in the figure. For example, once the first round of the import shock from China hits Saudi Arabia, Kuwait, Oman, Angola, and Venezuela, the spillover immediately dies out. However, these countries are among China's important sources of imports and, as seen in figure 9b, are located at the periphery of the network. All other spillover-blockers are really marginal for China. Therefore, there are really very few natural impediments on the way for shock spillovers with the epicenter in China, and most remaining countries pass through the shock by either amplifying it or absorbing part of its strength.

51. **Several countries would most likely reduce their imports as a consequence of the loss of revenue from exports to China**. The jurisdiction of Hong Kong SAR would reduce its imports from all other countries the most, followed by Mongolia and Singapore, Solomon Islands, and the Kyrgyz Republic. Given the network structure of China's trading partners, the largest overall impact after four rounds of spillovers will be broadly on the same countries as at the first round, plus Malaysia, Thailand, and Korea. The average level of the

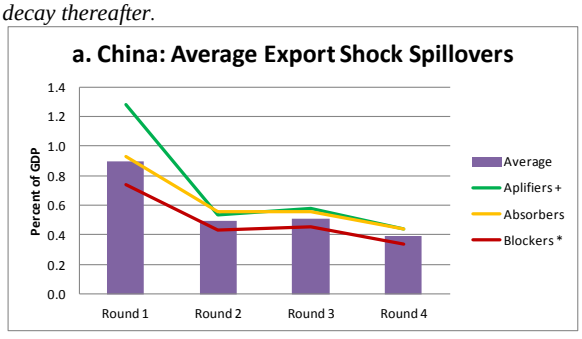
spillin effect (the difference between the total spillover and the spillover at the second round) is not large, about 2.1 percent of GDP of affected countries, and is the highest (in percent of GDP) for the economy of Hong Kong SAR (11.3), Singapore (6.3), and the Kyrgyz Republic (5.1). However, the strongest spillin effect (the ratio of the total effect to the second round effect) is unexpectedly high for Dominica (30.8), Malta (18.5), and the Slovak Republic (14.6). There is also a *spillback effect* of 0.6 percent of GDP on China itself, which can be interpreted as a reduction of China's imports, on top of the original shock of 4.3 percent of GDP, as a consequence of the drop of other countries' exports to China driven by the spillover of China's own shock through the trade network.

52. **Originated in China export and import shock spillovers have different profiles.** The export shock is the strongest at the first round, as on average all China's partners immediately lose about 1 percent of their GDP (Figure 11a). Once at the second round the drop in revenue from exports transforms into an import demand shock for countries that can pass it through and then again into an export revenue shock for their partners. The second through the fourth rounds add on average about 0.5 percent of GDP to the first round shock to arrive to the total shock magnitude after all four rounds of spillovers of about 2.3 percent of GDP on average for all countries. Countries capable of amplifying the shock would experience above average spillovers, compared to countries that absorb or block shocks. Surprisingly, the export shock does not decay and remains broadly unchanged after four rounds.

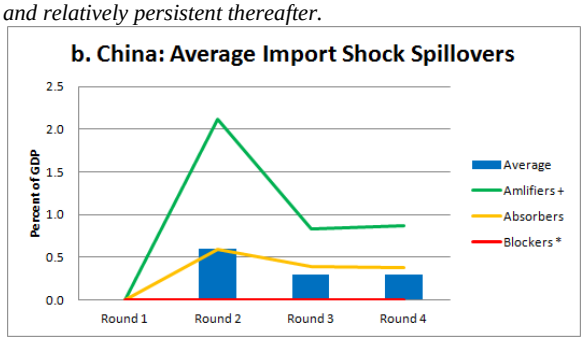
53. **The spillover profile of the import shock is clearly different from the export shock**. At the first round the spillover is obviously zero for all countries, as only China itself experiences the shock (Figure 11b). On average, the shock magnitude at the second round is approximately twice as high (0.6 percent of GDP) as the shock at the third and fourth rounds (0.3 percent of GDP). Average spillovers through shock amplifiers are the highest at the second round, decaying fast but remaining persistent through the ensuing rounds. The spillovers through shock absorbers are at about the average level. Finally, shock blockers do not pass through spillovers at all.

Figure 11. China: Spillover Round Profile
(In Percent of GDP)

Export shock spillovers are the strongest at the first round and decay thereafter.



Import shock spillovers are the strongest at the second round and relatively persistent thereafter.



