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International Trade and Real Transmission Channels of Financial Shocks in Globalized Production Networks

International Trade and Real Transmission Channels of Financial Shocks in Globalized Production Networks

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Abstract: The article analyses the role of international supply chains as transmission channels of a financial shock. Because individual firms are interdependent and rely on each other, either as supplier

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I. INTRODUCTION

For the past 20 years, globalization has implied not only the expansion of international trade and finance, but also the geographical fragmentation of the production processes within networks of firms associated through contractual arrangements or belonging to trans-national corporations. Nowadays, specific industrial operations, from the conception to the assembly of final products, are no longer undertaken by a single establishment but increasingly outsourced within these global value chains, giving place to what is known as "trade in tasks" (Baldwin, 2006).

It is becoming common practice for firms to send their unfinished goods to an affiliate or non affiliate for processing. Sometimes the material is sent to firms within the domestic economy; sometimes the material is sent abroad. This process is very common among processing industries such as chemical, electronic and metallic manufacturing. In the industry, the process is often referred to as toll manufacturing, toll processing or custom manufacturing. Indeed, most of the enormous growth in trade recorded in the last 20 years consisted in relatively similar goods (manufactures) between relatively similar countries; moreover, this feature is robust to the level of disaggregation: no matter how finely industries are defined, a high proportion of trade takes place within industries rather than between them (Neary, 2009). In 2007, almost half of the world trade in merchandises, excluding oil, was attributed to intermediate goods. This proportion (relative to imported goods) raised to 68% for Malaysia and 61% for China.

These linkages have been taking more and more importance in what has been called the "new economy", characterised by a rapid pace of technological change, and a closer integration of capital, labour and product markets. Vertical integration helps fi

existing line of credit will, therefore, replicate through the productive chain. Through this "real transmission channel", the initial financial shock will propagate itself along the productive chain, affecting all firms in the supply-chain network. Modelling how these supply-driven impulses propagate through open economies and feed-back into the monetary circuit are the main objectives of the paper. An application is made on the USA-Asian case, using international I-O matrices developed for China, Japan, Malaysia, Thailand and the USA. A section of conclusions presents the main findings and the shortcomings of the proposed methodology.

II. THE CONCEPTUAL BUILDING BLOCKS: MONETARY CIRCUIT, INPUT-OUTPUT AND CREDIT TRANSITION

1) INTER-INDUSTRY VALUE CHAIN AND THE MONETARY CIRCUIT.

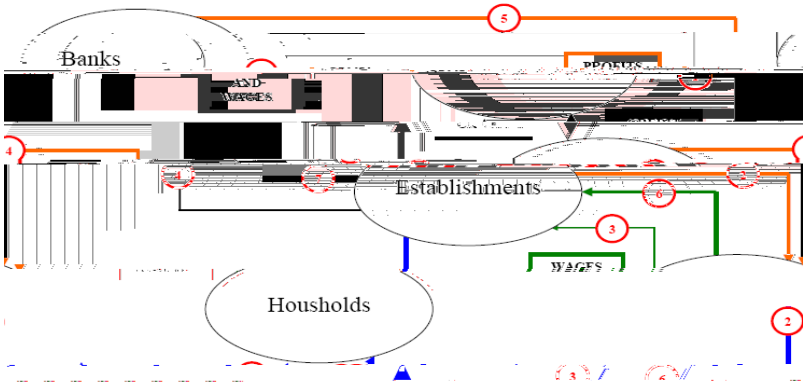
The methodology used in this essay builds on two concepts introduced by the Physiocrats – supply-use matrix and monetary circuit – to jointly model the interactions between "real" and "monetary" processes in an open economy. Physiocrats viewed money solely as a medium of exchange, a mere "signe représentatif" (token money) while the alternative approach favoured by Mercantilists considered money as exogenous, an asset (gold) available in fixed quantities. In the "entrepreneur" economy described by the Physiocrats, credits make deposits and money is a means, not an end. [2] Money circulates in the economy as a counterpart of the exchange of goods and services. The monetary counterpart of production begins with credit granted by the banks to the producers, and it ends when the goods that were produced are sold and the initial loan is reimbursed (money is "destroyed" at the end of the circuit).

After several years of relative neglect during the 1980s when the focus of macroeconomics was the control of inflation (exogenous money was central to monetarist policies), the contagion of financial crisis in the late 1990s and the present situation of financial crisis and debt deflation call for new

supplier will affect the entire productive chain in the short and medium term. At best, as a result of this supply shock, the client-firm will suffer an increase in costs of production when shifting to an alternative supplier; at worse, it will have to stop its production. In times of crisis, the firms with a greater market power (and financial capacities) will help their key suppliers in resolving their cash-flow problems, even when it means worsening their own cash-flow situation (see Box 1 for a recent example on the automobile industry).

