

Information and Coordination: Towards East Asian Regional Financial Integration¹

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Abstract:

We study how economic institutions intertwine with political institutions. A theoretical study of a simple strategic complementary game with private and public information among partially informed agents such as central banks shows that initial fundamentals might give rise to different levels of transparency. An empirical study shows that both economic fundamentals such as the reserve ratio of broad money to foreign exchange reserves and non-economic fundamentals such as an occurrence of crisis and the level of democracy do affect transparency of central banks. We apply this analysis to study the coordination effect of information on the progress towards regional financial integration among East Asian countries. We find that the progress towards regional financial integration might rely more on polity rather than on economic fundamentals.

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"In macroeconomic models with imperfect information, strategic complementarities arise also naturally. The economy can get stuck at a low activity equilibrium and there may exist a role for policy to move to a better equilibrium." (Vives, 1990)

0.1 Motivation

The primary motivation for this paper is to study how East Asian countries could better coordinate themselves to achieve greater cooperation. This paper begins with coordination analysis from the perspective of information theory. Information is a fundamental issue in any coordination problem. It is very important to discuss this issue in the context of coordination and cooperation because an *accidental* distrust among agents could create a vicious cycle between more distrust and more non-cooperative behaviors. It is also an institutional issue as institutions are places of information exchange. Institutional issues resemble those of a public good namely free-riding problem and collective action.

To understand this, consider the following simple example. There are two individuals who try to cooperate. Cooperation is better than non-cooperation for both individuals, but a defect by an opponent while cooperating is worse than non-cooperation. These individuals could be either mischievous or good-natured that are private information. The mischievous type is more likely to defect while the good-natured type is more likely to cooperate. However, because of some history, the belief about the other individual's type is biased towards mischievous that this belief will discourage cooperation. Thus, each individual never learns about the good nature of the opponent. This initial belief creates a cycle of distrust and non-cooperation. The only way to initiate cooperation, leaving out other frictions

and exogenous shocks that could affect the incentives to cooperate except for the initial beliefs and the observable actions, is to reveal the individuals' types. Hence, information in this case is a necessary condition. It is, however, not a sufficient condition because cooperation will only occur if both individuals are good-natured. Thus, information becomes very important if there is an accidental distrust among individuals that would discourage cooperation.

We first show theoretically that in a simple strategic complementary investment game with partially-informed agents who both have private information about their own fundamentals and private and public information about the others agents' fundamentals, agents with low and intermediate fundamentals may prefer less transparency in revealing information than agents with high fundamentals. If transparency is endogenous, then we might be facing an adverse selection problem or the *lemon car* issue. In this situation, the only agents who will not reveal their types are the worst-fundamental agents.

We then conduct an empirical study to analyze the effect of economic fundamentals on the transparency of central banks. We show that one-year lagged inflation, ratio of broad money to foreign exchange reserves, and ratio of current account deficit to nominal GDP affect the transparency of central banks after controlling for the other economic and non-economic factors, namely the level of development or GDP per capita, the exchange rate regimes, polity, region-specific biases, occurrence of crisis, and year-effect or general worldwide time trend. Countries with higher inflation, higher ratio of broad money to foreign exchange reserves, and high ratio of current account surpluses to nominal GDP tend to have lower transparency. This study also highlights the fact that economic fundamentals and economic institutions could be endogenous. That is, countries with higher economic fundamentals tend to have higher transparency that in turn creates higher economic fundamentals, and so on. Other observations include the convergence or

catching-up bias, in which countries with lower initial levels of transparency tend to have higher growths of transparency.

In many real-life cases, transparency is endogenous, and reputation effects or adverse selection biases arise. These might not be significant in a large group, such as a worldwide cross-country community, because there are many non-fundamental factors that could affect the level of transparency such that transparency does not sufficiently signal fundamentals. However, they are more prevalent in a smaller group, such as a regional community, because the non-fundamental factors such as region-specific biases are better controlled and information travels faster (see "localization of information" (Dixit, 2004) and "diminishing anonymity" (Greif, 2006)). Moreover, in a small group, there is a higher probability of future interactions. We argue that transparency-aversion by low-fundamental countries cannot completely explain the non-seeking behaviors towards regional institutions, whose members would have to abide by some laws regulating the adoption of some transparency measures, because of the reputation effects or adverse selection biases. Instead of transparency aversion, all countries except the lowest-fundamental countries will become transparency-seeking.

We show that economic fundamentals could not explain the variations in the transparency of central banks of eight ASEAN+3 countries. We find that variations and anomalies surrounding the transparency of central banks in these countries can be explained by the inherent levels of democracy. This suggests that the quality of economic institutions may not depend only on economic fundamentals but also on polity. Policy issues and efforts towards regional financial integration should therefore consider all of these factors. We also examine the non-economic factors that could slow progress towards regional integration among the ASEAN+3 countries, including military and security issues as well as socio-cultural factors.

This paper highlights not only the importance of information in coordination, but also the issues of institutions, including the endogenous system of institutions. An institution is a place of information exchange that enables countries to make transactions, borrow and lend, as well as invest. Many countries would turn to the IMF because it is the only way that other countries would lend to these countries under the monitoring and surveillance measures. The reserve pooling fund of the ASEAN+3 that amounts to at least US\$80 billion, as in February 2009, could only work if all countries agree to follow some set of monitoring and surveillance measures. The assistance of the IMF on Asian countries in the 1997-1998 crisis are accompanied by pressures to adopt transparency measures. At the other extreme, failures of an institution to properly regulate the monitoring and surveillance measures could lead to a crisis, such as the 2007 global financial crisis. Hence, institution is a way of exchanging information that helps coordination, where a failure of exchanging information could be detrimental. An institutionalized Asian regional financial arrangement is needed for the ASEAN+3 countries to coordinate better in the economic sector while an institutionalized Asian Community is crucial for the Asian countries to coordinate better in both their economic and non-economic sectors.

Moreover, a regional institution could also better collect information and solve asymmetric information issues because of the close proximity of member countries. Despite the urgency for better coordination among East Asian countries especially after the 1997-1998 Asian financial crisis and during the 2007 global financial crisis, there has not been any economic institution officially established. Economic explanations, however, seem to be limited and unsatisfying. This is a case in which we witness how economic institutions and politics intertwine. This paper also highlights the importance of an institution as a place of information exchange, and just like a public good, it faces collective action or free-riding problems.

This paper consists of two main parts: theory and empirical study (part 1), and application (part 2). In the first part of the paper, we analyze the optimal publicity of private information among partially informed agents, such as central banks, ministries of finance, or other countries' representatives (call them "countries"), when they sit down together to discuss regional policy issues. Each country knows its own true fundamentals but not the others' fundamentals, and hence incompleteness of information is asymmetric. We assume that each country makes an investment decision given random private and public information about the true economic fundamentals of these countries. A concrete example of this model may be seen with countries that invest through the Sovereign Wealth Funds. Investments are strategic complements. The contribution of this paper in the literature of social value of public information is to introduce a K -dimensional true fundamental corresponding to the K countries and an asymmetry of incompleteness of information among partially informed agents. Assuming the precision of public signals is exogenously given and does not convey any information about the fundamentals, we show that for some intermediate values of the fundamentals, in which a multiplicity of equilibria exists in the complete information game, a multiplicity of equilibria recovers in the incomplete information game if the relative precision of private to public information is sufficiently low. Hence, lower precision of public information might be preferable in order to avoid coordination failure if there is a high probability of low-investment or Pareto-dominated equilibrium being played because of some non-fundamental volatilities or sunspots. Moreover, if there are some bad reputation effects from revealing bad fundamental on the countries' payoffs that are not captured in the payoffs from investment, then there are countries with low and intermediate fundamentals that are better off with a lower level of transparency than full revelation. We conduct an empirical study to test the hypothesis that economic fundamentals, controlling for non-economic

fundamentals, affect the level of transparency of central banks.

In the second part of the paper, we apply our theory to the policy issues surrounding the Asian regional financial arrangement and regional integration. We argue that there are three main barriers to institutionalizing regional financial arrangements and moving towards regional integration. First, we argue that distrust that is prolonged by US military presence in Japan after the Sino-Japan war, religious shrines honoring Japanese war-time heroes, and Japanese textbooks that do not expose the true history of the Sino-Japan war could be a barrier to integration in the asymmetric information environment. An accidental distrust could create a vicious cycle of distrust and non-cooperation. The policy question here is how we could break this vicious cycle. We argue that greater strides towards economic integration in the midst of recovery from the Asian financial crisis and the current global financial crisis are positive shocks that could break the cycle of distrust and non-cooperation. Second, we argue that asymmetric bargaining power of powerful countries, particularly China could create a barrier to regional financial integration because distribution of power might be problematic. China has a disproportionately gigantic population, geography, amount of strategic commodities, international reserves, and trade surplus. Moreover, China's nuclear weapons escalate its power and could create security disagreements with its ASEAN neighborhood who signed the Bangkok Treaty of Nuclear Weapons Free Trade Zone in 1995. This could create a disincentive for China and other countries to move towards greater integration. We briefly discuss how the threat points of the ASEAN+3 countries with asymmetric bargaining power, coalitional analysis, and a consensus-based decision-making process could affect the outcomes of bargaining. Third, we argue that transparency-aversion that is predicted by the theoretical model and worldwide empirical study could have been a barrier to institutionalizing a regional financial arrangement and move towards greater

integration. As an institution is established, member countries have to comply to some transparency measures. However, this transparency-aversion effect is eroded by reputation effects and adverse selection biases as well as international pressures to adopt transparency measures. Thus, eventually, all countries, except countries with the lowest fundamentals, become transparency-seeking and adopt transparency measures. Hence, transparency-aversion related to low economic fundamentals does not seem to be the salient issue in regional integration among ASEAN+3 countries. One of non-fundamental issues that could affect preferences towards transparency is the degree of democracy, which affects attitudes towards regional openness. This seems to be a more compelling explanation of non-cooperative attitudes because we find that less democratic countries are more opaque. Other issues surrounding the establishment of an institutionalized regional financial arrangement are social and cultural factors, as well as the lack of international support, such as the IMF in fears of double standards and moral hazard.

0.2 Literature Review

Morris and Shin (2002) show that, with a Keynesian Beauty Contest utility function, more transparency of public information increases welfare only if the precision of the public information is relatively high, as compared to the precision of the private information. Given a slightly different model than that of Morris and Shin (2002), Angeletos and Pavan (2004) show that when investors' strategies are complementary and social value also takes into account externality of aggregate investment, then transparency of public information is necessarily good for welfare. Such is not the case, however, when investors' strategies are strongly complementary, such that a multiplicity of equilibria exists for high precision of public

information. They show that in the strong-complementary model, high precision of public information might be detrimental if there is a high probability of the low-investment equilibrium being played in the case in which a multiplicity of equilibria arises. Svensson (2005) however shows that the anti-transparency contention of Morris and Shin's (2002) result is often misinterpreted and in fact, the result is actually pro-transparency. He shows that given the highest possible critical point (i.e. the worst possible scenario) as a function of the share of the beauty contest term in the utility function, the area of sets of parameters of the relative precision of public information to private information, in which transparency decreases welfare is relatively small. The main difference between Morris and Shin's (2002) results and those of Angeletos and Pavan (2004) is the uniqueness of equilibrium in Morris and Shin's (2002) model as compared to the multiplicity of equilibria in Angeletos and Pavan's Model (2004). Tong (2006) endogenizes the precision of private information in Morris and Shin's (2002) model, and shows that higher precision of public information lowers (or "crowds out") the precision of private information, and the overall effect on dispersion of information is ambiguous.

Cooper (1999) argues that the main factor of coordination failures at the macroeconomic level is the "risk-dominant" factor. He provides experimental results that show failure to achieve the Pareto-Dominant Equilibrium in the case of coordination games. Vives (1990) shows that a Bayesian game with a parameterized family of supermodular games is itself a supermodular. Hence, the existence of an equilibrium theorem for a supermodular game applies directly to the incomplete information Bayesian game. Topkis (1998) proves the existence of a greatest and lowest Nash equilibria in a supermodular game. Milgrom and Roberts (1990) introduce an adaptive learning solution concept for dynamic stability in supermodular games with finite strategies.

In Geraats (2006), transparency of central banks is studied across and within

different monetary policy regimes. Geraats (2008) shows that transparency among central banks has been increasing in the past decade. Countries that show significant increases in transparency tend to have with high initial levels of inflation and higher economic development. Transparency is therefore positively correlated with initial level of inflation and GDP per capita. Transparency is also negatively correlated with subsequent level of inflation and positively correlated with GDP per capita in the same year. Inflation targeters are associated with high transparency, low inflation and high GDP per capita. Dincer and Eichengreen (2007) show that central banks in advanced countries are more transparent than central banks in emerging markets, which are defined as middle-income countries with significant links to international financial markets. They also show that GDP per capita significantly affects the level of transparency. Transparency index, however, affects inflation persistence, inflation variability, and output variability, suggesting that transparency and economic indicators are co-determined or endogenous. Crowe and Meade (2008) show that reforms of central bank independence is positively correlated with initial level of central bank independence, initial inflation, and democracy. They further show a negative correlation with flexibility of exchange rate regime. Transparency increase, albeit only significant in developed countries, is positively correlated with overall governance quality measures, central bank independence, and exchange rate flexibility.

Bernanke (2004) argues that transparency helps the public to better predict the central bank's monetary objectives, thereby increasing welfare by aligning the public's expectation with the central bank's objectives. Azis (2008) argues that one of the criteria that determines how successful Regional Financial Arrangement can be is the issue of macro-coordination and coordination failure as the benefit and cost, respectively. Soesastro (2008) argues that East Asian regional cooperation is indispensable in the midst of the 2007 global financial crisis, and gives a chronology

of actions and policy meetings that have occurred in attempts to achieve East Asian regional financial integration.

0.3 Theoretical Model: Exogenous Precision of Public Information

0.3.1 Examples

The following are real-life examples that motivate our model and of how our model may apply.

1. Public information sharing and macroeconomic coordination: People's Bank of China agreed in 2004-2005 to inform other Asian central bankers should they de-peg the Yuan and move to the managed floating exchange rate. On July 20, 2005, People's Bank of China announced their intention to de-peg the Yuan to the Asian central bankers and move to the managed floating exchange rate, and on July 21, 2005, they did so. Immediately after that, Bank Negara Malaysia, the central bank of Malaysia followed China's decision, de-pegged the Ringgit and moved to the managed floating exchange rate. This kind of information sharing among the central banks is never known to the public nor other financial institutions such as the Asian Development Bank, nor is sensitive information on macroeconomic policies leaked to the public.

2. Sovereign Wealth Funds are state-owned investments funds. Some SWFs are controlled by central banks who invest in financial assets. The most traditional investment instruments for SWFs are government bonds of industrialized nations, although some invest in riskier assets. Some SWFs have economic and fiscal importance, while some are state savings coming from excess foreign exchange reserves or revenues from oil and other commodities. Unlike foreign exchange

reserves, whose purpose is to safeguard sovereign countries against liquidity crisis, the main objective of SWFs is to maximize long-term return. Sovereign Wealth Funds have been attracting the attention of investors and regulators because of their growing size and number, and their potential to influence financial markets. Another growing issue is security, as investments are made not because of economic reasons but political reasons. The inadequate transparency of SWFs is also a growing concern. Assets under management of SWFs reached US\$3.3 trillion in 2007, born mostly from the Asian countries with massive foreign exchange reserves and the Middle Eastern countries with rising revenues from oil exports. The seven SWFs with assets over US\$100 billion are the Abu Dhabi Investment Authority, the Government Pension Fund of Norway, the Government of Singapore Investment Corporation, the Kuwait Investment Authority, the China Investment Corporation, the Singapore's Temasek Holdings, and the Stabilization Fund of the Russian Federation.

0.3.2 Model

Suppose there are K "countries" (for central banks, ministries of finance, or countries' representatives) that meet regularly to discuss regional policies at the Asian Regional Financial Arrangement's Economic Review and Policy Dialogue meetings. In the case of Asian Regional Financial Arrangement, $K=13$, corresponding to the 10 ASEAN countries plus China, Japan, and South Korea. Each country knows its own fundamental but does not know the fundamental of the other countries. Each country however receives two types of information, namely private and public information, about the other countries. Given this information, the country makes investment decisions in all of the countries, including its own. For example, central banks who have excess reserves and hold Sovereign

Wealth Fund (SWF) make foreign investments in stocks, bonds, property, precious metals and other financial instruments. Another example is the inter-ministrial coordination as part of an inter-regional development strategy by investing in environment, transport, communication infrastructures, or energy in the region in which decisions over spending priorities are made by ministries of finances². Or, if central banks' information is fully shared with the private sector who then make a foreign investment, then we may assume that the central banks make investment decisions as if they are the private investors. We are interested in how the precision of public information, given the precision of private information, affects individual countries' investment strategies to invest in their own countries (domestic investments) and in other countries (foreign investments) when there are K fundamentals and incompleteness of information about the K fundamentals is asymmetric.