54. **The import shock to China's trading partners is smaller than the export shock**. After four iterations, the export shock reached 2.3 percent of GDP compared to an import

shock of 1.2 percent of GDP. It can be explained by the fact that the shock to China itself is not taken into account as there cannot be immediate spillovers from a shock on itself. Also, while about 70 countries block spillovers before they transform into the next import shock, not all import shocks lead to the next round of export revenue shocks for all countries. The countries that amplify shocks, a potentially offsetting factor, play an important role in the network structure of China's trade and lead to shock amplification, in particular at the second round.

B. Shock in a Medium-Size Country (Ukraine)

55. **Geopolitical tensions and armed conflict in Ukraine represents yet another shock in a medium-size country, with mainly regional spillovers.** This leads to economic deterioration, loss of confidence, and heighten risk aversion. As a result, trade may become more regional and investors may increase their home bias. On the other hand, geopolitical tensions involving a limited number of trade partners may also force geographical diversification of Ukraine's trade.

56. **Ukraine is a relatively small transition economy, which trades with most, but not all, countries in the world.** Ukraine's in/out degree is 151/156 out of maximum of 170, that is, Ukraine does not trade with at least 10 percent of countries in the world. The value of its trade in most directions is very unbalanced, with large trade deficits with some countries and surpluses with others. The network structure of Ukraine's trade (Figure 12) suggests at least half of its main exports and import partners are not the same. While Russia is clearly dominant as Ukraine's main export destination and the source of imports, China and Germany are important for Ukraine as export destinations but much less so as a source of imports. The opposite is true for Turkey, the Czech Republic, United States, and Hungary, which are among important export destinations but are not part of Ukraine's top import partners. On the contrary, Egypt, India, and Spain are important import sources but are not among the top export destinations. Trade with the EU is gaining importance.

57. **The network structure has important ramifications for shock spillovers originated in Ukraine**. The Fruchterman-Reingold (1991) force-directed layout algorithm allows visualizing the network structure of Ukraine's immediate trading partners. It uses export and import values to determine the attractive forces between countries. The larger the trade flow, the stronger the attractive force between the countries it links. Node areas are proportional to the share of a partner in Ukraine's exports and imports and link widths are proportional to the value of trade in each direction.

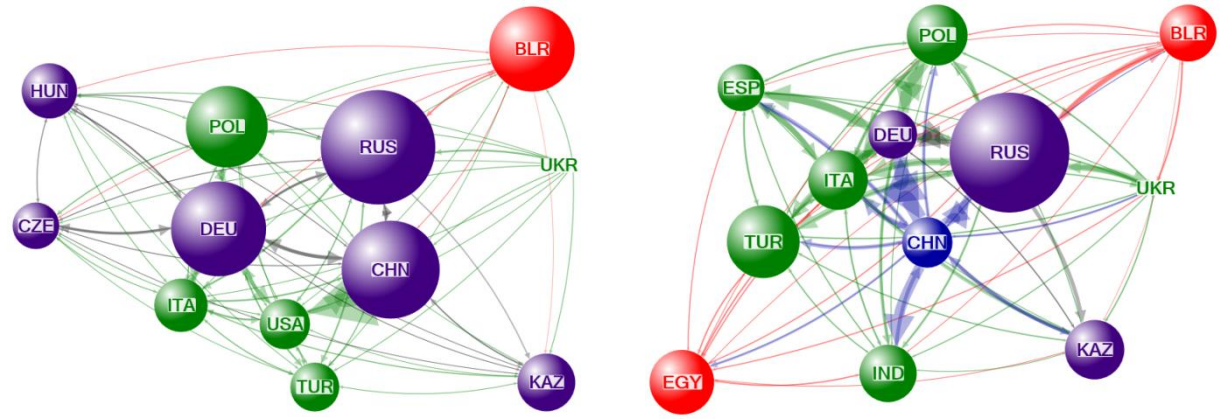
58. **Ukraine is a relatively small player in international trade**. Its immediate trading partners include countries that are important partners for Ukraine (large nodes) but relatively insignificant in international trade themselves (Russia, Bulgaria, Kazakhstan); countries that are leading international trade and are important trading partners for Ukraine (China, Germany); and countries that are major international traders but are not particularly important for Ukraine (United States, India). Also, key trading flows of Ukraine's partners bypass Ukraine and link such countries as China, the United States, Germany, Italy, and India. On this scale, the main relatively important link for Ukraine is its exports and imports to Russia.

Figure 12. Ukraine: Main Export and Import Trading Partners, 2012

(Node areas are proportional to the share of a partner in Ukraine's exports and imports, Link widths are proportional to the value of trade in each direction)

Ukraine's exports to main 11 partners amounts to 60 percent of its exports

Ukraine's imports from 11 main partners amounts to 77 percent of its imports.