Because production and commercialisation take time and payments are not immediate, credit money is needed to start and oil the system.[4] Thus, a higher level of production implies a higher level of lending. For reasons that will be developed later, a higher level of lending implies a higher probability of default over the full business cycle. To avoid too strong an exposure to risk, regulators force banks to respect a

overseas suppliers and clients is lower than in the case of other domestic counterparts. Thus firms incurring in import or export operations will need to request special lines of credit (or guarantees) from the banking sector or specialised financial institutions in order to realise their international operations.


Banks
Establishments
Housholds
5
4
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3
2

Table 2 Simple monetary circuit in a closed economy

Time	Capital Adequacy Ratio	Flow of Funds		
		Bank Account	Firm Account	Households
0. Initial situation	A	0	0	0
1. Credit	$A/\alpha L$	0	L	0
2. Production	$A/\alpha L$	0	L-W	W
3. First round of sales	$A/\alpha L$	0	$L-W+Q_1$	$W-Q_1$
4. Firm pays interest and distributes profit	$A/\alpha L$	rL	$L+Q_1-W-rL-pQ$	$W-Q_1+pQ$
5. Bank pays employees and distributes profits	$A/\alpha L$	0	$L+Q_1-W-rL-pQ$	$W-Q_1+pQ+rL$
6. Second round of sales	$A/\alpha L$	0	L+Q-W-rL-pQ	W-Q+pQ+rL
7. Firm repays loan	A	0	Q-W-rL-pQ	W-Q+pQ+rL

ii) The open monetary circuit

Table *mple monetary circuit in an open economy*

	Home Country				Rest of the World			
Time i	Capital Adequacy Ratio	Bank Account	Firm Account	Households	Bank Capital Adequacy	Bank Account	Firm Account	Households
0. Initi ation	A^d	0	0	0	A^w	0	0	0
1. Cred duction in home c y	A^d/α^d. L^d	0	L^d	0	A^w	0	0	0
2. Cred ermediate inputs fW	$A^d/\alpha^d(L^d)$	0	L^d	0	$A^w/\alpha^w.L^w$	0	L^w	0
3. Prod n interme inputs M	A^d/α^d ^{d}		^{d}	0	A^w ^{w} ^{w}		^{w}–W^w	^{w}

their intermediate inputs.

Because of the complexity and intricateness of the simultaneous production plans existing at any moment in an economy, there is always a large amount of outstanding credit money. Since this outstanding credit money has a counterpart in the capital adequacy ratio of banks, a limit may be reached (either because "too much" credit has already been extended –in relation to bank's assets– or because the underlying quality of the borrowing firms has deteriorated), constraining the supply of new loans and the renewal of existing lines of credit. In their most severe forms, the binding constraints may cause a "credit crunch".

The procyclical nature of prudential ratios is a central feature of the model, and the object of much debate. In many reports on the implications of minimum capital-requirements, the potential restrictions are often qualified by mentioning that most banks hold capital in excess of the regulatory minima or are able to circumvent the binding constraints. According to Repullo and Suarez (2008), this "benign neglect" of the potential procyclical effect is due to a series of misconceptions. Indeed, the global crisis of 2008/2009 showed that larger than expected market swings, with deteriorating balance-sheet quality, limit severely the access to equity and financial markets. As mentioned by Krugman (2008), in time of crisis, the core problem is capital rather than liquidity.

Since international transactions are more complex and riskier than domestic ones (because of the exchange rate risks), they may weigh more in the Capital Adequacy Ratio of banks, and will require additional guaranties such as separate trade credit or insurance to cover the transaction with the foreign country. It is also well known that international transactions may add very significant costs to the chain of supply (tariffs, but also administrative and waiting time, shipping, freight and insurance, etc.). The additional cost can be very high when the supplier is located in a developing country, as seen previously in Table 1. As a consequence, trade-related loans (e.g, import and export credits), especially for transactions with developing countries, are particularly affected by credit crunch. The probability of an exogenous credit shock on these transactions (loan L^w in Table 3) is therefore higher in times of crisis. *10*

iii)

This dynamic is also embedded in the methodology used by rating agencies. The credit rating of individual firms and their migration to higher or lower status are based on a combination of (i) micro-economic considerations, directly related to the financial situation of the firm and the quality of its management; (ii) sectoral specificities, such as the cyclical nature of the business in which the firm operates; and (iii) macro-economic considerations, such as the probability of expansion or recession.

Because these components are not independent, there is a resonance phenomenon. Small micro-shocks reverberate through the macro-waves and amplify them. When the business cycle is upward oriented, the price of assets is increasing, improving the prudential ratio $[A/\Sigma(\alpha_i L_i)]$, while firms and banks have a lower rate of underperforming clients. Thus both micro and macro components lower the perception of risk affecting firms (independently of their individual situation). This state of affairs pushes the banks to extend further loans, creating a positive environment (Krugman, 2008).