We assume that the precision of public information is exogenously given and does not convey any information about the fundamentals of the countries. For example, member countries are requested to reveal some specific information at the regional meetings rather than choosing information to reveal. Basel II is an example of disclosure requirement for banks globally. IMF's Article IV publication and IMF's public data dissemination, albeit voluntary, could set standard disclosures of macroeconomic data. This will enable us to derive how the precision of public information affects the equilibrium level of investments, assuming sources come only from private and public information. We assume that domestic in-

²An example of this is the case of mainstreaming trade policies in national development strategies among African countries by providing trade financing, building trade capacities, improving trade facilitation, and addressing negative impacts of trade liberalization (UNECA, 2004). Inter-ministrial coordination, in particular across ministries of finance is needed in achieving these goals through their roles in approving spending priorities as well as their roles in regulating complementary policies. Investments as parts of these goals include investments on environment, transport, communication infrastructures, and energy.

vestment strategy is monotonic in the true fundamental, while foreign investment is monotonic in private information about those foreign countries. Monotonicity of strategies allows us to derive critical values of domestic and foreign investment that depend on public signals. For any true fundamental above a critical value that depends on the private signal, a country will invest in its own country. For any private information about another country that is above a critical value that depends on the public signal, a country will invest in that country. Public information is therefore used as a public signalling device to coordinate strategies among countries. An equilibrium concept therefore resembles that of the correlated equilibrium. At equilibrium, no country will deviate from the prescribed strategy. We also show that multiple equilibria recover in the incomplete information game for some interval of the fundamentals in which a multiplicity of equilibria exists in the complete information game.

Notation

There are K countries denoted by $i=1, \dots, K$. Each country i has private information about its type denoted by θ_i . The type of each country is the fundamental of that country. High fundamental means the economy is in good condition, while low fundamental means that economy is in bad condition. The distribution of the type is uniform in the unit interval $[0,1]$ ³. Each country has two sources of information, namely private and public information. The precision of private signal is equal across all countries. The private information can be written as:

³Without a loss of generality, we may assume that θ is uniformly distributed in real line (improper distribution). We choose this proper distribution that allows us to take conditional probability with respect to θ when precisions of public information are endogenous. In various places in this paper, we will assume θ to be uniformly distributed in real line (improper distribution).

write the investment strategy in a country: $k_j^i : \mathfrak{R}^4 \rightarrow \mathfrak{R}, \forall j = 1, \dots, K$.

The utility function of each country exhibits a strong strategic complementarity of investment (Angeletos and Pavan, 2004):

$$u_i = (\theta + i_{K>1} - 1)'k^i,$$

where θ is a $K \times 1$ vector with θ_k in its k -th row, k^i is a $K \times 1$ vector with its k -th row equal to k_k^i , $i_{K>1}$ is a $K \times 1$ indicator function, $i_{K_k>1}$ is the k -th row of $i_{K>1}$, $i_{K_k>1}=1$ if $K_k > 1$, $i_{K_k>1}=0$ if $K_k \leq 0$, and $K_k = \sum_{j=1}^K k_k^j$. Note: the utility from investing in country k alone is equal to $(\theta_k + i_{K_k>1} - 1)k_k$ and the utility is the sum of the utilities from investing in country 1 to K . Without uncertainty, there exists a multiplicity of equilibria for $\theta_i = [0, 1]$ that is either $k_i^j = 1$ for all $j=1, \dots, K$ (all countries invest in country i), or $k_i^j = 0$ for all $j=1, \dots, K$ (all countries do not invest in country i). This utility function exhibits increasing first differences in the players' actions, but exhibits only weak supermodularity in a player's own actions, i.e. $\frac{\partial^2 f_i(s_i, s_j)}{\partial s_{im} \partial s_{ik}} = 0$, for all $m \neq k$. In the incomplete information game, the utility is taken at the expectation: $Eu_i = E[(\theta + i_{K>1} - 1)'k^i]$.

The Nash equilibrium strategy for country i is denoted by:

$$k^{i*} = \text{argmax}_i. Eu_i(k^i | k^{-i*}, \theta, x^i, z, P, \sigma_x^2), \forall i=1, \dots, K.$$

Given (x^i, z, P, σ_x^2) , k^{i*} is the Nash Equilibrium investment strategy of country i and k^* is the Nash Equilibrium. Note: for simplicity, we assume there is no budget constraint. In other words, the available funds to invest are high enough to allow

⁴A supermodular game (Cooper, 1999) must satisfy the following properties: 1. the strategy set (k^i) is a lattice, 2. the payoff function increases in the first difference in the players' actions (in k^i and k^{-i}), 3. the payoff function is supermodular in a player's actions (in k^i given k^{-i}). Hence, this game is a supermodular game.

countries to invest the maximum amounts of investment in all countries. This allows us to focus only on informational issues.

Lemma 1 *Country i 's expected fundamental of country $j \neq i$ conditional on private and public information is given by: $(\theta_j | x_j^i, z_j) \sim N(\frac{\frac{1}{\sigma_x^2}}{P_j + \frac{1}{\sigma_x^2}} x_j^i + \frac{P_j}{P_j + \frac{1}{\sigma_x^2}} z_j, \frac{1}{P_j + \frac{1}{\sigma_x^2}})$.*

Proof. (See Appendix 1) ■

Corollary 1 *Let θ_j be uniformly distributed in the real line (improper distribution). Analogous to the uniform distribution in the unit interval, country i 's expected fundamental of country $j \neq i$ conditional on private and public information is given by: $(\theta_j | x_j^i, z_j) \sim N(\frac{\frac{1}{\sigma_x^2}}{P_j + \frac{1}{\sigma_x^2}} x_j^i + \frac{P_j}{P_j + \frac{1}{\sigma_x^2}} z_j, \frac{1}{P_j + \frac{1}{\sigma_x^2}})$.*

Proof. (See Appendix 2) ■

We can write in matrix form:

$$\begin{aligned} E(\theta | (x^i, z)) = & (\Omega_z^2)^{-1} ((\Omega_{x^i}^2)^{-1} + (\Omega_z^2)^{-1})^{-1} z + (\Omega_{x^i}^2)^{-1} ((\Omega_{x^i}^2)^{-1} + (\Omega_z^2)^{-1})^{-1} x^i \\ & \frac{\frac{1}{\sigma_x^2}}{P_1 + \frac{1}{\sigma_x^2}} x_1^i + \frac{P_1}{P_1 + \frac{1}{\sigma_x^2}} z_1 \\ & \frac{\frac{1}{\sigma_x^2}}{P_2 + \frac{1}{\sigma_x^2}} x_2^i + \frac{P_2}{P_2 + \frac{1}{\sigma_x^2}} z_2 \end{aligned}$$

$$E(\theta | (x^i, z)) = \left(\begin{array}{c} \dots \\ x_i^i \\ \dots \end{array} \right), \text{ where } \frac{1}{\sigma_x^2} \text{ is the absolute precision of}$$

$$\frac{\frac{1}{\sigma_x^2}}{P_K + \frac{1}{\sigma_x^2}} x_K^i + \frac{P_K}{P_K + \frac{1}{\sigma_x^2}} z_K$$

private information and P_i is the absolute precision of public information of country i .

Strong Strategic Complementary Investments

The following example with strong strategic complementary investments will show the effect of public information on coordination among the countries, in particular when a multiplicity of equilibria arises.

Lemma 2 For each of the element in $k^i = \{k_k^i\}$, and $i, k=1, \dots, K$:

$$k_k^i = 1 \text{ if } \theta_k + i_{K_k > 1} - 1 \geq 0,$$

$$k_k^i = 0 \text{ if } \theta_k + i_{K_k > 1} - 1 < 0,$$

Investment strategy is therefore a corner solution.

By the above lemma, we know that the investment strategies are going to be corner solutions that is investment strategies in a country by another country or by its own country are equal to either zero or one. Denote the precision of public information of country i by P_i . Country i "fully reveals" its fundamental if $P_i = \infty$, and "babbles" if $P_i < \infty$. First, let us suppose there are three countries. Following Angeletos and Pavan (2004), we assume that strategies are monotonic. That is the investment strategy of each country is to invest in its own country if the true economic fundamental is higher than some critical value that depends on the public signal, while each country is to invest in other countries if the private signals about those countries are higher than some critical values that depend on the public signal. Public information is therefore used as a public signalling device for countries to coordinate their strategies and predict other countries' actions. The equilibrium concept for the investment strategies thus resembles the correlated equilibrium concept. We are particularly interested in determining the optimal level of precision of public information on coordination given the true fundamental is between zero and one. This is the "critical" values in which a multiplicity of equilibria exists in the complete information game (Angeletos and Werning, 2006). Given that precision of public information is exogenous and does not signal any information about fundamentals, we derive the equilibrium levels of investments given the relative precision of private to public information (Proposition 1 and 2).

Proposition 1 1. *The investment strategy of country i , for $i=1,2,3$, is given by the following:*

(i) $k_i^i=1$ if $\theta_i \geq \theta^*(z_i)$; $k_i^i=0$, otherwise,

where $\theta^*(z_i)$ solves:

$$\theta_i + (1 - \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp.(\frac{-u^2}{2\sigma_x^2}) du) (1 + \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp.(\frac{-u^2}{2\sigma_x^2}) du) - 1 = 0.$$

(ii) for $j \neq i$, $k_j^i=1$ if $x_j^i \geq x^*(z_j)$; $k_j^i=0$, otherwise,

where $x^*(z_j)$ solves:

$$(w_{x_j^i} x_j^i + w_{z_j} z_j) + (1 - \int_{-\infty}^{\theta(z_j^*)} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp.(-\frac{(u - E(\theta_j | x_j^i, z_j))^2}{2\sigma_\theta^2}) du) +$$

$$(\int_{-\infty}^{\theta(z_j^*)} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp.(-\frac{(u - E(\theta_j | x_j^i, z_j))^2}{2\sigma_\theta^2}) du)$$

$$(1 - \int_{-\infty}^{x(z_j)} \frac{1}{\sigma_x \sqrt{2\pi}} \exp.(-\frac{(u - E(x_j^{-j \neq i} | x_j^i, z_j))^2}{2\sigma_x^2}) du) - 1 = 0,$$

$(\theta_j | x_j^i, z_j)$ is distributed with mean $E(\theta_j | x_j^i, z_j) = (w_{x_j^i} x_j^i + w_{z_j} z_j)$ and

$$\text{variance } \sigma_\theta^2 = \frac{1}{\frac{1}{\sigma_x^2} + P},$$

$x_j^{-j \neq i} = (\theta_j + \varepsilon_j^{-j \neq i} | x_j^i, z_j)$ is distributed mean $E(w_{x_j^i} x_j^i + w_{z_j} z_j)$ and

$$\text{variance } \sigma_x^2 = \frac{1}{\frac{1}{\sigma_x^2} + P} + \sigma_x^2,$$

2. Local solutions $\theta^*(z_i)$ and $x^*(z_i)$ exist for some values of P and σ_x^2 :

$$|D_{x,\theta} F(x(z_i), \theta(z_i); z_i)| \neq 0.$$

Proof. (See Appendix 3) ■

Proposition 2 1. The investment strategy of country i , for $i=1, \dots, K$ is given by the following:

(i) $k_i^i=1$ if $\theta_i \geq \theta^*(z_i)$;

$k_i^i=0$, otherwise,

$$\text{where } \theta^*(z_i) \text{ solves: } \theta_i + \sum_{j=1}^{K-1} \frac{(K-1)!}{(K-1-j)!j!} (1 - \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp.(\frac{-u^2}{2\sigma_x^2}) du)^j$$

$$(\int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp.(\frac{-u^2}{2\sigma_x^2}) du)^{K-1-j} - 1 = 0.$$

(ii) $k_j^i=1$ if $x_j^i \geq x^*(z_j)$;

$k_j^i=0$, otherwise,

where $x^*(z_j)$ solves:

$$(w_{x_j^i} x_j^i + w_{z_j} z_j) + (1 - \int_{-\infty}^{\theta(z_j^*)} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp.(-\frac{(u - E(\theta_j | x_j^i, z_j))^2}{2\sigma_\theta^2}) du)$$

$$\sum_{j=0}^{K-2} \frac{(K-2)!}{(K-2-j)!j!} (1 - \int_{-\infty}^{x(z_j^*)} \frac{1}{\sigma_x \sqrt{2\pi}} \exp.(\frac{-u^2}{2\sigma_x^2}) du)^j$$

$$\begin{aligned}
& \left(\int_{-\infty}^{x(z_j^*)} \frac{1}{\sigma_x \sqrt{2\pi}} \exp \left(-\frac{(u - E(x_j^{-j \neq i} | x_j^i, z_j))^2}{2\sigma_x^2} \right) du \right)^{K-2-j} + \\
& \left(\int_{-\infty}^{\theta(z_j^*)} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp \left(-\frac{(u - E(\theta_j | x_j^i, z_j))^2}{2\sigma_\theta^2} \right) du \right) \\
& \sum_{j=1}^{K-2} \frac{(K-2)!}{(K-2-j)!j!} \left(1 - \int_{-\infty}^{x(z_j^*)} \frac{1}{\sigma_x \sqrt{2\pi}} \exp \left(-\frac{(u - E(x_j^{-j \neq i} | x_j^i, z_j))^2}{2\sigma_x^2} \right) du \right)^j \\
& \left(\int_{-\infty}^{x(z_j^*)} \frac{1}{\sigma_x \sqrt{2\pi}} \exp \left(-\frac{(u - E(x_j^{-j \neq i} | x_j^i, z_j))^2}{2\sigma_x^2} \right) du \right)^{K-2-j} - 1 = 0,
\end{aligned}$$

$(\theta_j | x_j^i, z_j)$ is distributed with mean $E(\theta_j | x_j^i, z_j) = (w_{x_j^i} x_j^i + w_{z_j} z_j)$ and

$$\text{variance } \sigma_\theta^2 = \frac{1}{\frac{1}{\sigma_x^2} + P}.$$

$$x_j^{-j \neq i} = (\theta_j + \varepsilon_j^{-j \neq i} | x_j^i, z_j) \text{ is distributed mean } E(x_j^{-j \neq i} | x_j^i, z_j) = (w_{x_j^i} x_j^i + w_{z_j} z_j)$$

and

$$\text{variance of } \sigma_x^2 = \left(\frac{1}{\frac{1}{\sigma_x^2} + P} + \sigma_x^2 \right).$$

2. Local solutions $\theta^*(z_i)$ and $x^*(z_j)$ exist for some values of P and σ_x^2 :

$$|D_{x,\theta} F(x(z_i), \theta(z_i); z_i)| \neq 0.$$

Proof. (See Appendix 4) ■

Corollary 2 For a two-country case, $x^*(z_i)$ is given by $x^*(z_i) = A - \frac{P}{\frac{1}{\sigma_x^2}} z_i$, and $\theta^*(z_i)$ solves: $\theta_i + (1 - \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp \left(\frac{-u^2}{2\sigma_x^2} \right) du) - 1 = 0$, for $i=1,2$ (see Table 3.1).

Table 1: Critical Values for a 2-country Case

P	$\frac{P}{\frac{1}{\sigma_x^2}}$	z	$\theta^*(z)$	$x^*(z)$
1	1	1	.12-.13	-1
10	10	1	0-.01	-10
.5	.5	1	.7-.8	-.5
1	1	2	.02-.03	-2
10	10	2	0-.01	-20
.5	.5	2	.1-.2	-1

0.3.3 Numerical Examples and Observations

Solving for the implicit functions, $x^*(z_i)$ and $\theta^*(z_i)$, can be very complex. We resort to numerical examples. In the following numerical examples, we show the critical values of $\theta^*(z_i)$ and $x^*(z_i)$ that solve the non-linear equations system above:

$F(\theta^*(z_i), x^*(z_i); z_i) = 0$ for a wide range of parameters. This enables us to get an idea of what kinds of functions $\theta^*(z_i)$ and $x^*(z_i)$ are. The following table (Table 3.2) summarizes the initial parameters to get $(\theta^*(z_i), x^*(z_i))$, including the absolute precision of private and public information, the relative precision of private and public information, and the public signals z_i . We fix the number of countries equal to 3. We vary the relative precision of private to public information by either varying the precision of public signal while keeping the precision of private signal fixed, or vice versa. We vary the public signal in the range of [-1000 to 1000], and first set $K=3$.

Table 2: Initial Parameters

$\mathbf{K=3}, \frac{1}{\sigma_x^2}=1$ (or $P_i=1$)	$\frac{1}{P_i}=[.0001-10000]$
$z_i=[-1000-1000]$	$(\theta^*(z_i), x^*(z_i) z_i, P_i, \frac{1}{\sigma_x^2})$

The following properties of $x(z_i)$ and $\theta(z_i)$ are observed for $K=3$. We use at least six-decimal working precision (see Appendix 5). First, we observe that $\theta^*(z_i)$ and $x^*(z_i)$ co-move. This is not surprising since strategies are complements. If domestic investment of a country is higher, other countries will best-respond by investing more in that country. Second, we observe that fixing the precision of private information and increasing the precision of public information, or decreasing the relative precision of private to public information, increases the level of investment or decreases the values of $\theta^*(z_i)$ and $x^*(z_i)$ if the realization of public information, z_i , is sufficiently large, $z_i > .25$. It further decreases the level of investment or increases the values of $\theta^*(z_i)$ and $x^*(z_i)$ if the realization of public information, z_i , is sufficiently low, $z_i < .25$. At $z_i = .25$, $\theta^*(z_i)$ and $x^*(z_i)$ do not change in the relative precision of private to public information.

Claim 1 *Given the precision of public information is exogenous and does not signal any information about the fundamentals of the countries, in the case of $K=3$,*

for high relative precision of private to public information, increasing the precision of public information while keeping the precision of private information fixed, weakly decreases $\theta^*(z)$ and $x^*(z)$ for $z \geq .25$ while increasing $\theta^*(z_i)$ and $x^*(z_i)$ for $z < .25$.