59. **Most of Ukraine's trading partners can pass through shocks**. On the import side, from where the demand shock would be initiated, all partners, with the exception of Belarus and Egypt, can pass through potential spillovers; but both are quite peripheral in the network. The largest countries from where Ukraine obtains its imports, Russia and Kazakhstan absorb part of the shock and Bulgaria blocks spillovers altogether. At the same time, Turkey, Italy, Poland, and Spain can amplify their share of the shock. When at the second round the import shock transforms into an export shock, there will be even fewer blockers on its ways, only Belarus. All other countries would pass through the spillover, by either amplifying or absorbing a part of it. A similar shock spillover mechanism would apply to all of Ukraine's other trading partners, beyond the top eleven.

60. **The shock originates in a drop of Ukraine's imports and would immediately translate into lower export revenue for all its trading partners.** This first round of the import shock is trivial, as the 11 percent of GDP decline in Ukraine's imports would spillover and be distributed among countries that export to Ukraine proportionally to Ukraine's share in their exports. The network structure of trade plays no role at this round.

61. **Once the import shock at the epicenter becomes an export revenue shock for partners, the network structure enters into play.** Given this structure, the spillovers from a nominal shock would affect Ukraine's trading partners in several rounds. If expressed as a share of GDP of affected countries, the largest impact from a crisis in Ukraine will be on countries that are not included on the list of its main trading partners (Figure 13a). Considering only the countries where the impact from the nominal shock in Ukraine is above

the average, the first round *direct spillover* effects would amount on average to 0.2 percent of their GDP. The largest impact would be on Belarus of 2.2 percent of GDP in its export revenue loss and Lithuania of 0.6 percent of GDP.

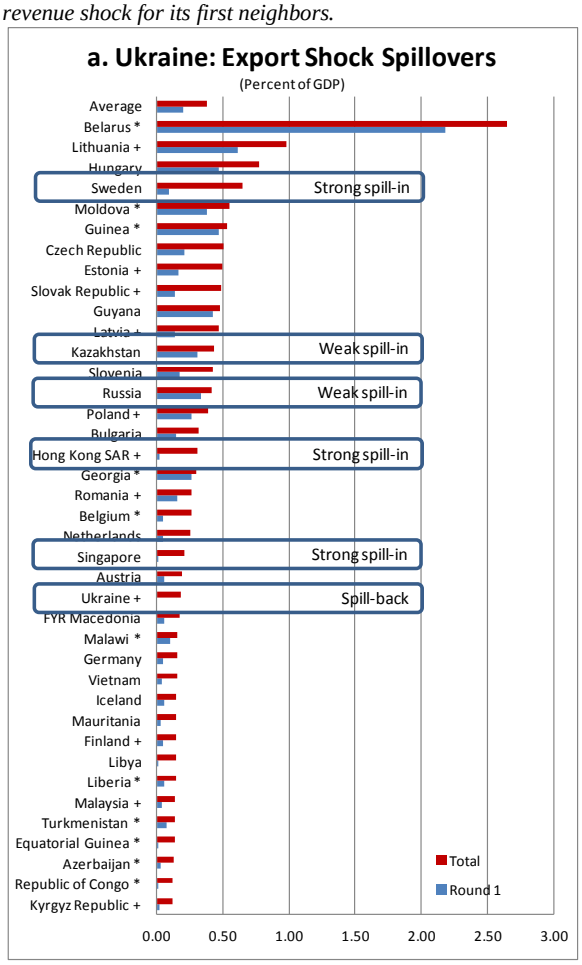
62. **Taking into account the four rounds of shock spillovers, the negative impact on export revenue of Ukraine's affected partners would be substantially higher.** On average, the *indirect spillovers* between countries other than Ukraine provoked by the nominal shock in Ukraine would add additional 0.2 percent to export revenue losses to all its trading partners. The total average impact would then be about 0.4 percent of GDP. For example, the total spillover impact on Belarus would be 2.7 percent of GDP and on Lithuania about 1 percent of GDP. The difference between the total spillover after four rounds and the direct spillover after the first round can be considered the *spillin* effect, a ricochet impact on first neighbors from the second to the *n*th neighbors. On average the absolute size of spillin effect amounts to 0.2 percent of GDP. Not surprisingly however, its strength (the ratio of the total spillover to the spillover at the first round) is the highest for medium-sized open economies, such as Singapore, Hong Kong SAR, Sweden, and small oil-producers such as Equatorial Guiney, Republic of Congo, and Libya. There is also a visible *spillback* effect, that is, the ricochet impact from trading partner on Ukraine itself, of about 0.2 percent of its GDP.