On the contrary, when the business cycle is downward oriented, asset prices detained by banks (when priced to market) tend to decrease and the perception of risks increases, resulting in a downward migration of credit rating. As a consequence, banks are increasingly adverse to risk, and less likely to extend credit for similar projects. The resulting effect on the credit rating of these micro-decisions can lead to a credit crunch and even to a recession.

2) PRODUCTIVE CHAINS, NATIONAL ACCOUNTS AND INTERNATIONAL INPUT-OUTPUT MATRIX

On the supply side, firms produce intermediate goods and final goods that are sold domestically or exported; on the demand side they use intermediate inputs (either domestic or imported) including financial and non-financial services and generate value added which is used to compensate employees, pay taxes and generate (distributed and retained) profits. In actual terms, production involves a continuum of individual projects that are closely interrelated and take place in different countries.

The System of National Accounts allows us to describe and model these supply-demand interrelations. As seen earlier, the interdependence is not only real, but also financial and the flows of goods and services captured by the productive accounts have their counterpart in the monetary circuit.

i) The basic circuit of goods and services

In a simple two-sector economy, the real flows of goods and services (including factorial services, i.e, labour and capital) are as follows:

Table 4 Flows of goods and services in a simple two-sector economy

Sectors	Intermediate demand 1	Intermediate demand 2	Final demand	Exports	Total output
Sector 1	Q_{11}	Q_{12}	F_1	X_1	Q_1
Sector 2	Q_{21}	Q_{22}	F_2	X_2	Q_2
Imports	M_1	M_2	M_f		
Value Added	VA_1	VA_2			
Total inputs	Q_1	Q_2			

Notes: Q_{ij}: intermediate consumption of products from sector i by j; F_i: final demand for products produced by i = 1,2 or imported from rest of the world ("RoW"); X_i: exports of i to "RoW"
M_i: imports of intermediate goods used by i from "RoW"; Q_i: total production of i
VA_i: value added (factorial services, corresponding to wages and profits)

The horizontal lines show the use of goods and services to supply other firms, final consumers and rest

of the world (exports). The vertical columns describe the requirements by sector j: purchases from domestic and rest of the world suppliers needed to produce the goods, remuneration of factors of productions (capital and labour, equal to the generation of value added). Following the recommendations of the SNA2008, the payment of financial services is considered as an intermediate consumption.

Inter-sectoral relationships are represented by the coefficients Q_{ij}. The technical coefficients conforming the input-output matrix (I-O) are derived by normalizing the intermediate coefficients Q_{ij} by the value of total production ($a_{ij}= Q_{ij}/Q_i$). These I-O coefficients present the direct requirements of inputs from "i" for producing one unit of output of industry "j". For example, to produce one unit of output, sector 2 will require a_{12} units from sector 1.

The technical coefficients tell only part of the story of the productive chain. In order to be able to produce the a_{12} units demanded by sector 2, the productive sector 1 will need inputs from sector 2 ($a_{21}.a_{12}$ units). To satisfy the demand created by one additional unit of output in sector 2, individual firms in each sector 1 and 2 will also require inputs produced by suppliers operating from the same sector (a_{22} and $a_{22}.a_{12}$). And so on, as the indirect demands generated at every step create in turn additional requirements.

It can be shown that the feed-back sequence resulting from the initial demand injection can be obtained by the series $I + A + A^2 + A^3 + \ldots + A^n$

Where:
I is an identity matrix representing the initial demand injection and A is the input-output matrix.
A^n is the progressive impact of initial demands at the n^{th} stage of the production chain.

When n tends towards infinity, the series has a limit (known as Leontief Inverse Matrix) $L=(I-A)^{-1}$
The coefficients l_{ij} of the Leontief Inverse measure the depth (intensity) of the backward linkages between sectors. They describe entirely the direct and indirect flows of intermediate products involved by the productive chains.

ii) The open circuit of goods and services

In an open economy where firms are vertically integrated, firms can import their intermediate inputs from external suppliers or sell goods for processing

Table 5 Flows of goods and services in a two-country two-sector model.

Sectors/country	Country a Intermediate demand 1	Country a Intermediate demand 2	Country b Intermediate demand 1	Country b Intermediate demand 2	Final demand (a+b)	Exports to Rest of the World	Total output
Country a Sector 1	Q^{aa}_{11}	Q^{aa}_{12}	Q^{ab}_{11}	Q^{ab}_{12}	F^{a}_{1}	X^{a}_{1}	Q^{a}_{1}
Country a Sector 2	Q^{aa}_{21}	Q^{aa}_{22}	Q^{ab}_{21}	Q^{ab}_{22}	F^{a}_{2}	X^{a}_{2}	Q^{a}_{2}
Country b Sector 1	Q^{ba}_{11}	Q^{ba}_{12}	Q^{bb}_{11}	Q^{bb}_{12}	F^{b}_{1}	X^{b}_{1}	Q^{b}_{1}
Country b Sector 2	Q^{ba}_{21}	Q^{ba}_{22}	Q^{bb}_{21}	Q^{bb}_{22}	F^{b}_{2}	X^{b}_{2}	Q^{b}_{2}
Imports from R. of World	M^{a}_{1}	M^{a}_{2}	M^{b}_{1}	M^{b}_{2}	M_{f}		
Value Added	VA^{a}_{1}	VA^{a}_{2}	VA^{b}_{1}	VA^{b}_{2}			
Total inputs	Q^{a}_{1}	Q^{a}_{2}	Q^{b}_{1}	Q^{b}_{2}			