This second observation suggests that if public signal is sufficiently low, with high precision of public information, other countries will expect the true economic fundamental of that country to be approximately close to the public signal, which is low, reducing the incentive to invest. The reverse is true for high public signals. The following table (Table 3.3⁵) shows examples of this observation for $z_i \geq .25$ and $z_i < .25$.

Table 3: Example of Claim 3.1

$K=3, \frac{1}{\sigma_x^2} = 1$	$\frac{1}{\frac{\sigma_x^2}{P}} = .0001$	$\frac{1}{\frac{\sigma_x^2}{P}} = 1$	$\frac{1}{\frac{\sigma_x^2}{P}} = 10000$
$z = -.5$	(1,14796)	(.622147,1.42428)	(.250025,.250088)
$z = .4$	(0,-4000),(1,5796.53)*	(.189758,.0276531)	(.249995,.249982)

We can show that the critical values of $\theta^*(z_i)$ and $x^*(z_i)$ do not change if we change the absolute precision of public information or the absolute precision of private information while keeping the relative precision of private to public information constant. In other words, what matters is not the absolute precision but the relative precision. Similar results are shown in Svensson (2005) in response to Morris and Shin's Keynesian Beauty Contests model (2002) in which the optimal precision of public information depends on the relative precision rather than the absolute precision.

Claim 2 *Given the precision of public information is exogenous and does not signal any information about the fundamentals of the countries, in the case of $K=3$, it*

⁵*=Multiplicity of equilibria

is the relative precision of private information to public information that affects the investment level, and not the absolute precision of private nor public information.

We also observe that both $\theta^*(z_i)$ and $x^*(z_i)$ decrease in z_i for any relative precision of private to public information (see Appendix 6).

Claim 3 *The higher the public signal, the lower $\theta^*(z_i)$ and $x^*(z_i)$ are, for any relative precision of private to public information.*

Moreover, we observe that $\theta^*(z_i)$ is more sensitive to changes in z_i as the precision of public information increases while fixing the precision of private information, or if the relative precision of private to public information decreases. This suggests that the lower the relative precision of private to public information, the more sensitive investment strategies are to changes in public signals. For sufficiently low precision of public information for some given precision of private information, the slope of $\theta^*(z_i)$ with respect to z_i is flat at $\theta^*(z_i)=.25$. Similarly, $x^*(z_i)$ is more sensitive to changes in z_i as the precision of public information increases while fixing the precision of private information, or if the relative precision of private to public information decreases. As the relative precision of private to public information increases, the slope of $x^*(z_i)$ with respect to z_i becomes flat at $x^*(z_i)=.25$. The critical values of $\theta^*(z_i)$ is bounded above by 1, in which countries will not invest for any fundamental, and bounded below by 0, in which countries will invest for any fundamental.

Claim 4 *The lower the relative precision of private to public information, the more sensitive $\theta^*(z_i)$ and $x^*(z_i)$ are to changes in public signal.*

One of the main results of this study is that a multiplicity of equilibria can be shown to exist in the incomplete information game with a critical fundamental

and high precision of public information (see Figure 1 and 2). We show that a multiplicity of equilibria exists for $z_i = [0, 1)$ as the precision of public information increases while fixing the precision of private information, or if the relative precision of private to public information decreases. Except at $z_i=.25$, there are two equilibria, the high and the low equilibria. At $z_i=.25$, there are three equilibria, the high, the intermediate, and the low equilibria. For very low relative precision of private to public information, the two critical points for theta are $\theta^*(z_i)=0$ and $\theta^*(z_i)=1$. Hence, either countries invest domestically for all values of the fundamental, or do not invest domestically for all values of the fundamental, similar to the case of complete information. For both the critical values, $\theta^*(z_i)$ and $x^*(z_i)$, in the case of multiple equilibria, the low-investment equilibrium is lower than some equilibrium investment level at lower transparency with a unique equilibrium and the high-investment equilibrium is higher than some equilibrium investment level at lower transparency with a unique equilibrium. Multiple equilibria arise at a relative precision of private to public information as low as one fourth.

Claim 5 *Given the precision of public information is exogenous and does not signal any information about the fundamentals of the countries, the critical values, $\theta^*(z_i)$ and $x^*(z_i)$, are unique for $z_i=[0,1)$, for high relative precision of private to public information, but are multiple for low relative precision of private to public information. In the case when a multiplicity of critical values arises, there are high and low critical values, $\theta^*(z_i)$ and $x^*(z_i)$, for $z_i=[0,1)$, and there are high, intermediate, and low critical values, $\theta^*(z_i)$ and $x^*(z_i)$, at $z_i=.25$ given $K=3$.*

Proposition 3 *Given the precision of public information is exogenous and does not signal any information about the fundamentals of the countries, in the case of $K=3$, lower precision of public information might be preferable for intermediate fundamentals, $\theta_i = [0, 1)$, in which a multiplicity of equilibria arises at high preci-*

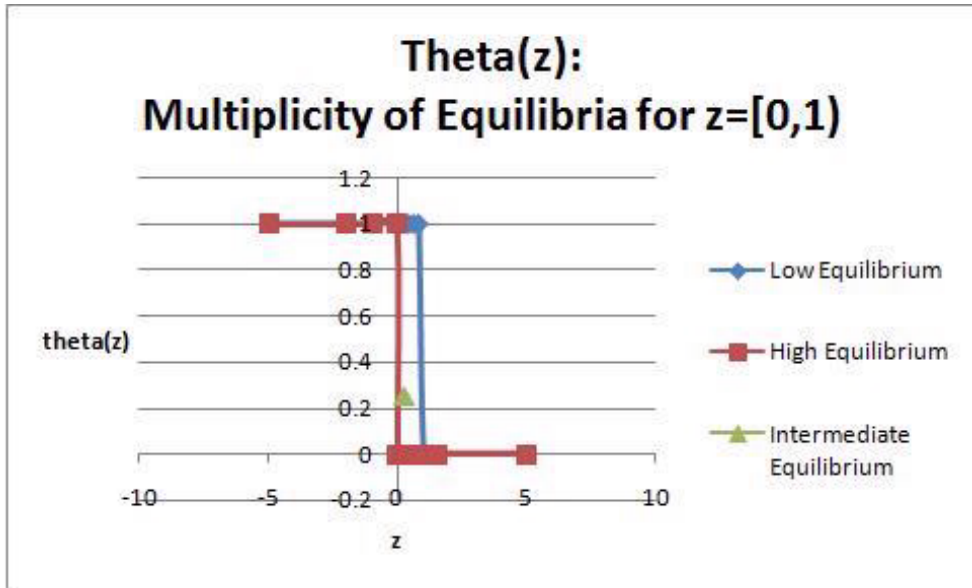


Figure 0-1: Multiplicity of Equilibria, $\theta(z)$.

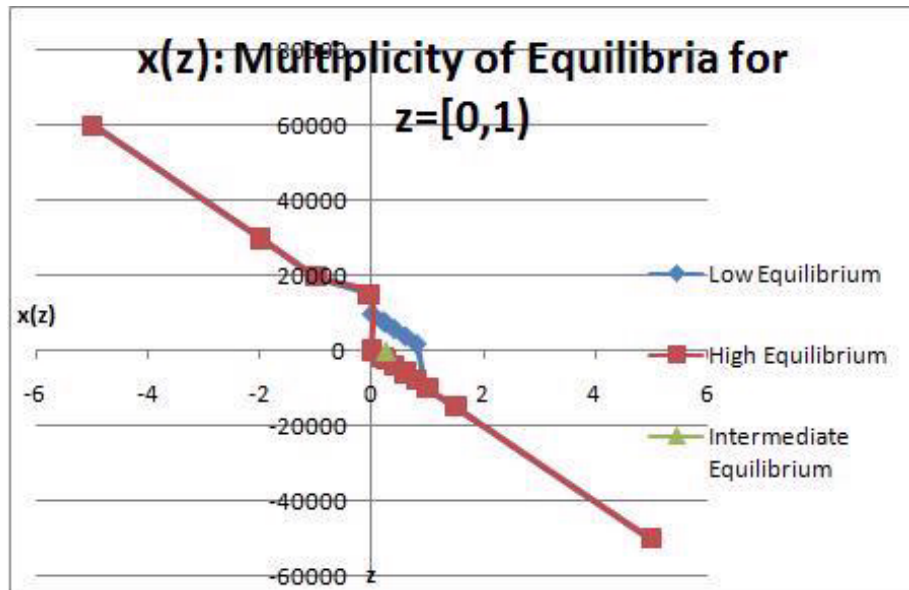


Figure 0-2: Multiplicity of Equilibria, $x(z)$.

sion of public information and there are non-fundamental volatilities or sunspots that dictate the low-investment equilibrium to be played with a high probability.

Proof. If the level of investment is higher under high relative precision of private to public information, in which equilibrium is unique, than that of under low relative precision of private and public information, in which equilibrium is not unique and the low equilibrium is played, then choosing sufficiently high relative precision of private to public information to avoid a multiplicity of equilibria is optimal. ■

This proposition says that a country with an intermediate fundamental might choose lower precision of public signal if the multiplicity of equilibria that arises as information becomes more complete will be more likely to create coordination failures than coordination. Hence, if the precision of public information is exogenous and the low equilibrium is played when a multiplicity of equilibria arises, then a country will choose sufficiently low precision of public information to eliminate the multiplicity of equilibria. This result is analogous to the result of the model with one-dimensional fundamental and symmetric incompleteness of information (Angeletos and Pavan, 2004).

High precision of public information allows countries to coordinate better on multiple levels of investment, as is argued by Angeletos and Werning (2006). Intuitively, with low precision of public information, partially-informed agents are informatively constrained to coordinate among themselves resulting in a unique equilibrium. Conversely, with high precision of public information, partially informed-agents are better able to coordinate among themselves if the underlying complete-information game has a multiplicity of equilibria. Morris and Shin (2002) and Amato, Morris and Shin (2002) also suggest that high precision of public information might be detrimental if the precision of private information is

high enough relative to the precision of private information. In this case, people overreact to the public information that is relatively imprecise compared to the private information. Although both Angeletos and Werning's model and Morris and Shin's model suggest that high transparency may not always be good, they offer slightly different insights as to why high transparency is not always good for welfare.

Now, assume that the fundamental is uniformly distributed in the real number (improper distribution). We can show that the utilities of countries with $\theta \geq 1$ are maximized at the highest level of transparency or full revelation, while the utilities of countries with $\theta < 0$ are unchanged with respect to the level of transparency, because these countries will not invest in their own countries regardless of the investments of the other countries. Suppose now there are informational externalities from revealing bad fundamentals such as bad reputation, and hence, countries with $\theta < 0$ will be strictly better off without transparency.

Proposition 4 *For $K=3$, suppose there are negative informational externalities from revealing low fundamentals. The utilities of countries with $\theta \geq 1$ are maximized at $P=\infty$ (full revelation) and the utilities of countries with $\theta < 0$ are maximized at $P=0$ (no revelation). The utilities of countries with critical fundamentals, $0 \leq \theta < 1$, are maximized at $\infty \geq P \geq 0$ depending on the fundamental and the non-fundamental volatilities or sunspots in the case of a multiplicity of equilibria.*

Proof. (1) It is trivial to prove that the utilities of countries with $\theta \geq 1$ are maximized at full revelation. (2) From Proposition 3, intermediate-fundamental countries might choose a low level of transparency depending on which of the equilibria is played in the case of multiple equilibria. In both cases of low and high equilibrium, whether a country will be better off with more or less transparency depends on the fundamentals of the countries. For both the low and high equilib-

rium, as the relative precision of private to public information changes, the graphs of $\theta^*(z)$ and $x^*(z)$ also change, in which the level of investments of countries with dissimilar fundamentals will be affected differently. Take $x^*(z)$: for any equilibria, the graph $x^*(z)$ is downward sloping and intersects the x-axis at some value of public signal. It rotates clockwise as the relative precision of private to public information decreases (see Claim 3.4). As the relative precision of private to public information approaches zero, every country will invest in countries with fundamentals above the intersection point, because $x^*(z)$ will approach negative infinity at $z=\theta$. Conversely, no country will invest in countries with fundamentals below the intersection point because $x^*(z)$ will approach positive infinity at $z=\theta$. Note that we only consider the low and high equilibrium, and not the intermediate equilibrium, which only occurs at $z=.25$. In the case of improper distribution, this event occurs with probability zero. (3) Countries with $\theta < 0$, will be indifferent between revealing and babbling because these countries will not invest domestically regardless whether or not other countries will invest. However, because of negative externalities, such as bad reputation, they will strictly prefer not to reveal. ■

Proposition 5 (*Transparency-aversion*) *Suppose there are negative informational externalities from revealing low fundamentals. For $K=3$, there are some countries with $\theta < 1$ that will be better off at a lower level of transparency than full revelation.*

Proof. For countries with $\theta < 0$, non-transparency is always better than transparency. For countries with $0 \leq \theta < 1$, lower transparency might be preferred depending on the fundamentals and the non-fundamental volatilities or sunspots in the case of multiple equilibria. ■

Note that in order to prove the monotonicity of transparency, at which the utilities of intermediate-fundamental countries are maximized, with respect to the

fundamentals, a more elaborate proof is needed to solve the expected utility maximization problem with respect to the precision of public information.

0.3.4 K-country Case

We show that most of the observations we find in the 3-country case still hold in the 13-country case (corresponding to the ASEAN + 3 countries). Increasing the number of countries from 3 to 13 while keeping the strategic complementarity of investment the same will increase the level of investment. This observation is intuitive since the probability that at least one other country invests is higher if K is higher. All of the above observations for $K=3$ continue to hold except the cutting value for a public signal to be considered "sufficiently high" or "sufficiently low" is not $z_i=.25$, but $z_i=0$. This is because the higher the number of countries, the more effective is the public signal in coordinating strategies because there are more potential countries to invest. Since strategies are strategic complements, then given a higher number of countries, a lower value of public signals ($z_i=0$) is the pivoting point above which a lower relative precision of private to public information will increase the level of investment. Analogous to the 3-country case, in the 13-country case, a multiplicity of equilibria prevails if $z_i=[0,1)$ at high precision of public information.

Corollary 3 *Given the precision of public information is exogenous and does not signal any information about the fundamentals of the countries, in the case of $K=13$, lower precision of public information might be preferable for intermediate fundamentals, $\theta_i = [0, 1)$, in which a multiplicity of equilibria arises at high precision of public information and there are some exogenous factors, such as sunspots, that dictate the low-investment equilibrium to be played with a high probability.*

Corollary 4 *For $K=13$, suppose there are negative externalities from revealing*

low fundamentals. The utilities of countries with $\theta \geq 1$ are maximized at $P=\infty$ (full revelation) and the utilities of countries with $\theta < 0$ are maximized at $P=0$ (no revelation). The utilities of countries with critical fundamentals, $0 \leq \theta < 1$, are maximized at $\infty \geq P \geq 0$ depending on the fundamental and the non-fundamental volatilities or sunspots in the case of a multiplicity of equilibria.

Corollary 5 (*Transparency-aversion*) Suppose there are negative informational externalities from revealing low fundamentals. For $K=13$, there are some countries with $\theta < 1$ that will be better off at a lower level of transparency than full revelation.

The corollaries above for the K -country case come directly from observations of our numerical examples for $K=13$ that show similar patterns as the case for $K=3$.

Strategic Substitutes

We analyze the robustness of our results regarding the multiplicity of equilibria under strategic substitutability of investment. The utility of the investing countries is as follows: $u_i = (\theta - i_{K>1} - 1)k^i$, where the indicator variable i is similarly defined as it is in the previous section and all other elements of the game are unchanged. With this utility function, investments are strategic substitutes. The complete information game with this utility function has a unique equilibrium in dominant strategy for the parameters $\theta_i \leq 1$ (never invest), $\theta_i > 2$ (always invest). There is a multiplicity of equilibria for the parameters $\theta_i = (1, 2]$. As we can show, in the incomplete information game, a multiplicity of equilibria for the parameters $\theta_i = (1, 2]$ recovers for low relative precision of private to public information. We also show that $\theta^*(z_i)$ increases in z_i but $x^*(z_i)$ decreases in z_i for any relative precision of private to public information.

Given the precision of public information is exogenous and does not signal any information about the fundamentals of the countries and investments are strategic substitutes, the critical values, $\theta^*(z_i)$ and $x^*(z_i)$, are unique for $z_i \geq 2$ and $z_i < 1$, for any relative precision of private to public information. The critical values, $\theta^*(z_i)$ and $x^*(z_i)$, are unique for $z_i \in (1, 2]$, for high relative precision of private to public information, but are not unique for low relative precision of private to public information. Increasing the precision of public information while fixing the precision of private information changes the sensitivity of $\theta^*(z_i)$ and $x^*(z_i)$ with respect to changes in z_i .

0.3.5 Extensions: Endogenous Precision of Public Information

Important information may be shared not only during official regional meetings. Information may be shared while central bankers eat dinners, play golf, or sing in a Karaoke bar. There is no limit to how much information is revealed. Hence, the precision of public signal, i.e. how much private information is shared publicly, is not exogenous. Angeletos and Werning (2004) show how the precision of public signals, such as prices, can be endogenous, and is a function of private signal.