63. **The loss of export revenue by Ukraine's first neighbors leads to an import shock for their trading partners**. This import shock becomes nontrivial only starting from the second round, as the first round is represented just by the drop of Ukraine's own imports. Those of Ukraine's partners that are shock blockers, when affected by the drop of exports revenue from the first round of the import shock, will not pass through the shock further. For example, once the shock hits Belarus, Egypt, and some other of Ukraine's trading partners, the spillover immediately dies out. Therefore, no shock blocking countries are shown in Figure 11b, as the spillovers through them equal zero. At the same time, all remaining countries pass through the shock at the epicenter, by either amplifying it or absorbing part of its strength.

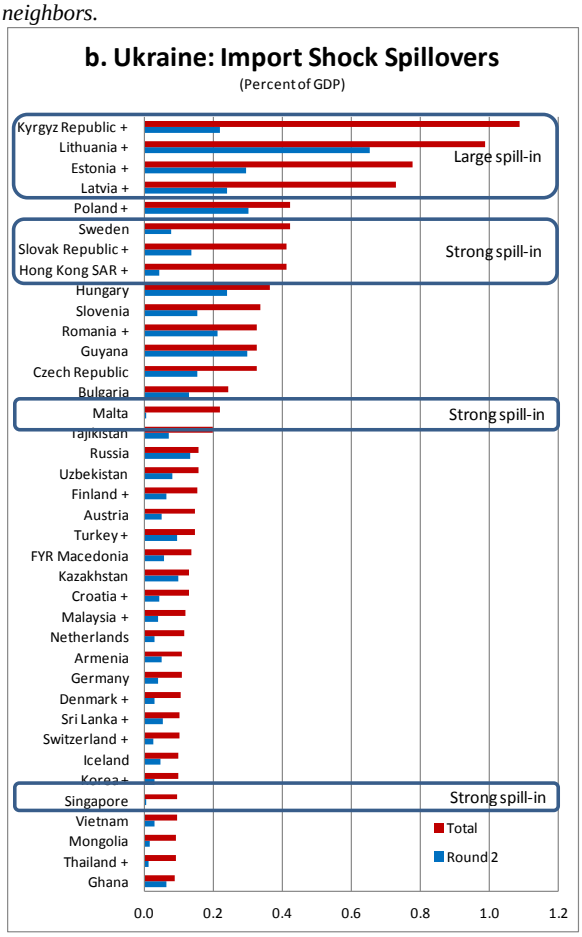
64. **Several countries would most likely reduce their imports as a consequence of the loss of revenue from exports to Ukraine**. At the second round the hardest impact will be on Lithuania, which would have to reduce its imports from all other countries by 0.7 percent of GDP (Poland, Estonia, Guyana) reducing their demand for further imports by 0.3 percent of GDP. However, given the network structure of Ukraine's trading partners, the largest overall impact after four rounds of spillovers will be on the Kyrgyz Republic (1.1 percent of GDP), Lithuania (1 percent of GDP), and Estonia and Latvia (about 0.8–1.0 percent of GDP). The average level of the spillin effect (the difference between the total spillover and the spillover at the second round) is about 0.2 percent of GDP of affected countries, and the largest for the Kyrgyz Republic of about 0.9 percent of GDP. However, the strongest spillin effect (the ratio of the total effect to the second round effect) is again the highest for medium-sized open economies, such as Hong Kong SAR, Malta, Sweden, and Singapore.

Figure 13. Spillovers From a Nominal Shock in Ukraine
(In percent of GDP for countries with above the average impact)

The drop of imports by Ukraine would translate into an export revenue shock for its first neighbors.



Lower revenue from exports lead to lower imports by first neighbors.



+ amplifiers; - absorbers; * blockers.

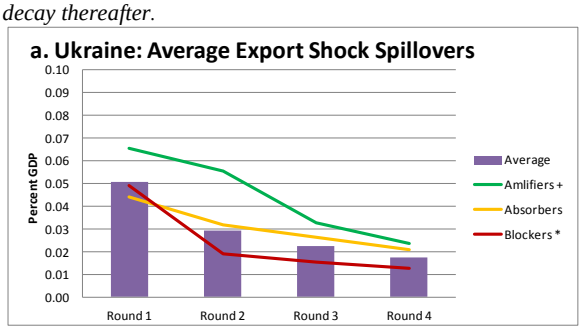
65. **In the case of Ukraine, exports and import shock spillovers have different profiles.** The export shock is the strongest at the first round as the drop in import demand by Ukraine is distributed proportionally to its trading partners (Figure 14a). On average all partners immediately lose 0.05 percent of their GDP. Once at the second round the export shock transforms into an import shock and then again into an exports shock, the second round adds on average a bit less than 0.03 percent of GDP. The third and the fourth rounds contribute further, about 0.02 of GDP each, to arrive to the total shock magnitude after all four rounds of spillovers of about 0.12 percent of GDP on average for all countries. Countries capable of amplifying the shock would experience on average above-average spillovers, compared to countries absorbing and blocking shocks. The export shock decays relatively fast and may not be statistically different from zero after four rounds.