Notes: See Table 4

These international I-O matrices can be used to measure vertical integration of production processes. For example, Hummels, Ishii and Yi (2001) proposes a VS index based on the imported content of exports (VS= M.L.X). When based on the Leontief-Inverse, these measures imply that all linkages take place in the same time (or that all the transactions take place within the unit of time chosen to measure M and X, usually a year). Inomata (2008) corrects for this short-coming and derives from international I-O tables a new measurement for international fragmentation of the production process that takes also into consideration the depth of vertical integration (the average propagation length of inter-industry linkages).

International I-O matrices such as the ones described in Table 5 provide a complete picture of the

Box 2. Demand-Driven and Supply-Driven Input-Output Models

The well-known "demand-driven" model was developed by Wassily Leontief in the 1930s; two decades later, Ambica Ghosh adapted the I-O model to analyse supply shocks. I-O models assume that all inputs are complementary (the production function is such that inputs should be used in a fixed proportion, with no substitution at least in the short time), and the demand impulses are transmitted primarily through backward linkages. When the final demand for a product "q" is altered exogenously, the primary impact is felt on the demand for those sectoral outputs and commodities that are used as inputs for the production of the product "q". The backward linkages trigger a series of secondary demand effects that progressively die down and are captured by the Leontief-inverse matrix $(I-A)^{-1}$.

The Ghosh approach states that each intermediate output is sold to a series of productive sectors in fixed proportions. When the production of an intermediate product "q" is exogenously altered, the primary effect is felt by those sectors that need "q" as input. This will trigger forward effects, either direct (to the sectors requiring "q" as input for their production) or secondary (sectors depending on intermediate goods that had required "q" as input). As in the Leontief case, the iterative process dies down to reach another equilibrium.

The accumulation of impacts can be measured by the Ghosh inverse $(I-B)^{-1}$. As in the Leontief case, the matrix B is build using the inter-sectoral transaction matrix Q_{ij}, but the allocation coefficients are normalized in line (destination of output) by the value of production, and not in column as for technical coefficients (origin of productive factors used in the production).

The Leontief logic for backward linkage is based on standard economics: sectors do respond to changes in demand, they increase their production when demand is higher and reduce it when demand is lower. The Ghoshian approach is much weaker, and its theoretical aspects are somewhat contentious. In absence of a change in effective demand, pushing-up production through additional supply of inputs would have the same effect as pushing on a string. Indeed, the theoretical reservations about the Ghosh model led to its relative demise as a macroeconomic modelling tool in the quantity space.

Nevertheless, the Ghosh approach is still useful in the price space, considering that it can be used to model the transmission of shocks to the costs of production (Mesnard, 2007). It is particularly true for short-term analysis, when firms have limited capacity for substituting the disrupted input by shifting to alternative and more expensive suppliers. The mechanism is as follows: a quantity restriction on any single intermediate good forces the client-firm to shift to other suppliers (foreign or domestic). While this is always possible in our model, it hmppil415 Tw((this)6.3s7)iilh [(alternative)5.8((h)5.9)-11.7(li)26.4(ew7(li)26.2(
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3) CREDIT CONTAGION AND THE FEED BACK FROM REAL TO FINANCIAL CHANNELS.

The previous two sections presented, from a monetary perspective and a supply-chain perspective, the linkages that exist within and between globalized industrial systems. The following section will formalise the connections between both financial and real circuits, through the modelling of the "α" parameter in the Capital Adequacy Ratio that appears originally as a simple accounting device in the monetary circuit (see Table 2 and Table 3). This institutional ratio constrains the total amount of credit that a bank may issue. As mentioned, international standards, issued by the Bank for International Settlements (BIS), set a 8% threshold for total risk-weighted assets.

i) Banks' assessment of business risks: Unifying the two circuits

We saw that the monetary circuit starts with a request for credit by a firm to a bank in order to finance a production process. The bank decisions of granting the loan is based on a mix of (i) macroeconomic perception, (ii) the sector of activity of the firm, (iii) a microeconomic component proper to the firm and (iv) the institutional capacity of the bank to extend new credit within the limit of its ratio loans/assets. These components are not independent; as we shall see, they are closely interrelated.