In the previous section, we consider the case of exogenous public information in which the precision of public information does not signal the fundamentals. This is the case, for example, when countries are dictated to reveal specific information. Now, consider the case in which the precision of public information is endogenous and hence, signals some information about the fundamentals of the countries. This is the case when countries have discretions to set the level of precision of public information. Suppose the precision of public signal is revealed prior to announcements of public information. The two-stage process of announcements of precision

of public information prior to investment choices constitutes a signalling game in which announcements of the precision of public information in the first stage may convey the fundamentals of the countries that affect investment strategy in the second stage. What differentiates this model from the previous model is the fact that the precision of public information in stage one may signal the fundamentals of the countries, $\theta^*(z_i|P)$ and $x^*(z_i|P)$, when in the two-stage signalling game, the Perfect Bayesian Nash Equilibrium is separating.

In a two-stage signalling game, investment strategies may depend on the announcements of precision of public signal if the equilibrium is separating. In general, the concept of Perfect Bayesian Nash Equilibrium is used in this signalling game, where the following requirements must be satisfied: the precision of public information, P^* ; investment strategies, $\theta^*(z|P)$ and $x^*(z|P)$, and the belief system, μ , constitute a Perfect Bayesian Nash Equilibrium if $\{P^*, \theta^*(z|P), x^*(z|P)\}$ are sequentially rational at each information set given the beliefs, and beliefs are consistent with the equilibrium strategies. In order to calculate the critical values of investments, we will need the conditional expectations of the fundamentals given public information and the precision of public information that may signal the fundamentals. These conditional expectations given the fundamental in some interval are given in the Lemma below.

Lemma 3 *Country i 's expected fundamental of country $j \neq i$ conditional on private and public information as well as θ_j being in some intervals $= [a, b]$, $(\theta_j|x_j^i, z_j, \theta_j = [a, b])$, has a truncated normal distribution with mean and variance equal to:*

$$E(\theta_j|x_j^i, z_j, \theta_j = [a, b]) = \mu + \frac{\phi(\frac{a-\mu}{\sigma}) - \phi(\frac{b-\mu}{\sigma})}{\Phi(\frac{b-\mu}{\sigma}) - \Phi(\frac{a-\mu}{\sigma})} \sigma$$

$$\text{Var}(\theta_j|x_j^i, z_j, \theta_j = [a, b]) = \sigma^2 \left[1 + \frac{(\frac{a-\mu}{\sigma})\phi(\frac{a-\mu}{\sigma}) - (\frac{b-\mu}{\sigma})\phi(\frac{b-\mu}{\sigma})}{\Phi(\frac{b-\mu}{\sigma}) - \Phi(\frac{a-\mu}{\sigma})} - \left(\frac{\phi(\frac{a-\mu}{\sigma}) - \phi(\frac{b-\mu}{\sigma})}{\Phi(\frac{b-\mu}{\sigma}) - \Phi(\frac{a-\mu}{\sigma})} \right)^2 \right],$$

where $\mu = \frac{\frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2} + P_j}$, $\sigma^2 = \frac{1}{(\frac{1}{\sigma_x^2} + P_j)}$, Φ and ϕ are the CDF and PDF of a standard normal distribution respectively.

Proof. (See Appendix 7). ■

This model is limited to the extent that in reality, agents or countries do not reveal the precision of their public announcements. Even if public information is given in terms of the quantity of information an agent reveals, it is still unclear whether there is some more important information kept hidden by an agent that could reduce the precision of the shared information. Take, for instance, the transparency of the financial market in the United States. It might seem that banks and funds were transparent in revealing their performance, but in reality, there had been a lot of off-balance-sheet transactions that were unknown to potential investors. In other words, the precision of public information is a relative measure and not an absolute measure that does not have a clear-cut standard. However, without knowing the precision of their public announcements, expectations over their fundamentals given private and public information are difficult to derive.

For simplicity, suppose there are only two possible levels of precision of public information, namely F for full revelation and B for babbling. Each country may choose either to reveal their information or stay quiet and not reveal their information. Assume that the fundamental is uniformly distributed in the real number (improper distribution). From our previous result, we show that countries with high fundamentals ($\theta \geq 1$) will choose to reveal their information, while countries with low fundamentals ($\theta < 0$) will choose not to reveal their information. Countries with intermediate fundamentals ($0 \leq \theta < 1$) may or may not choose to reveal their information. In the case of intermediate fundamentals, there is a critical point above which a country will choose transparency over non-transparency and below which a country will choose non-transparency over transparency. This is because for both the low and high equilibrium in the case of multiple equilibria and for the case of the unique equilibrium, there are some values of the public signal at which the graphs of $\theta^*(z)$ and $x^*(z)$ touch or intersect the x-axis. There is a pivot-

ing point about each of these intersection points (some of these pivoting points are the intersection points themselves), around which the downward-sloping graphs of $\theta^*(z)$ and $x^*(z)$ rotate clockwise as the precision of public information increases for some fixed precision of private information (see Claim 3.4). Note: we only consider the high and low equilibrium, and not the intermediate equilibrium that only occurs at a point in z . In the case of improper distribution, the probability of z or θ equal to this point is zero. Countries with fundamentals above a pivoting point will prefer transparency over non-transparency while countries with fundamentals below this pivoting point will prefer non-transparency over transparency.

Lemma 4 *Suppose transparency of a country does not reveal the fundamental of this country and there are only two possible levels of precision of public information: full revelation (F) and babbling (B). In the case of K countries, there is a critical value at which a country with a fundamental above this critical value will be better off at F and a country with a fundamental below this critical value will be better off at B.*

Proof. At zero precision of public information, or B, given non-zero fixed precision of private information, both $\theta^*(z)$ and $x^*(z)$ are flat at some positive value below infinity. At infinite precision of public information, or F, given non-zero fixed precision of private information, the slope of $x^*(z)$ approaches negative infinity and $x^*(z)$ intersects the x-axis at some z (see Claim 3.4). At infinite precision of public information, or F, given non-zero fixed precision of private information, the graph $\theta^*(z)$ approaches one for all values below some z and zero for all values above this value of z . This holds for the low and high equilibria in the case of multiple equilibria, and the unique equilibrium. The intermediate equilibrium may occur only at a point in z , which occurs with probability zero.

■

When the level of precision is endogenous, there are reputation effects that associate revealing information with high fundamentals and staying quiet with low fundamentals. Let the fundamentals associated with revealing information be in the interval of $[a^F, b^F]$ and the fundamentals associated with staying quiet be in the interval of $[a^B, b^B)$, where $a^F = b^B$. Taking the derivatives of the conditional mean with respect to both a and b , the above lemma shows that the expected fundamental given the interval a and b that is associated with either revealing or staying quiet increases in both a and b . This means that if only those countries with fundamentals in $[a^F, b^F]$ will reveal and countries in $[a^B, b^B)$ will stay quiet, then $E(\theta_j | x_j^i, z_j, F) > E(\theta_j | x_j^i, z_j, B)$. Since investment strategy is non-decreasing in fundamental, it is always better for a country, except the countries with the lowest fundamental, to reveal than not to reveal. In the most extreme case, we may observe the *lemon car* issue, in which all countries will choose to reveal except countries with the lowest level of fundamental (Economics Review, RIETI, 2009). Geraats (2002) shows that in a simple model of endogenous transparency of central banks, the unique pure-strategy perfect equilibrium is transparency for all types, i.e. the *lemon car* problem does occur.

Proposition 6 *Suppose the level of transparency of a country could partly reveal the fundamental of this country and there are only two possible levels of precision of public information: full revelation (F) and babbling (B). All countries, except countries with the lowest fundamentals, will choose F.*

Proof. Starting from the countries at the high end of $[a^B, b^B)$, i.e. countries whose fundamentals are close to b^B , these countries will choose revealing over babbling because the other countries' expectation of their fundamentals given their fundamentals are in $[a^B, b^B)$ is lower than their true fundamentals. The expected fundamental of the countries who choose babbling is even lower. More countries

will choose revealing. Using this induction, only the countries with the lowest fundamentals will choose B. ■

What makes the endogenous transparency model powerful is that it could drive countries to adopt transparency measures without mandates. More work on this endogenous model is needed. In real life, transparency of a country or a central bank is partly exogenous and partly endogenous. Sovereign countries have sovereign rights to choose the level of transparency, but there are transparency standards by which they are obliged to comply, such as the IMF's Article IV Publication or the Basel II Accord.

0.3.6 Further Remarks: Critiques and Applications

We have assumed that central bankers, ministries of finance, and other country's representatives make investment decisions. It is true that it is atypical, except in the case of Sovereign Wealth Funds. In other words, central bankers, ministries of finance, and other country's representatives are not investors. Moreover, assuming that policy coordination depends on information about the fundamentals alone is too simplistic. Diplomatic, strategic, and political factors may matter more than just economic factors. For example, despite a bad economic fundamental, a country might invest in another country because of strategic commodities, such as oil, gas, uranium, or nuclear technologies.

Another criticism of the model in this paper is that some public officials do have access to other countries' information that is not publicly available. All IMF Country Reports are distributed to the Executive Directors of the IMF member countries. We may argue, however, that in this case the precision of private information about the other countries can be made very high. Analogously, a public official who could have prevented the country from falling into crisis may

not know the fundamental of the country, and hence, fails to save the country. Private investors, for example, might know more than public officials from their daily business activities.

Optimal transparency is not a matter of being pro- nor anti - transparency. But to answer the question whether pro- or anti-transparency is optimal might simplify a lot of important issues. Hiding bad information over a collapsing bank for example, might be preferable in order to provide a blanket guarantee⁶ and prevent a bank run. Once the blanket guarantee is provided, the bank can be publicly announced as being under supervision. However, for the same situation, hiding bad information over a collapsing bank while having a third party find out about the situation might damage the central bank's credibility.

In response to the critiques above that might arise, we leave it to the readers to judge when our model is appropriate to apply. It is true that the issue of transparency on macroeconomic fundamentals is very broad that any model would seem to oversimplify the situation. However, what we attempt in this paper is to focus on one dimension of it, namely the issue of information on coordination in a case when strategic decisions can be categorized as being complements or substitutes. Multiple equilibria in both the complete and incomplete information games that we have shown are not uncommon. In fact, in many real-life cases, it is more likely that a multiplicity of equilibria rather than a unique equilibrium arises. Hence, our theoretical result above is not surprising. What we hope to determine is whether coordination can be better achieved in the case of a multiplicity of equilibria by constraining the level of public information that can serve as public signals.

The role of institution to regulate transparency measures is important. The

⁶A blanket guarantee is a declaration by the government that all deposits and perhaps other financial instruments will be guaranteed (Refence: Banking Glossary).

Basel II Accord, for example, is the second version of the Basel Accord that regulates minimum capital requirements, supervisory review process, and disclosure requirements. Disclosure requirements are transparency measures in which banks are supposed to release relevant financial data in a timely fashion to the public, for example, through their websites. Proper regulation on transparency measures is indispensable, as is evident in the global financial crisis that started in 2007. One of the reasons for the global financial crisis is the lax regulation on transparency among mortgage banks, hedge funds, and investment banks.

The above investment model with public-private information and partially informed agents fits the real-life examples of countries with Sovereign Wealth Funds that invest in other countries. This situation became more relevant since the total assets and number of Sovereign Wealth Funds have been growing rapidly (Azis, 2009). This is partly because of excess foreign exchange reserves of the Asian countries and petrodollars of the Middle-Eastern countries. East Asian international reserves amounted to US\$4 trillion in 2008. In 2007, Asian and Middle Eastern countries had invested 43 billion Euro in European and American countries through their Sovereign Wealth Funds. The IMF had estimated that there were more than 20 Sovereign Wealth Funds financed by petrodollars and foreign exchange reserves with total assets of between US\$1.9 trillion and US\$2.9 trillion around the world. Another study shows that the total asset under management of SWF reached US\$3.3 trillion (Wikipedia). It is expected to grow by US\$1 trillion per year. Among the concerns about Sovereign Wealth Funds are security issues, that a country might "buy" other countries and might therefore control domestic issues, including tax regulations on companies whose assets partly belong to foreign governments. What this paper shows is that the role of information among these partially informed agents is indispensable, and affects the investment strategies among these countries.

0.4 Empirical Study

In this empirical study, we are going to test the above theoretical propositions by testing how transparency of central banks could be affected by the economic fundamentals. Our theoretical propositions suggest that central banks with low and intermediate economic indicators can be associated with a lower level of transparency than full revelation. Empirical studies on transparency of an economic institution and economic fundamentals are difficult because most of the effects of transparency come not only from economic incentives but also political, social, and other incentives, and even a third variable that may affect both transparency and fundamentals, such as the level of development or the GDP per capita. Thus, it is hard to separate between the two factors and to determine the direction of the cause and causality. The second obstacle is that there is no clear-cut criteria of having a good or bad economic fundamental. The third obstacle is that some of economic indicators experience sudden shocks, such as hyperinflation or rapid exchange rate appreciation, or consistent anomalies, such as the extremely high ratio of broad money to foreign exchange reserves of the United States of America and Australia. We will address these obstacles in the next section. The fourth obstacle is that some of the variables of interest might be correlated.

In order to address the first obstacle, endogeneity of the variables, we will take a panel data that run between 1998 to 2005 across 83 countries. We use multilevel mixed-effect linear regression that combines both fixed-effect and random-effect models. This could identify the persistency of effects of the independent variables on the dependent variables over time. In order to address the second obstacle, we will show how certain economic indicators may affect transparency. It is not only a question of whether good economic fundamentals increase transparency, but also the intuition behind how certain economic indicators may affect transparency. For

example, high ratio of current account deficit to nominal GDP could be associated with a low fundamental because it could speculate an attack on the exchange rate if there is a sudden capital inflow reversal and the foreign exchange reserve is low. However, countries with high capital account surpluses might boast upon their investment booms. In order to address the third obstacles we eliminate observations that we identify as outliers or anomalies that could distort the regression. In order to address the fourth obstacle, we check the robustness of our results by orthogonalizing the independent variables.

There are at least a few variables that past literature has suggested could affect transparency of a central bank. These include: the level of development or the GDP per capita (Geraats, 2008; Dincer and Eichengreen, 2007), the independence of central banks (Crowe and Meade, 2008), the level of inflation (Geraats, 2008), the exchange arrangement and monetary regime (Geraats, 2008; Dincer and Eichengreen, 2007; Crowe and Meade, 2008), and the rule of law (Dincer and Eichengreen, 2007). We will show how economic fundamentals of a country namely unemployment rate, inflation, real exchange rate appreciation, ratio of broad money to foreign exchange reserves, and ratio of current account balance to nominal GDP affect the transparency of the central bank, controlling for the level of development, exchange rate arrangements, polity, region, crisis, and year.

0.4.1 Data

Dependent Variable: Transparency Index of Central Banks

We use the Dincer and Eichengreen (2007) transparency index data for central banks in 100 countries over five continents. This transparency index is based on Eijffinger-Geraats transparency measures for central banks (Eijffinger and Geraats, 2006) that consist of five pillars: political transparency, economic transparency,

procedural transparency, policy transparency, and operational transparency. Policy transparency focuses on the openness of policy objectives, economic transparency focuses on the openness of economic information that is used to formulate monetary policy, procedural transparency focuses on the openness of the procedures that are used to formulate monetary policy, policy transparency focuses on the disclosure of policies taken, and operational transparency focuses on the openness of the implementation of policy actions. The questionnaires for this survey are given in Appendix 8. This is the largest data for transparency of central banks that was collected over the period of 1998 to 2005 for 100 central banks, gathered from the central banks' websites, statutes, annual reports, and other published documents.

Out of these 100 central banks, we drop fourteen countries because there is no data on one or more variable(s) of interest. These countries are: European central bank because of the difficulty in measuring an aggregate economic fundamental of the European Monetary Union; The Bermuda, Cuba, East Caribbean because there is no data on most of the variables of interests; (if unemployment rate is included as a regressor) Aruba, Ethiopia, Malawi, Nigeria, Rwanda, Sierra Leon, Solomon Islands, Tajikistan, Vanuatu, Yemen, Zambia because there is no systematic measurement on unemployment rate. Since there are other countries in our observations that are in the same regions as these eliminated countries, we avoid selection bias.

Independent Variable 1: Economic Fundamentals

There are four main economic indicators that we consider: inflation, the ratio of broad money to foreign exchange reserves (the inverse reserve ratio), the ratio of current account balance to nominal GDP, and the real exchange rate appreciation/depreciation. The data is taken annually from the International Financial

Statistics and CEIC Data. Data on the ratio of broad money to foreign exchange reserves for some countries that are missing from the IFS and CEIC are taken from the ratio of broad money to total reserve from indexmundi.com, which upon investigation, does not deviate significantly much from the ratio of broad money to foreign exchange reserves from the IFS and CEIC. Accounting for inflation and the ratio of current account balance to nominal GDP, there are two economic indicators used in Sachs, et.al. (1996) to measure liquidity assets (the ratio of broad money to foreign exchange reserves) and the overvaluation of exchange rate (real exchange rate appreciation⁷). Inflation could indicate a decreasing purchasing power, overheating economy, and/or distortion to terms-of-trade caused by appreciation of exchange rate.

We observe outliers and anomalies in our observations of these economic fundamentals. In our data, Bulgaria was recorded as having a 1000% inflation in 1998. There were four other outliers of more than 200% inflation that we eliminate. We dropped the ratio of broad money to foreign exchange reserves of the United States and Australia that were much higher than other countries (more than 100 for the USA and more than 40 for Australia, while the average was 6). In order to predict the effects, we plotted the graphs of these variables alone against the transparency index (see Figure 3-6). Because of the indications of quadratic relationships, we take both the linear and quadratic terms of these variables, except for inflation.