66. **The spillover profile of the import shock is clearly different from the export shock**. At the first round the spillover is obviously zero for all countries, as only Ukraine itself experiences the shock (Figure 14b). Shock magnitudes at the second and third rounds

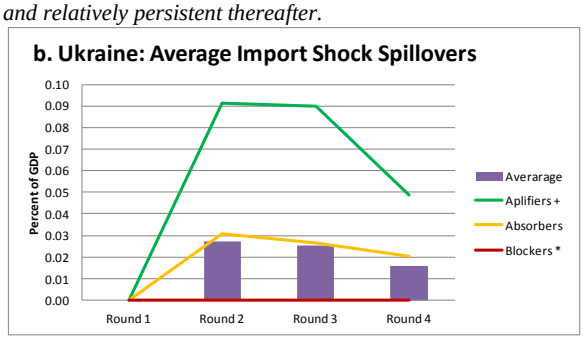
are approximately the same, between 0.02–0.03 percent of GDP, and at the fourth round the spillover decays to below 0.02 percent of GDP. The total import shock is just 0.07 percent of GDP. Naturally, average spillovers through shock amplifiers are the highest and relatively persistent through the rounds. The spillovers through shock absorbers are about the average. Finally, shock blockers do not pass through spillovers at all.

Figure 14. Ukraine: Spillover Round Profiles
(In percent of GDP)

Export shock spillovers are the strongest at the first round and decay thereafter.



Import shock spillovers are the strongest at the second round and relatively persistent thereafter.



67. **The total size of the import shock to Ukraine's trading partners is a little more than half of the export shock**. It can be explained by the fact that the shock to Ukraine itself is not taken into account as there cannot be immediate spillovers from a shock on itself. Also, while about 70 countries block spillovers before they transform into the next import shock, all import shocks lead to the next round of export revenue shocks for all countries. The countries that amplify shocks, a potentially offsetting factor, do not play a sufficiently important role in the network structure of Ukraine's trade.

V. Conclusions and Policy Implications

68. **A network model allows capturing second round network effects of spillovers that can be substantial but have been largely disregarded.** The network effects originate from the feedback process starting from the second round of shock propagation. Their strength depends 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 can become comparable and often exceed the initial shock at the epicenter country.

69. **Individual countries may amplify, absorb, or block spillovers.** About 20 percent of countries amplify spillovers, 40 percent are shock absorbers as they can pass through the spillovers but reduce their strength and the remaining 40 percent are spillover blockers as spillovers die out once they reach these countries. Most developed countries and major international trading nations are well integrated into the international trading system and

therefore pass through shocks, as their imports react contemporaneously to the changes in export revenue. Most commodity exporters, in particular oil producing countries and low-income countries block shock spillovers, as they finance a substantial part of their imports by sovereign funds and donor resources, which delink imports from export proceeds in times of an economic stress.

70. **The capacity of a country to amplify, absorb or block shocks depends on its economic and structural characteristics**. Typically, the higher the level of development and openness to trade, and the better the business environment, the higher the probability that a country would pass-through international shocks by either amplifying or partially absorbing them. Conversely, the lower the level of development and openness to trade and the weaker the business environment, the higher the probability that a country would block shock spillovers.

71. **The macroeconomic policies of the spillover-conducive countries play an important role in preserving global stability**. The macroeconomic policies in all countries capable of passing through shocks play a particularly important role for constraining the spillovers of negative shocks and expanding the effects of positive shocks to the rest of the world economy. Core spillover amplifying countries, which include the United States, Switzerland, Italy, Korea, and India, as well as spillover absorbers with relatively high pass-through coefficients (Japan, Germany, France) bear significant responsibility for overall international economic stability. Negative shock spillovers, originated outside the core, may be successfully mitigated by coordinated macroeconomic policies of core countries.