The microeconomic component of the bank's decision-making process is based, *inter alia*, on the direct business connections of the firm requesting a loan. In a vertically integrated production chain, the

financial and productive aspects, associated with (i) the firm itself and its management (what we called the microeconomic dimension), (ii) its mode of insertion in the productive economy and the related risks of supply-driven shocks transmitted through the supply-chain and (iii) its exposure to the macroeconomic business cycle, as captured by the demand-driven shocks.

- From a "stock" perspective, the real shocks translate into the accumulation of undesired stocks and extend the life expectancy of credit money, wi

In conclusion, a reduced model of contagion through the supply chain only requires two variables to simulate and track the systemic implications of an exogenous financial shock: one variable of flow (IRSIC constructed on the real circuit, possibly augmented for secondary demand driven effects) and one of stock (Capital Adequacy Ratio) derived from the monetary circuit. Because the stock-variable is partially dependent on the flow-variable, the strategic variable to be measured in order to evaluate the risk of contagion is the imported real impact coefficient (IRSIC).

III. APPLICATION TO THE US-ASIA COMPACT

International I-O matrices are necessary to measure IRSIC. Building these tables from national I-O data is a painstaking exercise, requiring the harmonization of national formats and classifications, the inclusion additional information such as disaggregating imports into sectoral intermediates and final

Table 6 Direct and indirect shares of imported inputs in sectoral production, 2006 (percent)

Direct share of imported inputs in total output	Agriculture	Mining	Textile	Electronics	Transport Equipment	Other Manufactures	Electricity Water Gas	Construction	Trade Transport	Other Services
a. Direct share of imported inputs in sectoral output [a]										
China	5.0	6.5	7.1	11.4	6.6	7.3	6.5	6.0	4.9	6.5
Japan	11.9	3.0	9.1	9.1	4.5	9.7	10.6	8.1	4.0	3.1
USA	5.5	6.7	8.1	12.2	10.4	7.9	6.5	3.9	2.8	3.1
Malaysia	20.3	19.1	31.1	54.4	29.5	26.2	18.1	24.2	19.4	19.9
Thailand	7.5	20.2	14.0	64.1	41.9	27.7	18.8	22.3	5.3	19.4
b. Direct and indirect share of imported inputs in sectoral output [b]										
Chine	16.1	19.4	20.3	26.0	20.9	20.5	19.9	20.1	16.9	19.6
Japon	17.0	9.3	16.6	17.4	14.2	17.2	15.0	14.6	6.9	6.2
Etats-Unis	9.9	10.0	13.9	16.9	16.8	13.0	10.4	9.0	5.5	5.8
Malaisie	34.0	27.9	48.0	62.3	43.9	42.3	30.1	40.7	29.8	31.3
Thaïlande	17.4	30.9	30.5	68.3	53.8	38.9	30.3	34.2	16.0	30.2

Notes a/ Imports of intermediate goods of the branch, relative to the value of total output, including factorial

As seen in Table 7, the largest secondary impacts are felt domestically. The relative effect of the shock on the domestic economy depends on its degree of openness, and also on the relative size of the originating sector in relation to the rest of the economy. Thus, despite their relative inward-oriented economies, a supply shock originating from the Japanese and American manufacturing sectors has a relatively lower impact because Japan and the US are mostly services-oriented economies. On the contrary, Malaysia and Thailand are less exposed to a domestic shock because of their openness and reliance on imported inputs.

Table 8 presents a summary of the results obtained for shocks initiating from the manufacturing sectors, which are more integrated in international supply chains. Imported and exported supply shocks are expressed as a weighted average of the national increase in sectoral production costs resulting from an initial 30% price shock on the manufacturing sectors. Based on the existing inter and intra-industrial linkages, in 2000 and 2006, Japan is potentially the largest exporter of supply shocks (1.6% and 1.4%, respectively). Malaysia and Thailand, on the other hand, are the largest importers of such shocks, because of the high degree of integration of their manufacturing sectors and reliance on imported inputs from the other partners.

The other outstanding results relate to China, with a notable increase in both forward international linkages and domestic backward linkages. First, China's influence as an exporter of "shocks" (i.e., a supplier of intermediate goods to the other economies via the supply chain) between 2000 and 2006 has increased (in 2006, China shares the highest influence with Japan), while its vulnerability to an imported shock remained relatively stable. Second, the large increase in the overall feed-back impact of its domestic sector itself shows that Chinese manufacturing sectors are relying more and more on domestic suppliers for their industrial inputs.