⁷Sachs, et.al. (1996) use trade-weighted real exchange rate.

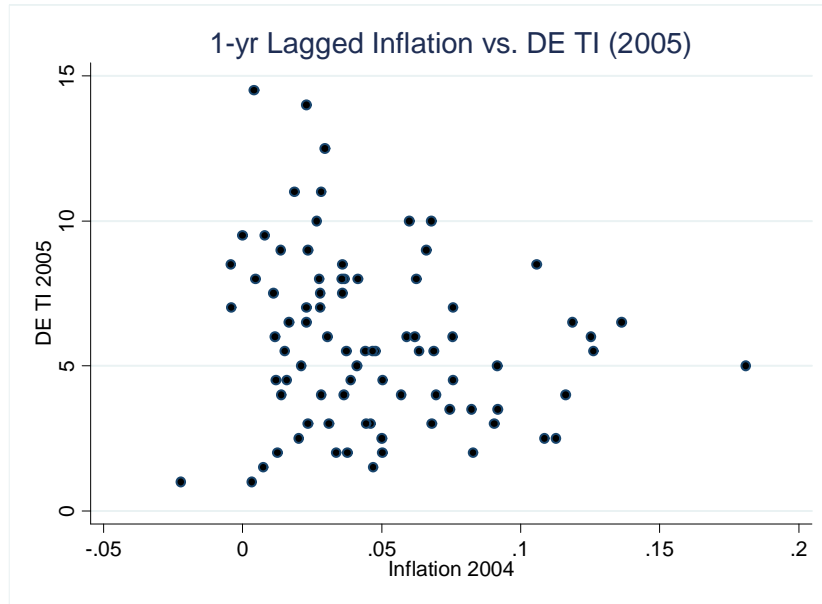


Figure 0-3: Inflation 2004 vs. DE TI 2005

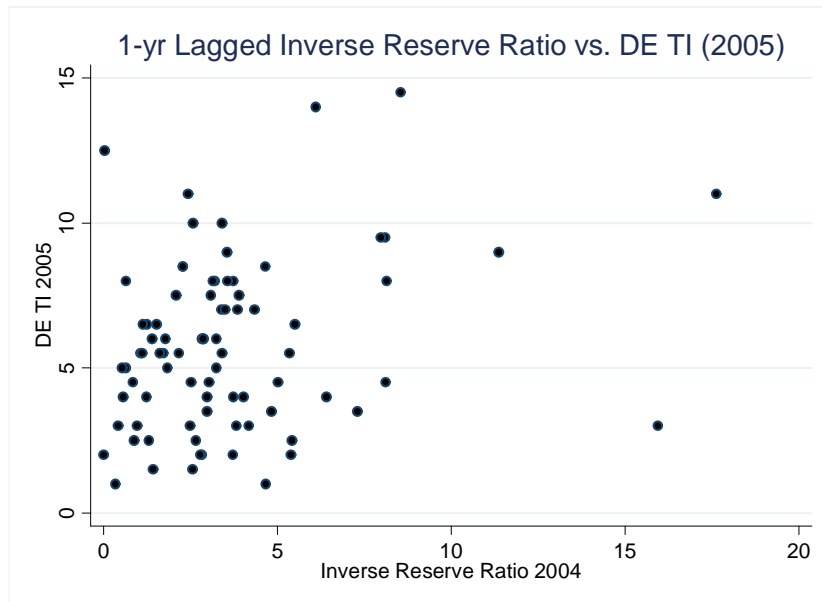


Figure 0-4: Inverse Reserve Ratio 2004 vs. DE TI 2005

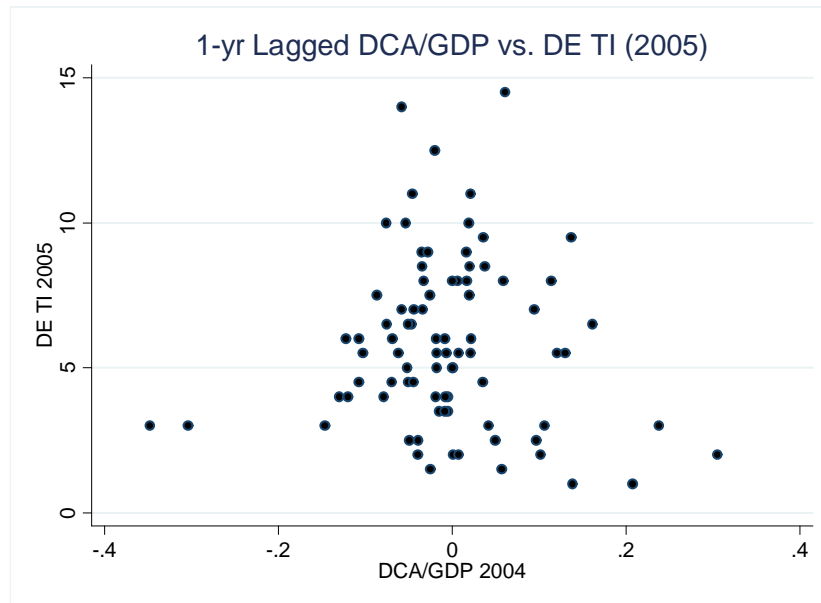


Figure 0-5: DCA/GDP 2004 vs. DE TI 2005

Independent Variable 2: Socioeconomic Fundamentals

The quality of economic institution could depend not only on economic fundamentals but also on social and political fundamentals. In order to account for the effect of social conditions, we take data on a socioeconomic variable, namely the unemployment rate. Data on unemployment rate is particularly difficult because most of the African countries do not collect such data. There are four countries in East Africa, two countries in West Africa, one country in Latin America and the Caribbean, two countries in the Melanesia, one country in Central Asia, and one country in Western Asia, whose unemployment rates are not systematically collected. The unemployment data is collected from the IFS, CEIC, indexmundi.com, and other websites. High unemployment rate might weaken the economic fundamental of a country. Because of the indication of quadratic relationship of unemployment rate, we take both the linear and quadratic relationships

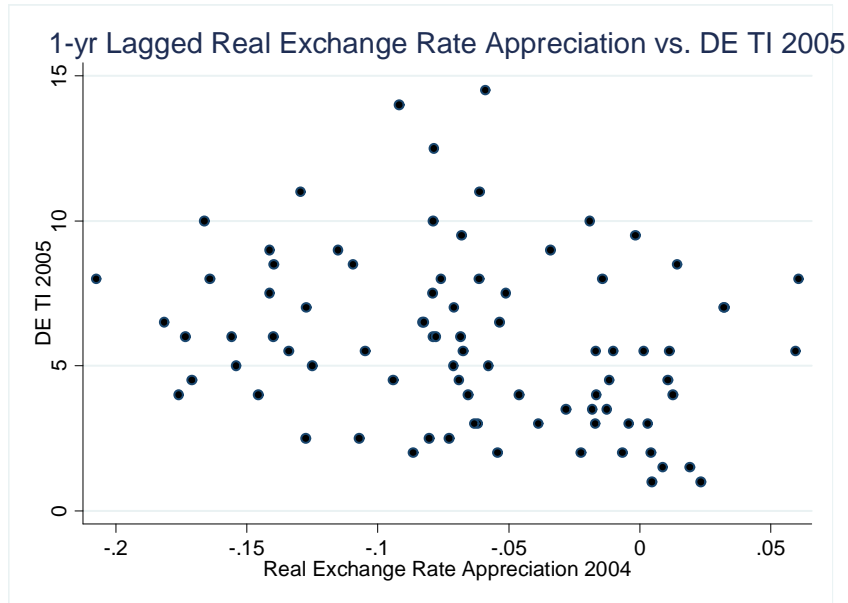


Figure 0-6: Real Exchange Rate Appreciation (-) 2004 vs. DE TI 2005

(see Figure 7).

Independent Variable 3: Political Fundamentals

We take an index on the level of democracy from the Polity IV Project conducted by the Center for Systemic Peace⁸. The index is equal to the democratic index minus the autocratic index. The democratic index measures three main pillars: the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders, the existence of institutionalized constraints on the exercise of power by the executive, and the guarantee of civil liberties to all citizens in their daily lives and in acts of political participants (Marshall and Jaggers, 2009). The autocratic index measures the competitiveness of political participation, the regulation of participation, the openness and compet-

⁸The data is available at:
<http://www.systemicpeace.org/polity/polity4.htm>.

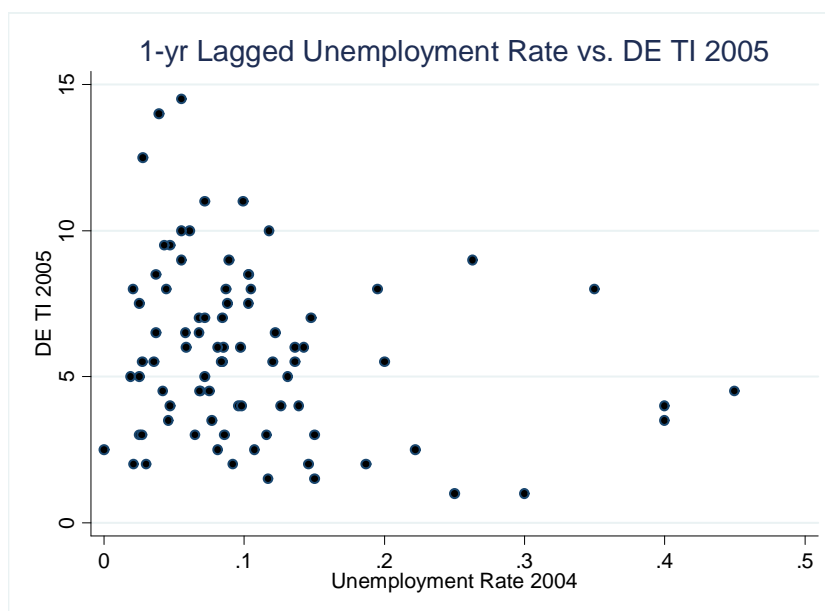


Figure 0-7: Unemployment Rate 2004 vs. DE TI 2005

itiveness of executive recruitment and constraints on the chief executives. Each of the democratic and autocratic index ranges from 0 to 10, and the polity index ranges from -10 (most autocratic) to 10 (most democratic). A two-variable scatter plot of polity index and transparency is given in Figure 8. Because the index is categorical, from -10 to 10, we run fixed-effect dummy variables on polity instead of assuming a continuous linear relationship.

Independent Variables 4: The Level of Development

The level of development may capture other eliminated biases that are specific to development of a region. These include institutional differences, development priorities, technology, social indicators and so on. Because of the prediction of a quadratic relationship between GDP per capita and transparency index (see Figure 9), we take both linear and quadratic terms in our regression. The data on GDP per capita is taken mostly from indexmundi.com.

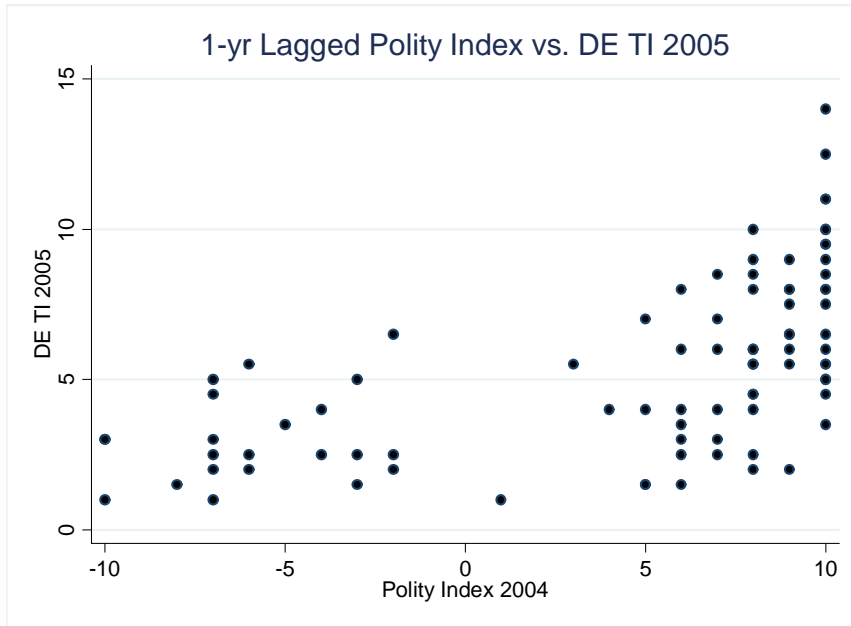


Figure 0-8: Polity Index 2004 vs. DE TI 2005

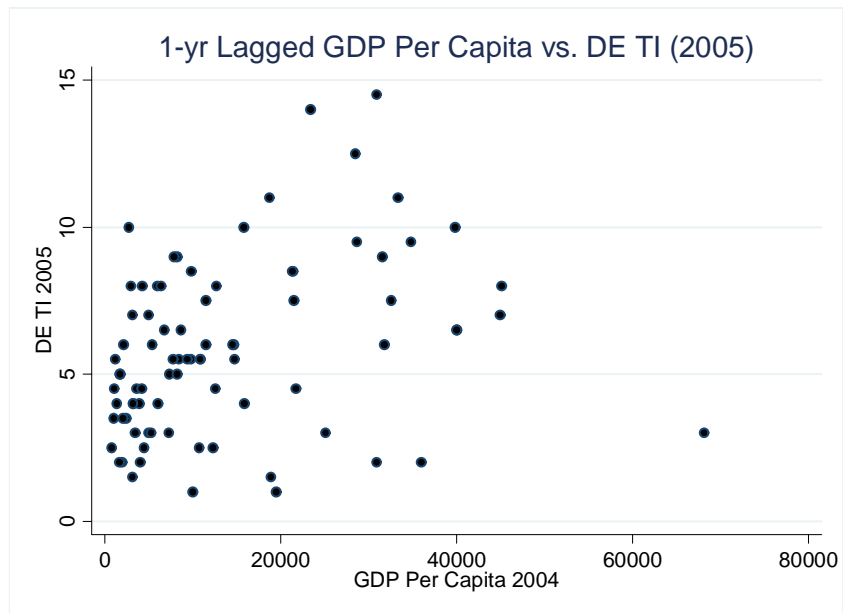


Figure 0-9: GDP per Capita 2004 vs. DE TI 2005

Controlling Variables: Exchange Arrangement, Crisis, Year, Region

We control our regression by the exchange rate arrangement that is shown to be strongly correlated with transparency index, the occurrence of financial crisis in the late 1990's/early 2000's possibly because of international pressures on countries in crisis to adopt transparency measures, the year or time-effect that might pick up the worldwide trend on transparency, and the region to control for region-specific biases that could be cultural or geographic. The exchange arrangements are categorized into eight arrangements as they are defined by the IMF: exchange arrangements with no separate legal tender (1), currency board arrangements (2), other conventional fixed peg arrangements (3), pegged exchange rates within horizontal bands (4), crawling pegs (5), exchange rates within crawling bands (6), managed floating with no pre-announced path for the exchange rate (7), and independently floating (8). The source of this data is the IMF's De Facto Classification of Exchange Rate Arrangement and Monetary Policy Frameworks⁹. The effect of exchange arrangement on transparency is given in Figure 10. We do not control for monetary policy framework because of the lack of early data, which would have reduced the size of our original panel data. We argue that the effects on monetary policy framework could be picked up by other variables that underlie the establishment of a particular monetary policy framework, such as the GDP per capita of the country. The countries that are considered to be in crisis or experience spillover effects from countries in crisis are: Argentina, Brazil, Hong Kong, Hungary, Indonesia, Peru, Philippines, Thailand, Venezuela (Mexican crisis); Argentina, Brazil, Czech Republic, Hong Kong, Hungary, Indonesia, Korea, Malaysia, Mexico, Pakistan, Philippines, Poland, Singapore, South Africa,

⁹These reports are available from 2003-current year at: <http://www.imf.org/external/np/mfd/er/index.asp>. The earlier reports are available in the IMF's Annual Reports of Exchange Arrangement and Exchange Restrictions.