72. **The profile of shock spillovers largely depends on the epicenter country and the pass-through characteristics of its key trading partners**. Roughly half of the countries can transmit shocks, but only a few may play an important role in shock diffusion. The examples discussed in the paper illustrate fundamental differences in spillover effects depending on the size of the epicenter country and its position in the international trade network. Even if a country is large but its first neighbors do not pass through spillovers from the original shock, the shock may largely die at the first round and have very insignificant spillover effects. At the same time, a relatively modest shock in a medium-sized country, whose immediate neighbors can transmit and amplify the initial shock, can lead to major spillovers across the international trading system. Finally, direct trade connections are needed for the epicenter country to feel the spillback effect of a shock it generates. In particular for small economies, the spillin effect can be very substantial and bounce back from just a few of its trading partners. In the same vein, the spillback effect can also be substantial for countries that have very few links with both the epicenter country and its main trading partners, just by the virtue of the network properties of the international trading system.

73. **The strength and the profile of spillovers depend on the properties of the export-import matrix.** It leads to changes of the network structure at each wave of the shock in one iteration. Shock spillovers can be changed by macroeconomic policies that influence the properties of the export-import matrices of individual countries by changing their in- and out-degrees, the weighted centrality, the in- and outflow weights, the pass-through coefficients, and other network properties. This area requires substantial further research.

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Annex 1. Country Acronyms

ISO	Country	ISO	Country	ISO	Country
AFG	Islamic Republic of Afghanistan	DEU	Germany	OMN	Oman
ALB	Albania	GHA	Ghana	PAK	Pakistan
DZA	Algeria	GRC	Greece	PAN	Panama
AGO	Angola	GRD	Grenada	PNG	Papua New Guinea
ATG	Antigua and Barbuda	GTM	Guatemala	PRY	Paraguay
ARG	Argentina	GIN	Guinea	PER	Peru
ARM	Armenia	GNB	Guinea-Bissau	PHL	Philippines
AUS	Australia	GUY	Guyana	POL	Poland
AUT	Austria	HTI	Haiti	PRT	Portugal
AZE	Azerbaijan	HND	Honduras	QAT	Qatar
BHS	The Bahamas	HKG	Hong Kong SAR	ROU	Romania
BHR	Bahrain	HUN	Hungary	RUS	Russia
BGD	Bangladesh	ISL	Iceland	RWA	Rwanda
BRB	Barbados	IND	India	WSM	Samoa
BLR	Belarus	IDN	Indonesia	STP	São Tomé and Príncipe
BEL	Belgium	IRN	Islamic Republic of Iran	SAU	Saudi Arabia
BLZ	Belize	IRQ	Iraq	SEN	Senegal
BEN	Benin	IRL	Ireland	SRB	Serbia
BTN	Bhutan	ISR	Israel	SYC	Seychelles
BOL	Bolivia	ITA	Italy	SLE	Sierra Leone
BIH	Bosnia and Herzegovina	JAM	Jamaica	SGP	Singapore
BWA	Botswana	JPN	Japan	SVK	Slovak Republic
BRA	Brazil	JOR	Jordan	SVN	Slovenia
BRN	Brunei Darussalam	KAZ	Kazakhstan	SLB	Solomon Islands
BGR	Bulgaria	KEN	Kenya	ZAF	South Africa
BFA	Burkina Faso	KIR	Kiribati	ESP	Spain
BDI	Burundi	KOR	Korea	LKA	Sri Lanka
KHM	Cambodia	UVK	Kosovo	KNA	St. Kitts and Nevis
CMR	Cameroon	KWT	Kuwait	LCA	St. Lucia
CAN	Canada	KGZ	Kyrgyz Republic	VCT	St. Vincent and the Grenadines
CPV	Cape Verde	LAO	Lao People's Democratic Republic	SDN	Sudan
CAF	Central African Republic	LVA	Latvia	SUR	Suriname
TCD	Chad	LBN	Lebanon	SWZ	Swaziland
CHL	Chile	LSO	Lesotho	SWE	Sweden
CHN	China	LBR	Liberia	CHE	Switzerland
COL	Colombia	LBY	Libya	SYR	Syrian Arab Republic
COM	Comoros	LTU	Lithuania	TWN	Taiwan Province of China
COD	Democratic Republic of Congo	LUX	Luxembourg	TJK	Tajikistan
COG	Republic of Congo	MKD	Former Yugoslav Republic of Macedonia	TZA	Tanzania
CRI	Costa Rica	MDG	Madagascar	THA	Thailand
CIV	Côte d'Ivoire	MWI	Malawi	TLS	Democratic Republic of Timor-Leste
HRV	Croatia	MYS	Malaysia	TGO	Togo
CYP	Cyprus	MDV	Maldives	TON	Tonga
CZE	Czech Republic	MLI	Mali	TTO	Trinidad and Tobago
DNK	Denmark	MLT	Malta	TUN	Tunisia
DJI	Djibouti	MRT	Mauritania	TUR	Turkey
DMA	Dominica	MUS	Mauritius	TKM	Turkmenistan
DOM	Dominican Republic	MEX	Mexico	TUV	Tuvalu
ECU	Ecuador	MDA	Moldova	UGA	Uganda
EGY	Egypt	MNG	Mongolia	UKR	Ukraine
SLV	El Salvador	MNE	Montenegro	ARE	United Arab Emirates
GNQ	Equatorial Guinea	MAR	Morocco	GBR	United Kingdom
ERI	Eritrea	MOZ	Mozambique	USA	United States
EST	Estonia	MMR	Myanmar	URY	Uruguay
ETH	Ethiopia	NAM	Namibia	UZB	Uzbekistan
FJI	Fiji	NPL	Nepal	VUT	Vanuatu
FIN	Finland	NLD	Netherlands	VEN	Venezuela
FRA	France	NZL	New Zealand	VNM	Vietnam
GAB	Gabon	NIC	Nicaragua	YEM	Republic of Yemen
GMB	The Gambia	NER	Niger	ZMB	Zambia
GEO	Georgia	NGA	Nigeria	ZWE	Zimbabwe
		NOR	Norway		