Table 7 Transmission of an initial 30% supply-driven price shock from manufacture sectors, 2000 and 2006 [a]
(percentage)

Origin of the shock, year.	From all manufacturing sectors, 2000 [b]					From all manufacturing sectors, 2006 [b]				
From China to:	China	Japan	USA	Malaysia	Thailand	China	Japan	USA	Malaysia	Thailand
Agriculture	13.9	0.1	0.1	0.3	0.3	25.7	1.0	0.6	3.5	0.7
Mining	14.0	0.1	0.1	0.1	0.1	29.0	0.5	0.3	2.5	1.8
Textile and clothing	...	0.9	0.5	2.1	1.5	...	1.5	0.8	3.7	2.1
Electronics	...	0.4	0.4	1.1	2.2	...	0.9	0.7	2.6	2.6
Transport equipment	...	0.3	0.4	0.7	0.6	...	0.8	0.7	2.6	1.0
Other manufactures	...	0.3	0.2	0.7	0.6	...	0.7	0.5	2.5	1.1
Utilities (water, gas, elect.)	17.7	0.1	0.1	0.2	0.1	27.8	0.4	0.3	2.9	1.7
Construction	30.3	0.2	0.3	0.6	0.7	36.1	1.0	0.5	2.5	1.8
Trade and transport services	18.9	0.1	0.1	0.1	0.2	28.2	0.3	0.3	2.0	0.7
Other services	16.2	0.1	0.1	0.3	0.2	28.6	0.4	0.3	2.9	1.9
From Japan to:	China	Japan	USA	Malaysia	Thailand	China	Japan	USA	Malaysia	Thailand
Agriculture	0.3	10.3	0.2	1.1	0.7	0.8	9.5	0.1	0.7	0.9
Mining	0.6	13.9	0.2	0.6	0.6	1.0	13.8	0.1	0.5	1.8
Textile and clothing	1.1	...	0.4	4.2	2.4	1.1	...	0.2	2.9	2.5
Electronics	1.7	...	1.3	0.9	1.0	1.5	...	0.9	0.7	1.0
Transport equipment	1.8	...	1.5	8.1	9.4	1.5	...	1.0	5.6	9.0
Other manufactures	0.9	...	0.4	2.4	2.2	1.1	...	0.2	1.6	2.3
Utilities (water, gas, elect.)	0.7	6.7	0.1	0.7	0.5	1.1	6.5	0.1	0.5	1.7
Construction	1.0	14.8	0.3	2.5	2.4	1.2	14.4	0.2	1.8	2.3
Trade and transport services	0.6	4.7	0.1	0.5	0.9	1.0	4.5	0.1	0.5	1.2
Other services	0.6	5.3	0.1	0.6	0.8	1.1	5.1	0.1	0.5	1.7
From USA to:	China	Japan	USA	Malaysia	Thailand	China	Japan	USA	Malaysia	Thailand
Agriculture	0.2	0.2	9.8	0.4	0.4	0.4	0.2	6.9	0.6	0.4
Mining	0.2	0.2	4.9	0.3	0.2	0.5	0.2	5.0	0.4	0.3
Textile and clothing	0.3	0.5	...	2.2	1.4	0.4	0.5	...	1.7	1.2
Electronics	0.8	0.8	...	0.4	0.3	0.7	0.8	...	0.4	0.3
Transport equipment	0.5	0.8	...	1.2	1.2	0.5	0.8	...	1.0	1.1
Other manufactures	0.4	0.4	...	1.1	0.9	0.5	0.4	...	1.0	0.8
Utilities (water, gas, elect.)	0.3	0.1	3.3	0.4	0.2	0.5	0.1	3.1	0.4	0.2
Construction	0.4	0.2	12.6	0.9	0.5	0.5	0.2	12.1	0.8	0.4
Trade and transport services	0.3	0.1	4.0	0.4	0.2	0.4	0.1	4.0	0.4	0.2
Other services	0.3	0.1	4.0	0.5	0.3	0.5	0.1	4.1	0.5	0.3

Continued .../...

Table 7 Transmission of an initial 30% supply-driven price shock from manufacture sectors, 2000 and 2006 [a]
(Cont.)