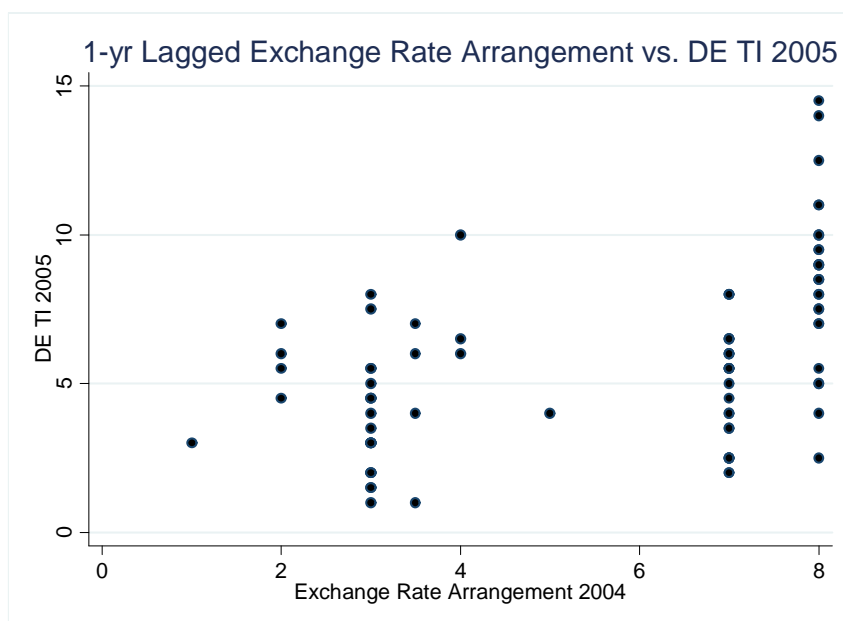


Figure 0-10: Exchange Rate Arrangement 2004 vs. DE TI 2005

Taiwan Province of China, Vietnam (Asian crisis); Argentina, Belarus, Bolivia, Brazil, Colombia, Czech Republic, Ecuador, Georgia, Hong Kong, Indonesia, Korea, Mexico, Moldova, Pakistan, Paraguay, Poland, South Africa, Tajikistan, Thailand, Turkey, Turkmenistan, Ukraine, Uruguay, Uzbekistan, Venezuela (Russian crisis)¹⁰. The region dummy variables total to 19. We categorize each country into one of the following regions: (Africa) 1=E. Africa, 2=N. Africa, 3=S. Africa, 4=W. Africa; (Americas) 5=Latin America and Caribbean, 6=C. America, 7=S. America, 8=N. America; (Oceania) 9=Australia and New Zealand, 10=Melanesia; (Asia) 11=C. Asia, 12=E. Asia, 13=S. Asia, 14=S-E Asia, 15=W. Asia; (Europe) 16=E. Europe, 17=N. Europe, 18=S. Europe, 19=W. Europe. Based on the available data, the regression is run in the years of 1999, 2001, 2003, 2004, 2005.

¹⁰This list is taken from NBA595, Economics of Financial Crisis, Cornell University, Spring 2008.

0.4.2 Regression

The regression on the panel data is run using a multilevel mixed-effects linear regression. The fixed-effect is captured by specifying the fixed-effect dummies controlling for the year, region, and crisis as well as polity. The random-effect model is captured by specifying the grouping structures of the observations, which in this case is the country. We run a regression based on our hypothesis above (see Appendix 9). We test for robustness by running the regression with orthogonalized variables (using the Gram-Schmidt method¹¹) and show that unemployment becomes insignificant while the results for the other variables remain robust. We drop the unemployment variable because of possible collinearity, and run another regression without unemployment and the quadratic term on the ratio of current account balance to nominal GDP that we find is insignificant in the first regression. We test for robustness by running the regression with orthogonalized variables and find the results are robust. The following regression is the regression that we use:

$$\begin{aligned} DETI_{i,t} = & \alpha + \beta_1 GDPPERCAP_{i,t-1} + \beta_2 (GDPPERCAP_{i,t-1})^2 + \\ & \beta_3 EXREGIME_{i,t-1} + \beta_4 INFLATION_{i,t-1} + \\ & \beta_5 RESERVE_{i,t-1} + \beta_6 (RESERVE_{i,t-1})^2 \\ & \beta_7 RER_{i,t-1} + \beta_8 (RER_{i,t-1})^2 \\ & \beta_9 DCAGDP_{i,t-1} + \\ & + I(POLITY_{i,t-1}) + I(REGION_i) + I(CRISIS) + I(YEAR_t) \end{aligned}$$

¹¹State command: orthog.

where:

GDPPERCAP=GDP per capita

EXREGIME=exchange rate arrangement

INFLATION=inflation

RESERVE=the ratio of broad money to foreign exchange reserves

RER=Real Exchange Rate appreciation (-)/ depreciation (+)

DCAGDP= the ratio of current account balance to nominal GDP

I(POLITY)=indicator variable on polity (-10=most autocratic, +10=most democratic)

I(REGION)=indicator variable on region (1-19)

I(CRISIS)=1 if country is in crisis in the last 8 years (1998-2005), =0 otherwise

I(YEAR)=indicator variable on year (1998-2005)

We expect the coefficient β_1 to be positive while β_2 to be negative to be consistent with the argument that a country with a higher level of development has more advanced communication technology and a human-capital advantage to support high quality economic institutions such as public data dissemination. This effect is expected to be diminishing. The effect of the exchange rate arrangement on transparency, β_3 , is expected to be positive. That is, countries with a more independent or flexible exchange rate arrangement tend to be more transparent. The coefficient on inflation, β_4 , is expected to be negative. Inflation could decrease the purchasing power of the citizens. It could be a sign of an overheating economy, and it could distort the terms of trade by causing the real exchange rate to appreciate. The linear and quadratic coefficients on the ratio of broad money to foreign exchange reserve, β_5 and β_6 , are expected to be negative and positive respectively. Countries with higher foreign exchange reserves are more liquid with respect to their liquid assets and can better protect its exchange rate against devaluation should there be a capital inflow reversal, thus rendering them less prone

to a speculative attack. The quadratic term is evident from the graphs of the ratio against the transparency index.

The linear and quadratic coefficients on the real exchange rate appreciation (-)/depreciation (+), β_7 and β_8 , are expected to be positive and negative respectively. Real exchange rate appreciation might indicate an overvalued exchange rate that is prone to a speculative attack. The linear coefficient of the ratio of current account balance to nominal GDP, β_9 , is expected to be positive. Countries with high ratios of current account deficits to nominal GDP are more prone to capital inflow reversal and to speculative attack if foreign exchange reserves are low, real exchange rate is overvalued and/or the banking system is weak, which would imply low fundamentals. The question of whether this coefficient should be positive or negative is, however, subtle. Current account deficits do not necessarily mean low fundamentals because they might, for example, mirror capital account surpluses and reflect an investment boom. Some studies have also been done to show that current account deficit is not necessarily a sign of low fundamental (Ghosh and Ramakrishnan, 2006). We conjecture that the coefficient of polity is positive for high polity indexes. We expect the crisis indicator to be positive and significant to capture the pressures from the lending countries on crisis-hit countries to adopt transparency measures. We also expect the year-effect to be positive and significant to capture the increasing general trend of transparency across countries. Some region effects are significant to capture regional biases that might include climate, geography, biology, or culture.

The discussion of what constitutes a good economic fundamental is subtle. There are two types of fundamentals: macroeconomic fundamentals that fluctuate considerably over time, and structural fundamentals that do not fluctuate much over time. Countries with high structural fundamentals could still experience crisis because of poor macroeconomic fundamentals. Macroeconomic fundamentals

constitute variables including changes in real exchange rate, while structural fundamentals constitute variables such as exchange rate regime and hyperinflation. We use both macroeconomic fundamentals and structural fundamentals.

Another concern about the regression that one might address is that the change in real exchange rate might not be completely independent from the ratio of current account balance to GDP. As studied in Lee, Milesi-Ferretti, and Ricci (2006), the change in real exchange rate might be an adjustment from the current account balance to reach equilibrium. This collinearity is resolved by a robustness check running a regression with orthogonalized variables.

0.4.3 Result

The regression result is in Appendix 10, after dropping four observations that have very high residuals (outliers). We find that both the linear and quadratic terms of GDP per capita are positive and negative respectively with five and ten percent confidence interval. This is consistent with our prediction that countries with higher level of GDP per capita are associated with higher level of transparency.

The coefficient of the exchange rate arrangement is positive and significant at one percent confidence interval. Countries with more flexible exchange rate arrangements tend to have more transparent central banks. The coefficient of inflation is negative and significant at one percent confidence interval. Countries with higher inflation tend to have less transparent central banks. The linear and quadratic coefficients of the ratio of broad money to foreign exchange reserves are negative and positive respectively with one percent confidence interval, consistent with our hypothesis. Countries that are more liquid with respect to their assets tend to have more transparent central banks. The linear and quadratic coefficients of the changes of real exchange rate are negative and positive respec-

tively with five percent confidence interval. This means that countries with real exchange rate appreciation tend to have higher levels of transparency, which is inconsistent with our hypothesis. One argument for the inconsistency is that it is not the changes in real exchange rate that affect transparency, but rather the exchange rate regime. Hence, changes in real exchange rate after we control for exchange rate regime are not good indicators of fundamentals that could affect transparency. We argue that there is no macroeconomic theory that explains this negative relationship. Changes in real exchange rate fluctuate considerably and can be considered as macroeconomic fundamentals while exchange rate regime can be considered a structural fundamental. What seems to be more relevant in our study are structural fundamentals rather than macroeconomic fundamentals.

The coefficient of the ratio of current account balance to the nominal GDP is negative and significant at five percent confidence interval, which is inconsistent with our hypothesis. We argue that this is because high current account deficits mirror high capital account surpluses, and countries with capital account surpluses, which might reflect an investment boom, are more confident in revealing their fundamentals.

The polity index is positive and significant only for the highest level of polity, or the most democratic regime. Region effects are significant and positive: (one percent confidence interval for the following regions) North America, Australia and New Zealand, Northern Europe; and (five percent confidence interval for the following regions) Southern Africa. After controlling for the level of development, developed countries still show tendencies for higher transparency. Southern Africa has a significantly higher transparency than that of the controlled region, Eastern Africa, albeit with a lower coefficient than those of North America, Australia and New Zealand, and Northern Europe. Possible explanations include culture, biology, geography, and even weather or environment. The year or time-effect is

significant at one percent confidence interval and positive for all years, except 1999, which means that countries worldwide in general experience an increasing trend in transparency. Transparency in 1999 did not change significantly from transparency in 1998. The crisis index is significant at one percent confidence interval and positive, which suggests that countries under crisis, particularly because of the four crises between 1998-2005 including the Asian, Russian, and Mexican crises, tend to have higher transparency indexes. This suggests possible international pressures in particular from the IMF, which helped those countries and required them to adopt transparency measures. These non-economic effects on transparency are consistent with our hypothesis.

To check for robustness because of the possible collinearity of variables, we run the regression with orthogonalized independent variables and the result remains robust. Some existing literature including Geraats (2008) and Crowe and Meade (2007) show that certain monetary policy frameworks could affect the level of transparency. However, we did not control for the monetary policy framework in our model because it is only available from 2001 onwards, and hence, we would have to drop our observations from 1998 to 2001, which would have reduced the explanatory power of most of the variables of interest¹².

0.4.4 Policy Implications: Endogeneity of Institution and Convergence Bias

The policy implications of this study lay in that the results from the empirical study, which suggest that some economic fundamentals of a country could affect the level of transparency of central banks, which in turn could be a proxy to the quality

¹²We receive data on monetary policy framework prior to 2001 (1997-2005) from the IMF. However, due to inconsistencies in identifying monetary policy framework throughout this period, we do not use this data for the purpose of this paper.

of economic institution. These economic fundamentals include GDP per capita (the level of development), inflation, the ratio of broad money to foreign exchange reserves, the ratio of current account balance to nominal GDP and the exchange rate regime. However, these are not the only factors that affect the quality of economic institution. The polity, unobserved region-effect, international pressure from lenders, and year-effect also affect the quality of economic institution.

This result gives a more fundamental explanation of the determinants of the quality of economic institution than what has been done in previous literature. In this case, the primary determinant is transparency. Controlling for the level of development and the exchange rate regime, countries with lower inflation, lower ratio of broad money to foreign exchange reserves, and lower ratio of current account balance to nominal GDP tend to have higher transparency. Moreover, countries in crisis tend to have higher transparency. Countries located in Southern Africa, North America, Australia and New Zealand, and Northern Europe tend to have significantly higher transparency than those of the controlled region of Eastern Africa after controlling for the other variables. In general, all countries tend to have higher transparency over time.

We distinguish between macroeconomic fundamentals and structural fundamentals. Macroeconomic fundamentals include the changes in real exchange rate and structural fundamentals include the level of development, the exchange rate regime, (hyper)inflation, the ratio of broad money to foreign exchange reserves, and the ratio of current account balance to nominal GDP. We argue that the structural fundamental is a more relevant variable to study quality of institution than macroeconomic fundamental is. Of course, we cannot completely eliminate the fact that the level of transparency might affect the quality of the fundamentals, but the panel data of this study allows us to detect the persistency of the effects of these indicators on transparency over time.

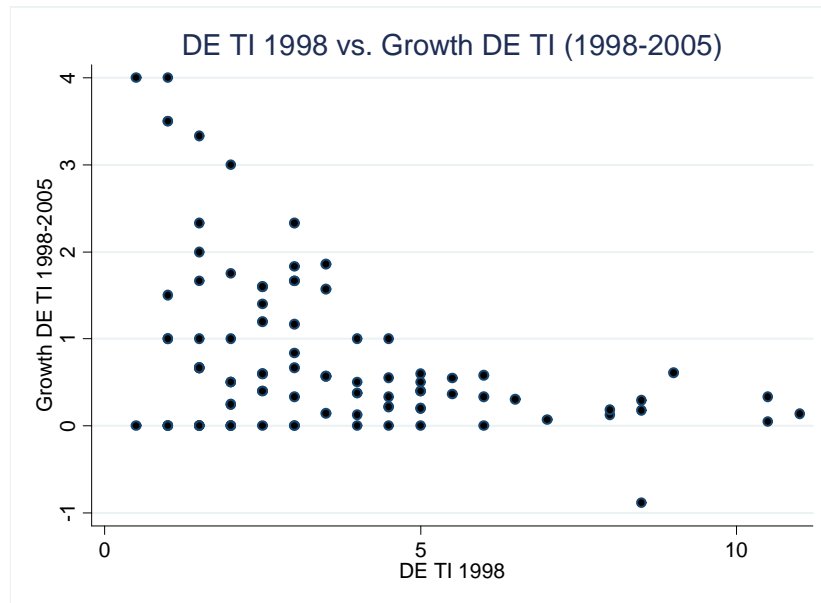


Figure 0-11: DE TI 1998 vs. Growth DE TI 1998-2005

A more meaningful implication of this empirical study is that the quality of economic institution is endogenous. Economic fundamentals may affect the quality of economic institution, which in turn affect the fundamentals. There is also a more general time-trend, as all countries generally experience an increasing level of transparency. In other words, even countries with low economic fundamentals and transparency will tend to experience an increase in their level of transparency over time. We can also show that the growth of DE TI from 1998 to 2005 is higher for countries with lower initial transparency index in 1998. This suggests the convergence or catching-up bias (see Figure 11).

Another interesting observation, although not directly related to this study, is the evidence of reversal of fortune (see Figure 12-14). In these figures, over time, we can show that GDP per capita could have a negative effect on the quality of political institution, such as the Rule of Index from the Worldwide Governance Indicators. Countries with very high values of GDP per capita with relatively low

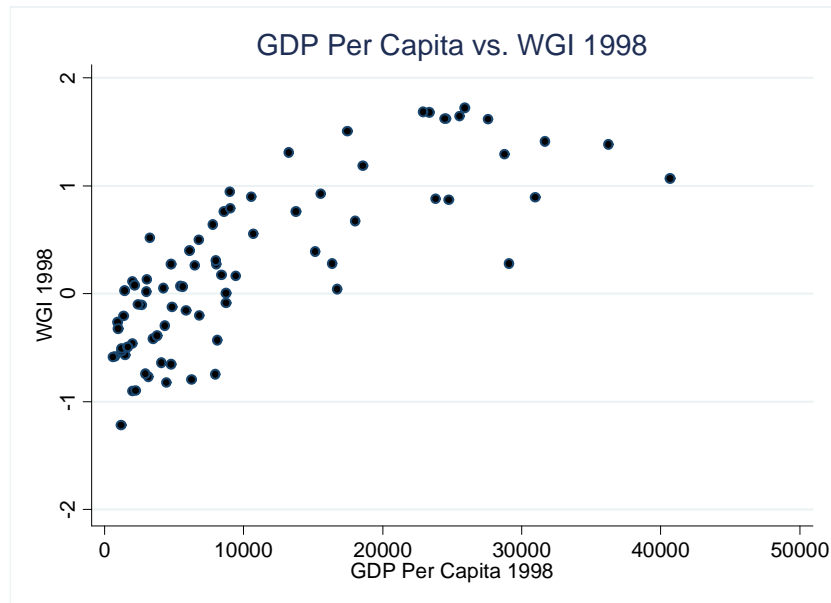


Figure 0-12: GDP per Capita 1998 vs. WGI 1998

Rule of Law Index include Qatar, Kuwait, and United Arab Emirate. These are countries that are rich in oil, petroleum, and natural gas. These countries tend to be reluctant to improve their institutions because, even without high quality of institution, they could still enjoy high standards of living.