Annex 2. Shock Pass-Through Coefficients: Full Country Classification

Spillover amplifiers	Pass-through coefficient	GDP per capita	Trade openness	Doing business rating
Argentina	1.68	14,789	29	124
Thailand	1.46	13,932	144	26
Korea	1.32	32,708	103	0
Hong Kong SAR	1.29	51,509	458	3
Denmark	1.29	42,483	103	4
Indonesia	1.29	9,254	49	114
India	1.27	5,244	53	142
Ukraine	1.22	8,508	102	96
Sri Lanka	1.20	9,426	54	99
Turkey	1.18	18,567	58	55
Romania	1.17	18,184	85	48
Malaysia	1.17	22,589	154	18
Croatia	1.11	20,049	85	65
Estonia	1.11	25,254	171	17
Latvia	1.08	21,833	122	23
Switzerland	1.08	54,993	132	20
Poland	1.07	22,835	90	32
Israel	1.07	30,927	64	40
Italy	1.07	33,924	55	56
Finland	1.06	38,821	77	9
United States	1.05	51,340	30	7
Spain	1.05	31,683	60	33
Lithuania	1.05	24,470	156	24
Pakistan	1.05	4,454	33	128
Brazil	1.04	14,555	28	120
Uruguay	1.03	18,966	51	82
Slovak Republic	1.03	25,759	181	37
New Zealand	1.03	33,020	57	2
Kyrgyz Republic	1.01	3,110	143	102
Average	**1.16**	**24,248**	**101**	**53**

Spillover absorbers	Pass-through coefficient	GDP per capita	Trade openness	Doing business rating
Moldova	0.99	4,521	125	63
Slovenia	0.99	27,368	143	51
Japan	0.96	35,614	35	29
Iceland	0.95	40,789	103	12
Germany	0.95	42,884	85	14
France	0.92	37,217	58	31
Ireland	0.92	44,647	190	13
Colombia	0.92	12,025	38	34
Czech Republic	0.91	28,124	149	44
Peru	0.90	11,396	48	35
Sweden	0.89	43,540	83	11
Singapore	0.89	76,237	358	1
Austria	0.87	44,056	103	21
Portugal	0.82	25,933	78	25
Barbados	0.81	14,917	97	106
China	0.79	11,525	50	90
Mongolia	0.77	9,132	112	72
Bulgaria	0.75	15,695	137	38
Russia	0.74	23,564	51	62
Uzbekistan	0.73	5,002	59	141
Hungary	0.73	22,707	170	54
Guyana	0.72	6,336	65	123
Jamaica	0.72	8,607	83	58
Vietnam	0.72	5,125	164	78
Philippines	0.71	6,326	60	95
Greece	0.71	24,305	63	61
Chile	0.71	21,714	65	41
Mexico	0.70	16,291	64	39
South Africa	0.69	12,454	64	43
Canada	0.69	41,899	62	16
Armenia	0.68	7,527	75	45
Netherlands	0.68	45,021	156	27
United Kingdom	0.67	36,931	62	8
Albania	0.67	9,961	88	68
Senegal	0.66	2,170	74	161
Australia	0.66	42,834	41	10
Tajikistan	0.65	2,432	88	166
Former Yugoslav Republic of Macedonia	0.64	11,609	127	30
Bangladesh	0.62	2,853	46	173
Solomon Islands	0.60	2,003	119	87
Papua New Guinea	0.60	2,558		133
Kazakhstan	0.60	22,470	65	77
Malta	0.58	28,822	183	94
Tunisia	0.57	10,768	103	60
Libya	0.53	20,371		188
Bolivia	0.52	5,934	81	157
Brunei Darussalam	0.50	69,474	109	101
Jordan	0.49	11,405	114	117
Kenya	0.48	2,705	51	136
Ghana	0.46	3,864	89	70
Trinidad and Tobago	0.46	29,469	103	79
Venezuela	0.45	17,615		182
United Arab Emirates	0.44		176	22
Gabon	0.42	18,646	94	144
Norway	0.41	62,411	67	6
Cameroon	0.37	2,739	50	158
Oman	0.37	21,913	99	66
Zambia	0.35	3,800	82	111
Morocco	0.35	6,967	81	71
Iraq	0.35	14,471	67	156
Madagascar	0.33	1,369	73	163
Mauritania	0.33	2,945	134	176
Bahrain	0.32	42,444	122	53
The Bahamas	0.32	22,518	98	97
Uganda	0.31	1,621	51	150
Guatemala	0.25	7,063	59	73
El Salvador	0.25	7,515	72	109
Syrian Arab Republic	0.23			175
Saudi Arabia	0.22	52,068	82	49
Suriname	0.14	15,556		162
Average	**0.62**	**20,482**	**94**	**80**