Origin of the shock, year.	From all manufacturing sectors, 2000					From all manufacturing sectors, 2006				
From Malaysia to:	China	Japan	USA	Malaysia	Thailand	China	Japan	USA	Malaysia	Thailand
Agriculture	0.0	0.0	0.0	7.0	0.2	0.2	0.1	0.0	8.7	0.3
Mining	0.1	0.0	0.0	1.2	0.1	0.2	0.0	0.0	2.5	0.6
Textile and clothing	0.1	0.1	0.1	...	0.8	0.2	0.1	0.1	...	0.9
Electronics	0.4	0.2	0.3	...	0.2	0.3	0.3	0.2	...	0.2
Transport equipment	0.1	0.1	0.1	...	0.3	0.2	0.1	0.1	...	0.4
Other manufactures	0.1	0.1	0.0	...	0.4	0.2	0.1	0.0	...	0.5
Utilities (water, gas, elect.)	0.1	0.0	0.0	5.0	0.1	0.2	0.1	0.0	6.1	0.6
Construction	0.1	0.1	0.0	12.2	0.4	0.2	0.1	0.0	11.7	0.6
Trade and transport services	0.1	0.0	0.0	3.2	0.1	0.2	0.0	0.0	3.8	0.3
Other services	0.1	0.0	0.0	3.4	0.1	0.2	0.0	0.0	4.3	0.7
From Thailand to:	China	Japan	USA	Malaysia	Thailand	China	Japan	USA	Malaysia	Thailand
Agriculture	0.0	0.0	0.0	0.2	7.1	0.1	0.1	0.0	0.6	7.0
Mining	0.0	0.0	0.0	0.1	5.9	0.1	0.1	0.0	0.3	6.2
Textile and clothing	0.1	0.1	0.2	1.5	...	0.1	0.2	0.2	1.4	...
Electronics	0.2	0.1	0.1	0.1	...	0.2	0.1	0.1	0.3	...
Transport equipment	0.1	0.2	0.1	0.4	...	0.1	0.2	0.1	0.6	...
Other manufactures	0.1	0.1	0.0	0.4	...	0.1	0.1	0.0	0.6	...
Utilities (water, gas, elect.)	0.1	0.0	0.0	0.1	4.8	0.1	0.0	0.0	0.3	3.6
Construction	0.1	0.0	0.0	0.4	10.6	0.1	0.1	0.0	0.6	8.6
Trade and transport services	0.0	0.0	0.0	0.1	7.0	0.1	0.0	0.0	0.3	6.9
Other services	0.1	0.0	0.0	0.1	6.6	0.1	0.0	0.0	0.4	5.3

Notes: a/ Impact of an increase in 30% of the cost of inputs originating from the manufacturing sectors on the respective sectoral production costs. b/ The manufacturing sectors from where supply shocks originate are: Textile, Electronics, Transport Equipment, and Other Manufacturing.
Source: authors' calculations.

Table 8. Imported and exported shocks from/to the manufacturing sectors [a], 2000 and 2006

2000 To: / From:	China	Japan	USA	Malaysia	Thailand	Exported shocks
China	**...**	0.3	0.3	0.9	1.0	0.6
Japan	1.1	**...**	0.7	2.1	2.6	1.6
USA	0.5	0.6	**...**	0.9	0.8	0.7
Malaysia	0.1	0.1	0.1	**...**	0.4	0.2
Thailand	0.1	0.1	0.1	0.3	**...**	0.1
Imported shocks	0.4	0.3	0.3	1.1	1.2	

2006 To: / From:	China	Japan	USA	Malaysia	Thailand	Exported shocks [b]
China	**...**	0.8	0.5	2.6	1.5	1.4
Japan	1.2	**...**	0.5	1.5	2.7	1.4
USA	0.5	0.6	**...**	0.8	0.8	0.7
Malaysia	0.2	0.1	0.1	**...**	0.5	0.2
Thailand	0.1	0.1	0.0	0.5	**...**	0.2

production costs may be much higher than the standard 30% used in the simulation, due to, *inter alia*, the difference in the cost of factorial services.

As discussed previously, the input-output framework is inappropriate to measure the first type of disruptive shocks because the combination of strict complementarities of inputs and forward linkages would progressively bring the economy to an almost complete halt. In a more realistic scenario, one can consider that most of the export-oriented activities would stop, generating a severe macroeconomic shock to the economy.

For Japan and the US, the induced rise in domestic prices due to a shutdown of their Asian suppliers of intermediate manufacture goods is significant when differences in production costs are imputed. This is the case especially for the textile and clothing sectors (see Annex 3 for details on the calculation). The disruption of supply chains in the manufacturing sectors of the three developing Asian countries would lead to a 2% average increase in the price of sectoral outputs in the textile, electronics and transport equipment sectors. Japan would be more affected than the US in all sectors, and the average increase in prices would reach 2.5% (against 1.5% for the USA). Considering that only a minority of firms engage in off-shoring, this average impact will fall disproportionately on a few firms probably the most dynamic with potentially large disruptive impact. The results of this simulation also show the potential gains those firms were able to obtain by out-sourcing in the first place.

ii) Demand-driven secondary impacts.

Even in a static input-output framework, one cannot expect quantities to remain constant when prices change. The increase in production costs should reflect into higher output prices and, therefore, lead to lower final demand (considering a constant nominal income). Annex 2 illustrates these effects in the Asian-US context. [23] Demand-driven secondary impacts differ widely across country, but the summary results obtained tend to indicate that increases in output prices caused by a disruption of the supply chain in China would have significant implications for all the partner countries, with the exception of the USA. Disruptions originating in Japan also have important implications, and shock originating from the USA would affect more developing Asia than Japan.

IV. CONCLUSIONS

The international economy is a situation where the global financial crisis which started in 2008 could possibly replicate the pattern of Japan's lost decade, in particular its negative transmission mechanisms between the financial sectors and the real economy. In this context, the aim of the present study was to analyse the role of international supply chains as transmission channels of a financial shock from the monetary circuit into the real economy. The existence of feed-back effects between the two circuits may amplify the initial shock when the financial sector is facing credit-adequacy constraints. In such a case, credit restrictions affecting the production or the trade activity of a single firm participating in a production network has systemic "across the board" real and financial impacts. In an endogenous money framework, a credit-crunch situation is compatible with the accumulation of liquidity in the monetary circuit, as counterpart of the accumulation of unexpected inventories of unfinished goods in the supply chain.