0.5 The Role of Information In The Process Towards East Asian Integration

0.5.1 History of Asian Regional Financial Arrangement

After the 1997-1998 Asian Financial Crisis, East Asian economists, some of whom were disappointed with the management of the crisis under the IMF, realized the need to establish an economic institution to safeguard the East Asian countries from another financial crisis and to facilitate regional economic cooperation. Since

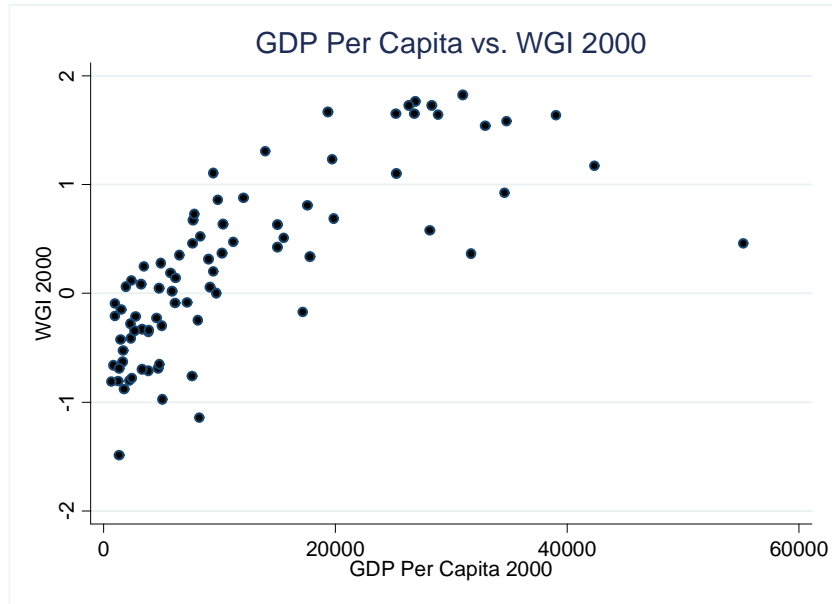


Figure 0-13: GDP per Capita 2000 vs. DE TI 2000

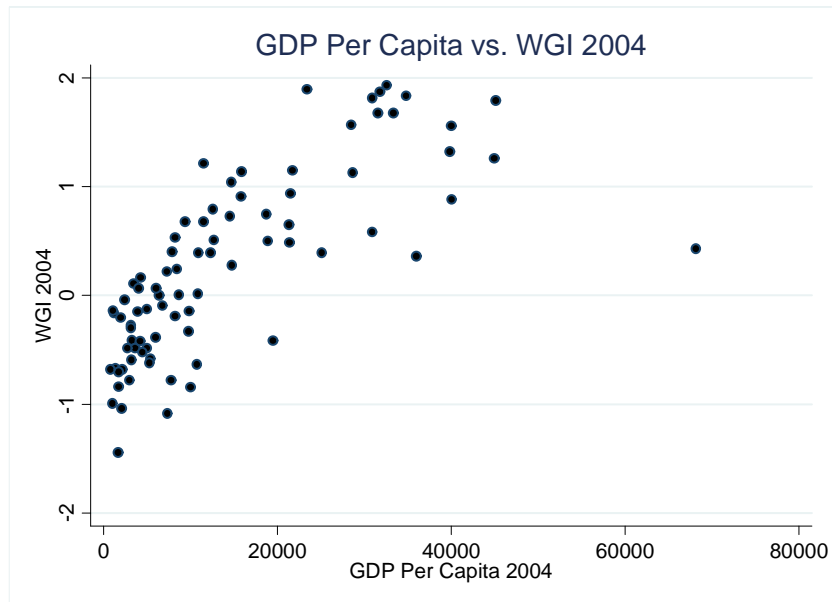


Figure 0-14: GDP per Capita 2004 vs. DE TI 2004

August 1997, Japan had already proposed an "Asian Monetary Fund". Thirteen countries consisting of the ten ASEAN countries plus China, Japan, and Korea, now termed the ASEAN+3 countries, gathered together in December 1997 in Kuala Lumpur, Malaysia, to discuss the establishment of a regional economic institution. This was the first summit to begin the Asian regional economic cooperation after the 1997-1998 financial crisis. On May 6, 2000, Chiang Mai Initiatives Bilateral Swap was initiated to facilitate bilateral swap arrangements and protect member countries from short-term liquidity crisis as well as to supplement the existing borrowing support facilities. By May 15, 2004, sixteen Bilateral Swap Agreements were already made totalling to US\$36.5 billion, and on the same day, finance ministers initiated the Asian Bond Market Initiatives, ASEAN+3 Research Groups, and regional monitoring of short-term capital flows. They also agreed to adopt the new Basel Capital Accord regulating banking laws. By this time, the ASEAN+3 countries had managed to agree on five main pillars of regional financial arrangements, namely the Chiang Mai Initiatives, the Asian Bond Market Initiatives, the regional surveillance and regional monitoring (which was consolidated in regular policy meetings known as the Economic Review and Policy Dialogue or ERPD), and the ASEAN+3 Research Groups. On May 5, 2007, a self-managed reserve pooling arrangement was envisaged. On May 4, 2008, the Chiang Mai Initiatives were transformed into a much stronger Chiang Mai Initiatives Multilateralization. On October 25, 2008, a self-managed reserve pool amounting to US\$80 billion based on the Chiang Mai Initiatives Multilateralization was created. The three countries, China, Japan and Korea, committed to provide 80 percent of the total fund of US\$80 billion while the rests of the ASEAN countries contributed the remainder. On December 13, 2008, a trilateral summit among China, Japan, and Korea was held. In this meeting, the three countries reiterated their commitments to the Chiang Mai Initiatives Multilateralization and most importantly, this meeting was

a development in their long-time reservation. On December 15, 2008, this foreign exchange reserve pool was envisaged to expand to US\$120 billion from US\$80 billion. On November 20 and 28, 2008, a technical-group meeting and deputy finance ministerial meeting were held to work out the technical details of the self-managed reserve pool. This self-managed reserve pool was expected to take effect in May 2009. On February 18, 2009, the Asian Development Bank kicked off studies to better facilitate cross-border, regional investment through the local Asian bond markets by aligning regulations, laws and policies on various local Asian bond markets. On February 19, 2009, ASEAN+3 countries met in Phuket, Thailand, to advance the agreement on expanding the reserve pool to US\$120 billion in order to better safeguard member countries against liquidity crisis. Commitment for more integration was reiterated as Asian exports slumped. They envisaged an Asian economic community by 2015. Free flows of trade and tolerance for culture differences were among the projected means of achieving regional integration. East Asian countries' international reserve currently totalled close to US\$4 trillion (Soesastro, 2008). Asian currency and Asian Monetary Union have also been envisioned. The chronology of the ASEAN+3 regional financial arrangement is given in Appendix 11.

0.5.2 Economic Factors: Distrust, Asymmetric Power, and Transparency Aversion

Despite this seemingly accelerating regional cooperation effort among East Asian countries after the 1997-1998 financial crisis and the first time a regional financial arrangement was envisaged by the thirteen East Asian countries in 1997, this regional financial arrangement was never officially institutionalized, unlike for example, the European Monetary Union. No secretariat office of Asian regional financial

arrangement was ever built. We argue using our theoretical propositions above and other game theoretical analysis that it is extremely difficult to institutionalize the existing regional financial arrangement in East Asia given its distinctive history, economic, and political background. We argue that economic fundamentals alone are not enough to fully explain the failure to institutionalize a regional financial arrangement. We further argue that political, security, military and sociocultural factors could be more serious in having slowed the progress towards an institutionalized Asian regional financial arrangement. A study shows that variations in the qualities of economic institutions, namely transparency of central banks, cannot be explained by economic fundamentals, but can be explained by polity. Institutionalizing an Asian regional financial arrangement could only take effect gradually because of these non-economic factors. Economic incentives, in fact, are more likely to bring East Asian countries toward greater integration during troubled times to counter the political, security, military and sociocultural factors. We will begin with three economic arguments based on game theoretical analysis to explain why it is difficult to institutionalize a regional financial arrangement. These three arguments are the values of trust, symmetry, and information.

The Value of Trust: Positive Economic Shocks vs. Security, Military, Political Issues

One of the reasons for miscoordination lays in institutionalized beliefs that discourage cooperative behavior. Consider a simple two-player coordination game where two equilibria exist, with the cooperative equilibrium Pareto-dominating the non-cooperative equilibrium. The players's beliefs of how other players behave will determine their strategies. Beliefs are formed by initial beliefs and observable actions afterwards if the games are repeated. Players can be "trapped" in the Pareto-dominated equilibrium in each period if initial beliefs dictate that they

begin by playing the Pareto-dominated equilibrium and the next period's beliefs will dictate the players to play the Pareto-dominated equilibrium with an even stronger belief that the others will play the Pareto-dominated equilibrium. In the long-run, this institutionalized belief becomes social norms. Initial belief is thus a vital factor in determining future trajectories. On one extreme, an *accidental* distrust can create a vicious cycle, while on the other extreme, an accidental trust can create a virtuous cycle. History can therefore create a feeling of distrust for a long period of time. Given the history of the Sino-Japan war, it is not unreasonable to believe that in the case of East Asian countries, particularly China and Japan, the feeling of distrust dictates non-cooperation despite economic outcomes that Pareto-dominate this non-cooperative outcome. A stronger case of trust is the Prisoners' Dilemma game. In this case, the rational outcome is not an equilibrium. Hence, in order to achieve the rational, Pareto-Dominant outcome, a stronger sense of trust is needed. Experimental studies, however, show that the predicted non-cooperative equilibrium does not necessarily prevail if the games are repeated. Thus, people do have an intrinsic desire to achieve cooperation. The question is how to initiate it.

Schelling (2007) introduces a solution to resolve the multiplicity of equilibria, such as in the case of the coordination game, that is a focal point. Basu's Taxi-Driver (2003) example or Myerson's (2004) justice, truthful equilibrium, and institution arguments illustrate Schelling's concept of a focal point to explain real-life phenomena that are subject to a multiplicity of equilibria. Myerson (2004) provides an argument that explains why, even in the case of a multiplicity of equilibria, our everyday lives are far from facing conflicts. Myerson explains more explicitly Schelling's idea of a focal point. He argues that a lot of situations we face and the self-enforcing actions we take are the result of an "arbitrator," such as an institution in a multiple-equilibria setting. In the Taxi-Driver example, Basu

(2003) argues that we observe particular equilibria being played and not the other possible outcomes because of the existence of a set “rules” that set a “focal point” of actions. Self-interested individuals can expect an equilibrium to be played through this “focal point,” and it is out of their selfish interest that they behave in this manner. To some extent, the role of an arbitrator or a focal point resembles the role of a coordination device in a correlated equilibrium. Suppose there were two possible economic outcomes in the case of East Asian regional economic cooperation context, and one of the outcomes Pareto-dominates the other outcome. We might argue that there could be a focal point that dictates these East Asian countries to behave non-cooperatively or choose the Pareto-dominated equilibrium. It could indeed be that past observations of non-cooperative behaviors during the war became institutionalized into implicit rules of social norms. Greif (2006) argues that, "even marginal changes in the rules of the game are not likely to cause behavioral changes, because past behavior constitutes a focal point." The Sino-Japan war, hence, could create not only an accidental distrust, but also a focal point for behaving non-cooperatively in the case of multiple outcomes. Moreover, the lack of institutions could be the cause of miscoordination because there is no focal point. The idea of the focal point becomes the basis of Myerson’s concept of cooperative game theory (Myerson, 1991).

The feeling of distrust could have died away because the two countries must have intrinsic values to cooperate, especially in repeated interactions. However, in the case of Japan and China, it seems that this feeling of distrust is prolonged by some of the elements from the war that are still carried on today. An example of these is the presence of the U.S. military base in Japan that might worsen the relationship between Japan and China¹³. Economic incentives to integrate, similar

¹³Private conversation with M. Fujita (RIETI, Japan) in August 2008.

to the European Union, might not work in East Asia because of the military power of the US in Japan, which creates a prolonged feeling of distrust between Japan and China. Another issue surrounding the prolonged distrust from the Sino-Japan lays in the education and communication sectors, as the history of the Sino-Japan war is never completely and truly disclosed in Japan. Most teenagers who have been educated in Japan never truly know the history of the Sino-Japan war. It has been recorded by many people that Japanese colonization was very cruel. The fact that the Japanese government does not fully reveal this history might create hatred among the war victims. Moreover, religious shrines to honor those who fought during the Sino-Japan have raised opposition from people who come from the formerly colonized countries.

The threat of a nuclear war could also prolong the feeling of distrust. China is the only country in East Asia that owns nuclear weapons and produces significant amounts of uranium. While the ASEAN countries had signed the treaty of South East Asian Nuclear Weapon Free-Zone (SEANWFZ) in Bangkok, Thailand, in 1995, none of the five nuclear weapon facilitators, including China, signed the SEANWFZ¹⁴. This threat could exacerbate the feeling of distrust against China. Nash Bargaining solution predicts that if China could threaten other countries with nuclear war in the case of a failure from bargaining, then this could reduce the expected payoffs of the less powerful countries from a negotiation. If the threat point is a nuclear war, then bargaining with China could be undesirable for the other countries.

To address the difficulty of cooperation that game theory already predicts, we begin our discussion of how to untangle the vicious cycle of distrust and non-cooperative behavior or to change the focal point that reinforces non-cooperative

¹⁴China is also the only country among the five countries that own nuclear weapons that is not a member country nor a partner member country of NATO.

outcomes. An important policy question in the case of the self-reinforcing, endogenous, evolutionary system is how we can break the cycle. History suggests that this cycle could be broken or the process to reformation could be sped up by exogenous shocks that may come from outside or within the cycle. European countries, for example, are able to integrate both politically and economically through the European Union and the European Monetary Union despite the Second World War. In the case of the European countries, economic incentives had overpowered the non-cooperative inclinations from the past. The European Coal and Steel Community in 1950 had been able to integrate the European communities both economically and politically starting from six founding countries, including Belgium, France, Germany, Luxembourg, Italy, and the Netherlands. In 1957, the European Economic Community was established. In 1032, Venice was able to restore economic cooperation because the elected monarchy was changed into a republican magistracy (Greif, 2006). This is an example of how a central rule that changed political structures could end economic disintegration. The Tsunami in Aceh, Indonesia, had brought a silver lining to the region by ending the long-time civil war. Mt. Geumgang, a recreational park located in the demilitarized zone between North and South Korea, could be a beginning of peace resolution between the two countries. This recreational park was initiated by two sides: a South Korean business elite (Hyundai) who had a personal longing to visit his native land in the North and the North Korean government, who was probably more economically motivated. The September 11, 2001, terrorist attack had brought the American people closer together. These exogenous shocks had changed the social, economic, or political condition of a region, state or country. Factors that break the vicious cycle of distrust and non-cooperative behaviors, however, do not necessarily come from elements outside the system. They may also come from elements inside the system, namely through "voice" or demand for a change of

the constituents (Hirschman, 1970). Hence, breaking a cycle of an endogenous system can come both from elements outside or within the system and can come gradually (e.g. the establishment of the European Union) or it can come in an instant (e.g. the peace resolution in Aceh).

In 1997-1998, some of the East Asian countries experienced a severe financial crisis, and currently are suffering from 2007 global financial crisis. The 1997-1998 Asian financial crisis and the 2007 global financial crisis can be exogenous shocks that call for a regional financial integration. The initiation of the regional financial arrangement was a sign that East Asian countries realized the need to break the cycle of non-cooperative behaviors and move towards regional economic integration. Looking to the future, the 2007 global financial crisis that was triggered by global economic imbalance, credit bubbles, and deregulation triggered an even greater regional economic integration to provide a firewall against financial crisis as economies slumped. The tendency to integrate in the presence of a threat is recorded by Greif among Genoese clan in 1155. Opposing Genoese clans in 1155 mobilized their resources to begin building walls around the city to protect themselves against the external threat from a new German emperor who intended to gain control over the northern Italian cities (Greif, 2006). These positive economic shocks could therefore counter the prolonged distrust and non-cooperative behavior since the Sino-Japan war. However, as East Asian countries regain their prosperity in the future, it might be that incentives to integrate will disappear and trigger non-cooperative behaviors, such was the case in Genoa in 1189-1194, when the external threat from the German emperor disappeared and economic prosperity and past investments in military ability made Genoese clans seek political dominance and engage in an arms race (Greif, 2006). This is probably why establishing a regional financial institution could be important in sustaining cooperative behaviors for the long-run.

The Value of Symmetry: Asymmetric Bargaining Power and Heterogeneity

We have partly explained why it can be very difficult to make countries commit to cooperation under institutionalized beliefs of distrust, although we argue it could be facilitated by positive economic shocks that call for regional financial integration. What we will discuss in this section is the asymmetric bargaining power, particularly that of China (see Tables 3.4-3.6).

Table 4: Population, Area, Nuclear Weapon (Source: UNData)

Country	Population(est.'07)(000)	Area(km ²)	Nuclear Weapon
Brunei Darussalam	390	5,765	x
Cambodia	14,444	181,035	x
Laos	5,859	236,800	x
Malaysia	26,572	329,847	x
Myanmar	48,798	676,578	x
Philippines	87,960	300,000	x
Singapore	4,436	699	x
Thailand	63,884	513,120	x
Vietnam	87,375	331,689	x
China	1,328,630	9,596,961	v
Japan	127,967	377,873	x
Korea	48,224	99,538	x
Indonesia	231,627	1,904,569	x

Economically and population-wise, China could overpower all other countries in the region. China's population is more than the total population of the rest of the ASEAN+3 countries. Its area is approximately five times bigger than the second biggest country in terms of its area among the ASEAN+3 countries, namely Indonesia. China is financially dominant with the world's highest international reserve and trade balance. Not only economically, geographically, and demographically does China dominate the other countries in the region, but it is one of the five countries in the world that owns a nuclear weapon and is the only country in the region that has enough uranium production to produce uranium weapons.