Spillover blockers	Pass-through coefficient	GDP per capita	Trade openness	Doing business rating
Algeria	0.00	12,893	63	154
Angola	0.00	7,488	96	181
Azerbaijan	0.00	16,593	76	80
Belarus	0.00	17,055	125	57
Belgium	0.00	40,609	164	42
Belize	0.00	8,215	127	118
Benin	0.00	1,733	52	151
Bosnia and Herzegovina	0.00	9,387	85	107
Burkina Faso	0.00	1,630	57	167
Burundi	0.00	747	42	152
Cambodia	0.00	2,944	140	135
Cape Verde	0.00	6,210	87	122
Central African Republic	0.00	584	33	187
Chad	0.00	2,022	70	185
Comoros	0.00	1,400	78	159
Costa Rica	0.00	13,431	74	83
Côte d'Ivoire	0.00	3,107	91	147
Cyprus	0.00	27,394	78	64
Dem. Rep. of Congo	0.00			
Djibouti	0.00	2,903		155
Dominica	0.00	10,011	81	97
Dominican Republic	0.00	11,795	57	84
Ecuador	0.00	10,541	61	115
Egypt	0.00	10,733	42	112
Equatorial Guinea	0.00	32,685	157	165
Ethiopia	0.00	1,336	42	132
Fiji	0.00	7,502	136	81
Georgia	0.00	6,930	102	15
Grenada	0.00	11,272	76	126
Guinea	0.00	1,213	83	169
Guinea-Bissau	0.00	1,362		179
Haiti	0.00	1,648	71	180
Honduras	0.00	4,445	117	104
Islamic Republic of Afghanistan	0.00	1,884	55	183
Islamic Republic of Iran	0.00	15,090		130
Kuwait	0.00	53,197	98	86
Lao People's Democratic Republic	0.00	4,667	83	148
Lebanon	0.00	16,623	139	104
Liberia	0.00	850	122	174
Luxembourg	0.00	88,850	371	59
Malawi	0.00	755	111	164
Maldives	0.00	11,283	222	116
Mali	0.00	1,589	69	146
Mauritius	0.00	17,146	121	28
Mozambique	0.00	1,070	71	127
Myanmar	0.00			177
Nepal	0.00	2,173	48	108
Nicaragua	0.00	4,494	93	119
Niger	0.00	887	65	168
Nigeria	0.00	5,423	31	170
Panama	0.00	18,793	155	52
Paraguay	0.00	7,833	94	92
Qatar	0.00	127,562	97	50
Republic of Congo	0.00	5,680	143	178
Republic of Yemen	0.00	3,832		137
Rwanda	0.00	1,426	45	46
Samoa	0.00	5,584	81	67
São Tomé and Príncipe	0.00	2,876	58	153
Seychelles	0.00	23,799	164	85
Sierra Leone	0.00	1,495	108	140
St. Kitts and Nevis	0.00	20,709	88	121
St. Lucia	0.00	10,152	97	100
St. Vincent and the Grenadines	0.00	10,154	87	103
Sudan	0.00	3,265	26	160
Tanzania	0.00	2,365	49	131
The Gambia	0.00	1,608	88	138
Togo	0.00	1,346	96	149
Tonga	0.00	5,134	80	69
Turkmenistan	0.00	13,555	118	
Vanuatu	0.00	2,895	99	76
Zimbabwe	0.00	1,773	86	171
Average	**0.00**	**11,386**	**94**	**122**