Because individual firms are interdependent and rely on each other, either as supplier of intermediate goods or client for their own production, an exogenous financial shock affecting a single firm, such as the termination of a line of credit, reverberates through the productive chain. The transmission of the shock through real channels can be tracked, at macroeconomic level, by modelling input-output interactions. Using an international version of the input-output matrices, the paper proposes the calculation of an indicator of supply-driven shocks based on forward linkages.

[23] Results are offered only for illustration, since a complete modelling of the supply-demand interactions would require a general equilibrium framework.

Assuming that the initial credit-crunch shock that constrains the productive capacity of some individual firms is not disruptive at macroeconomic level, the intensity of the real sectoral shock transmission is proportional to the direct and indirect increases in production costs. In the price space, the initial supply shocks are transmitted through the Ghosh matrix, while the transmission of the secondary demand shocks responds to the Leontief methodology.

As the initial monetary shock reverberates through the productive chains and affects final demand, more and more firms will face difficulties in completing their production plans or selling their output. These disruptions occurring in the real economy feed-back into the monetary circuit. The disruption of the productive chain and the building-up of undesired stocks impede the expected destruction of money and determine the accumulation of outstanding loans as well as a further downgrading of the exposed firms. Since the downgrading of an indebted individual firm affects the capital adequacy ratio of its banker, both flows and stocks are affected in the monetary circuit and all firms see their access to credit potentially restricted. Thus a limited credit shock initiating in the monetary circuit will be spread across various sectors and various countries through the supply chain, and then will feed-back into the monetary circuit with amplified effects.

The paper suggests that if banks were originally operating at the limit of their institutional capacity, defined by the capital adequacy ratio, and if assets are priced to market, then a resonance effect amplifies the back and forth transmission between real and monetary circuits, leading to strongly non linear results. The chaotic behaviour of the international financial system at the end of 2008, and its dire consequences on the real economy observed in 2009, are examples of such resonance and amplification. In that light, the present crisis should provide an opportunity to address problems of macro-prudential pro-cyclicality to minimize the risks of boom and bust cycles initiating from the financial sector.

The paper illustrates the proposed methodology by computing a supply-driven indicator (IRSIC) and the resulting demand-driven impacts on five interconnected economies of different characteristics: China, Japan, Malaysia, Thailand and the United States. Calculations are based on the international Input-Output matrices prepared on the basis of 2000 data, and an estimate for 2006. Results indicate that the real transmission effect through the international supply-chain linking firms among these economies were heterogeneous across countries and across sectors.

The largest impacts, as expected, are felt domestically. The relative size of the shock on the domestic economy depends on its degree of openness, and also on the relative size of the originating sector in

credit-migration matrices, but falls short of integrating them into the monetary circuit. Incorporating the various micro, sectoral and macroeconomic dimensions into computable general equilibrium models would be an option, but these models have limitations in their financial components. In particular, the reductive assumption of exogenous money typical of CGEs would have to be abandoned for the endogenous approach characterising monetary circuits.

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In order to avoid this loop effect, Papadas and Dahl (1999) have suggested splitting the I-O matrix into exogenous and endogenous sectors, and have captured the backward sectoral impacts of supply-driven multipliers only on the non-exogenized sectors. When the production of sector *n*

Table A2.1 Secondary demand shock in response to an initial 30% increase in the price of imported manufactured intermediate inputs, 2006 [a] (percent)

	Imported from China to:					Imported from Japan to:				
	China	Japan	USA	Malaysia	Thailand	China	Japan	USA	Malaysia	Thailand

Table A3.2 Combined disruptive shock from the manufacturing sectors of Asian developing countries (percentage)

	Japan	USA
Agriculture	3.2	1.8
Mining	1.6	1.0
Textile and clothing	4.6	2.8
Electronics	3.4	2.7
Transport equipment	3.1	2.1
Other manufactures	2.4	1.5
Utilities (water, gas, elect.)	1.3	1.0
Construction	3.1	1.5
Trade and transport services	1.0	0.8
Other services	1.1	1.0

Note: Expected increase in sectoral cost of production following a disruptive shock from China, Malaysia and Thailand manufacturing sectors.
Sources: Authors' calculations.

The induced rise in output prices is significant, especially in the sectors of textile, electronics and transport equipments, where the disruption of supply chains in the manufacturing sectors of the three developing Asian countries would lead to a 2% increase in the average price of sectoral outputs in the ex-importing countries. Japan is more affected the US in all sectors, especially for textile and clothing, construction and agriculture, showing her greater reliance on imported inputs and fragmented production.