Table 5: Strategic Commodities of ASEAN+3 (Source: CIA, WorldFact Book)

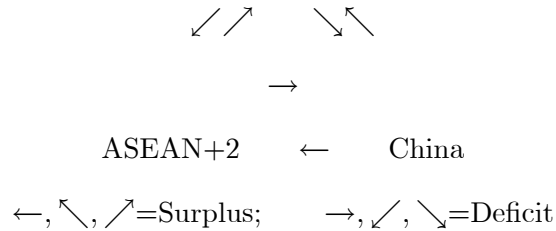
Country	Strategic Commodities
Brunei Darussalam	Petroleum, gas, timber
Cambodia	oil, gas, timber, gemstones, iron, ores, manganese phosphates, hydropower
Laos	timber, hydropower, gypsum, tin, gold, gemstones
Malaysia	tin, petroleum, timber, copper, iron, ore, natural gas, bauxite
Myanmar	petroleum, timber, tin, antimony, zinc, copper, tungsten, coal, marble, gemstones, precious stones, natural gas, lead, hydropower
Philippines	timber, petroleum, nickel, cobalt, silver, gold, salt, copper
Singapore	fish, deepwater ports
Thailand	tin, rubber, natural gas, tungsten, tantalum, lignite, timber lead, fish, gypsum, fluorite
Vietnam	phosphate, coal, manganese, bauxite, chromate, offshore oil, gas, forests, hydropower
China	coal, uranium, iron ore, petroleum, magnetite, natural gas, tin, tungsten, antimony, manganese, molybdenum, aluminium, lead, zinc, uranium, mercury, vanadium, hydropower (world's largest)
Japan	negligible natural resources, fish
Korea	coal, tungsten, graphite, molybdenum, lead, hydropower
Indonesia	petroleum, tin, natural gas, nickel, timber, bauxite, copper coal, gold, silver

Asymmetric power could make the decision-making process more complicated. At the moment, general policy decisions are based on consensus. Only in the case of disagreement or no consensus, will China or Japan dominate the decision-making process. Population-based decision-making could mean that China overpowers all other countries, which is undesirable for smaller countries. The consensus-based decision-making process results in a more equal division of power. Instead of China and Japan dominating in the case of no consensus, one voice from the less dominant countries could be included, for example.

USA

Table 6: Total Reserves, Trade Balance, Financial Account (Source: IFS)

Country\ (in mil.US\$)	Total Reserve-Gold	Trade balance	Financial Account
Brunei Darussalam	513570	6041	575
Cambodia	1157	-1056	324
Laos	328	-178	230
Malaysia	82132	36698	-11894
Myanmar	1235	2211	253
Philippines	20024	-6732	1351
Singapore	136260	43432	-18580
Thailand	65291	13844	5649
Vietnam	13384	-2776	3088
China	1068490	217746	2642
Japan	879682	81303	-102343
Korea	210317	32683	7104
Indonesia	41103	29660	2594



One way to measure the relative bargaining power among the ASEAN+3 countries is their trade surplus relative to other ASEAN+3 countries and to the U.S.A.. Consider the “trade triangle” above. China will have the most bargaining power given the size of its trade surplus. Non-symmetric Nash Bargaining Solution for cooperative games show that the unique solution in a bargaining game that satisfy the strong efficiency, individual rationality, scale covariance, and independence of irrelevant alternatives axioms is the solution to the maximization problem of the *generalized Nash product*. In a two-player game, for example, the degree of bargaining power, the power coefficient, will increase the expected utility of the player. Given the extremely strong bargaining power of China compared to the rest of the ASEAN+3 countries, China could overpower other countries and secure a signifi-

cant amount of the surplus. One way to solve this asymmetric bargaining power in the case of China is to change the threat points. Decreasing the opponent's payoff or increasing his/her payoff at the threat point will increase the payoff of a player from bargaining.

There are three ways in which threat points can be constructed depending on the communication structures among the countries (Myerson, 1991). The three kinds of threat points from different communication structures are called the equilibrium threat points, the minimax-value threat points, and the rational threat points. Let us consider the rational-threat theory. The rational threat points are useful to apply in situations where players could commit to a planned strategy at the threat point. This theory suggests that lowering the opponent's payoff at the threat point by, for example, acting antagonistically at the pre-play communication stage to create a more favorable disagreement payoff, could increase the negotiation payoff of the player. This is also called the *chilling effect*. ASEAN+2 countries could have credibly threatened to act aggressively against China should there be any disagreement among the ASEAN+3 countries in order to lower the size of the surplus that China would receive from the negotiation. For example, the ASEAN+2 countries could have committed to impose economic sanctions should they not end up in negotiation with China. In other words, in order to decrease the power of China, the ASEAN+2 countries could have committed to decrease the payoff of China at the threat point. However, there might not be any threat that is realistic because the power of China is so omnipresent that no country will rationally commit to ending their relationship with China.

Recently the ASEAN+3 countries expanded its coalition to ASEAN+6 adding India, Australia, and New Zealand. Some people speculate that this was done in order to reduce the power of China. Coalitional analysis could be done to find the optimal membership of the regional financial arrangement. It could also be

that any bargaining process between China and ASEAN+2 countries will always render China better off as independent because of the omnipresent power. During the times of crisis, there are more incentives for countries to integrate. This could probably be modeled as a Nash bargaining problem in which the payoff for each country at the threat point is very low, such that the game is *feasible* even for a set of low feasible payoffs.

Another factor that might impede the progress of an institutionalized regional financial arrangement is the number of the potential member countries. Intuitively, the higher the number of players, the more complex it is to regulate and hence, to institutionalize. This is exacerbated by the asymmetries and heterogeneity among the countries. Heterogeneity among the ASEAN +3 countries, particularly in terms of their level of development, might create different goals for setting up a regional integration (see Table 3.7). While the main interests of low-income countries such as Myanmar, Laos, or Cambodia are to eliminate poverty and other social issues, the main interests of high-income countries like Japan, Korea, and Singapore are to increase resilience to financial crisis by accumulating large foreign reserves. Heterogeneity among ASEAN+3 countries makes setting up common goals more difficult.

The Value of Information: Pro- or Anti-Transparency

The role of information is indispensable in any strategic interaction, including strategies to cooperate. Under incompleteness of information, cooperation is even harder to achieve because it has to be supported by beliefs about the type of the other players and that the other players are also going to cooperate. Moreover, beliefs are difficult to change because it takes a series of observable actions.

Table 7: GDP per Capita and Poverty of ASEAN+3 (Source: The WorldFact Book, IndexMundi)

Country	GDP per Capita (US\$)(Jan.'08)	Pop.below poverty line (%)
Brunei Darussalam	50,756	N.A.
Singapore	48,900	N.A.
China (Hongkong)	42,000	N.A.
Japan	33,800	N.A.
South Korea	24,600	15 (2003)
Malaysia	14,400	5.1 (2002)
Thailand	8,000	10 (2002)
China (Mainland)	5,300	8 (2006)
Indonesia	3,400	17.6 (2006)
Philippines	3,300	30 (2003)
Vietnam	2,900	14.75 (2007)
Laos	2,224	30.7 (2005)
Cambodia	1,942	35 (2004)
Myanmar	1,027	32.7 (2007)

Transparency can resolve asymmetric information. By being transparent, there is no agency problem, including moral hazard and adverse selection (or the hybrid of moral hazard and adverse selection). Establishing an institution, in fact, can resolve the issue of uncertainty by putting forth a stable structure for human interactions and information exchange (North, 1990). Hence, establishing an institution can resolve at least some uncertainty entailed in cooperation. It has so far been evident that establishing an institution, such as the IMF, promotes greater transparency that may resolve not only uncertainty but also risks, perhaps by a country's publication of the IMF's Article IV that contains the country's macroeconomic data and a staff report, which reduces imprecision of information.

However, as we argue earlier, heterogenous countries with different fundamentals, might prefer different levels of transparency. Hence, *transparency-aversion* (see Transparency-Aversion proposition above) by some low- and intermediate-fundamental countries might discourage these countries from seeking the establishment of an institution in the first place. What we are going to discuss here

is that although aversions to transparency could certainly impede the establishment of an institutionalized regional financial arrangement, their ill effects may be eroded or completely eliminated by the reputation effects and adverse selection biases. While aversions to transparency by some types of countries, in addition to distrust and asymmetric bargaining power, could have slowed the progress toward institutionalizing an Asian regional financial arrangement, reputation effects and adverse selection biases might instead promote institution-seeking behaviors and institutionalization.

Economists and policy makers may already know that transparency, or symmetry of information, could facilitate more cooperation. Transparency in monetary policies is often stated as being necessary to align people's expectations to the targeted policies. Studies have also been done to show that not only does the level of development of a country increase the level of transparency of its central bank, but further that the level of transparency increases the GDP per capita in the same year or decreases the subsequent inflation of that country (Geraats, 2008, and Dincer and Eichengreen, 2007). Hence, pro-transparency rather than anti-transparency should have been favored by all regional countries who perceive cooperation as beneficial to their economies. Furthermore, all regional countries should have had the incentives to seek the establishment of an institutionalized regional financial arrangement that promotes transparency. The question becomes, why has the progress towards an institutionalized regional financial arrangement been slow?

Since transparency could facilitate more cooperation, it may seem self - contradictory that potential member countries may not favor the institutionalization of the current regional financial arrangement. Despite this, it is not clear whether individual countries will indeed *self-interestedly* seek transparency. In other words, one could say that transparency is indeed necessary for regional cooperation that is

beneficial to the region and eventually one's own country, but it is unclear whether individual countries will seek transparency based on their own self-interests. The problem resembles that of a public good, namely a collective action problem, a free-rider problem, or a problem in a Prisoners' Dilemma game. Each country will benefit from increased transparency by other countries, but may or may not prefer to be transparent itself. In the end, no institution is built.

What we show in the theoretical model in this paper is that countries with critical fundamentals may be better off under low transparency if there is a high probability of the Pareto-dominated equilibrium being played in the case of multiple equilibria. This is because a multiplicity of equilibria arises with a high level of transparency under incompleteness of information if a multiplicity of equilibria exists under completeness of information. Moreover, we can expect that low-fundamental countries will always choose non-transparency if there are negative externalities from revealing bad fundamentals, such as bad reputation. Hence, both the intermediate- and low-fundamental countries are better off under low-level of transparency or no transparency.

Now, suppose that under an institutionalized regional financial arrangement, member countries will have to oblige to a high level of transparency, for example by having to comply to regional surveillance and monitoring measures. Therefore, it may not be in the best interests of countries with either an intermediate or low fundamental to seek the establishment of an institutionalized regional financial arrangement, because under a high level of transparency these countries will be worse off.

However, in this case, transparency is endogenous as the choice exists of whether to select one's own level of transparency or be subject to regulation by seeking an institutionalized regional financial arrangement. In other words, each country can choose its own level of transparency by joining or not joining the institutionalized

regional financial arrangement. Under such a situation, the choice of transparency or transparency-seeking behavior could signal the fundamentals. Not seeking the establishment of an institutionalized regional financial arrangement may signal a low fundamental, while seeking the establishment of an institutionalized regional financial arrangement may signal a high fundamental. Under this endogenous transparency model, we might see all countries, except countries with the lowest fundamental (the *lemon car*), choosing to seek the establishment of an institutionalized regional financial arrangement because of the reputation effects and adverse selection biases.

Based on our theoretical study, therefore, we predict that although some countries may be more averse to transparency than others and hence less inclined to seek the establishment of an institutionalized regional financial arrangement, the degree of transparency-aversion is eroded by the reputation effects and adverse selection biases. Only the worst-fundamental countries could be expected to remain opaque. These reputation effects are exacerbated if these happen in a close community, such as the ASEAN+3 community, since there is a localization of information in a smaller community (Dixit, 2004). Moreover, in a small community, anonymity diminishes (Greif, 2006). Thus, the endogenous rather than exogenous transparency model is the more appropriate model for the case of ASEAN+3.

In order to show these reputation effects and adverse selection biases, we look at the transparency level of the ASEAN+3 countries through the publication of Article IV and participation in the IMF's Special Data Dissemination Standard (SDDS) and the IMF's General Data Dissemination Standard (GDDS) (see Figure 8). We do not use the DE Transparency Index because not all thirteen countries are studied. However, this binary data, i.e. publish or not publish and join or not join, is probably preferable given the strategies of the players in the endogenous

transparency model is binary. IMF's Article IV publication is voluntary¹⁵. GDDS and SDDS are the IMF's public data dissemination facilities to promote, among other objectives, transparency of macroeconomic and financial data. SDDS portrays a country's access to international capital market by providing data in the economic and financial sectors¹⁶. GDDS is less prescriptive than the SDDS and focuses on the improvement in data quality by identifying plans for improvements as well as associated needs for assistance in implementing these needs. This is in contrast with SDDS, in which the focus is on data dissemination by countries, which in general already meet high standards of data quality (IMF.org).

Table 8: Publication of Article IV, SDDS, GDDS of ASEAN+3 (Source: IMF.org)

Country	Article IV Publication	SDDS	GDDS
Brunei Darussalam	Yes	x	v
Cambodia	Yes	x	v
Laos	Yes	x	x
Malaysia	Yes	v	x
Myanmar	No	x	x
Philippines	Yes	v	x
Singapore	Yes	v	x
Thailand	Yes	v	x
Vietnam	Yes	x	v
China	Yes	x	v
Japan	Yes	v	x
Korea	Yes	v	x
Indonesia	Yes	v	x

We observe what might have been the *lemon car* phenomenon. Among the thirteen ASEAN+3 countries, only one country, Myanmar, does not publish the IMF's Article IV, despite the fact that it had been encouraged among East Asian

¹⁵Most of published documents by Executive Board, including IMF's Article IV, are "voluntary but presumed." This means that it needs member country's consent to published. Documents are not consulted with country's authorities, and once published, only limited changes can be made. (IMF Seeks View of Its Transparency Policy, March 25, 2009)

¹⁶We assume that participation in SDDS is a measure of transparency in which public data is disseminated in order to get access of the international capital market. It might be that countries will not participate in SDDS for other reasons than to remain opaque.

countries after the 1997-1998 Asian financial crisis. Not only does Myanmar not publish Article IV, but it also does not participate in the IMF data dissemination standards. Laos is the only country who publishes IMF's Article IV, but does not participate in any of the public data dissemination. Four countries participate in the IMF's GDDS instead of SDDS, which means that these countries, Brunei Darussalam, Cambodia, Vietnam, and China, do not seek access to the international capital market and/or have low data quality standards and they are currently being assisted by the IMF.

In order to check whether this observation is consistent with the *lemon car* phenomenon, we take six indicators of macroeconomic fundamental from 1997-2008. The macroeconomic fundamentals include: real GDP growth, the ratio of current account deficit to nominal GDP, the ratio of M2 to total reserve minus gold, the growth of private sector lending, inflation, and real exchange rate appreciation. Following Sachs, et.al. (1996), we use real exchange rate appreciation and private sector lending boom to measure the vulnerability of the fundamentals to speculative attacks and the ratio of M2 to total reserves minus gold to measure the reserve availability to protect the exchange rate from devaluation. Real GDP growth is a sign of productivity, recession or boom, and high or low unemployment rate. The ratio of current account deficit to nominal GDP measures how large capital inflows are, in which a high current account deficit with a low international reserve can trigger speculation. Inflation is a sign of overheating economy and might distort the term-of-trade. Figure 15 shows six indicators of fundamentals for ASEAN+3 countries in 2003 (the complete data is in the Appendix 12)¹⁷.

¹⁷The use of the year (2003) is debatable. We would like to measure how fundamentals affect transparency, and hence data to measure fundamentals should be before the transparency measures, which is in 2009. More recent data on fundamental might be desirable. A lack of data for Myanmar impedes us to use a later data. Despite this issue, the result that Myanmar is the country with the lowest fundamental is robust.

	2003 %Real GDP	DCA/GDP	M2/Reserve,	Lending Boom	Inflation	%RER	Expert Ranking
Myanmar	0.0578835	0.121424	2.55857979	0.067191737	0.01	0.0126	13
Cambodia	0.087	-0.05018	1.02749899	0.262260249	0.0121	0.024	12
Laos	0.058	-0.032	1.94106075	-0.001954166	0.1549	-0.132	11
Philippines	0.0491542	0.003708	2.26876205	0.029153346	0.0345	0.0346	10
Vietnam	0.073	-0.04925	4.22248034	0.324	0.0322	0.0064	9
Indonesia	0.0477993	0.034079	3.22917063	0.192213629	0.0659	-0.091	8
Korea	0.031	0.019665	3.263	0.087	0.035	-0.007	7
Thailand	0.07	0.032	3.46920469	0.064020855	0.018	-0.078	6
Brunei	0.039222	0.46949	10.257	0.034153412	0.003	-0.002	5
China	0.1	0.027837	6.54865632	0.194983345	0.0116	0.011	4
Malaysia	0.0578835	0.121424	2.55857979	0.067191737	0.01	0.0126	3
Japan	0.015	0.029755	9.609	-0.039256361	-0.0025	-0.084	2
Singapore	0.035	0.226	1.19005999	0.028265763	0.0051	-0.003	1

Figure 0-15: ASEAN+3: Fundamental (2003) and Expert Ranking

What we observe here is that Myanmar is indeed ranked the lowest in terms of its fundamentals relative to its neighbors by an expert¹⁸. From the 2003 data, we see that although Myanmar's real GDP growth is accelerating, they have an extremely low foreign exchange reserve with respect to their broad money, extremely high inflation, and extremely high real exchange rate appreciation. With the exception of 2003, Myanmar also had a very high private lending. Although the year in which the fundamental measures are taken is lagged by six years because of the lack of complete, more recent data, the fact that Myanmar has the lowest fundamental among the countries seems to be robust. What is less obvious is whether Myanmar remains opaque because of its low fundamental or because of the fact that Myanmar is a military-regime country. If we are to consider rules of law

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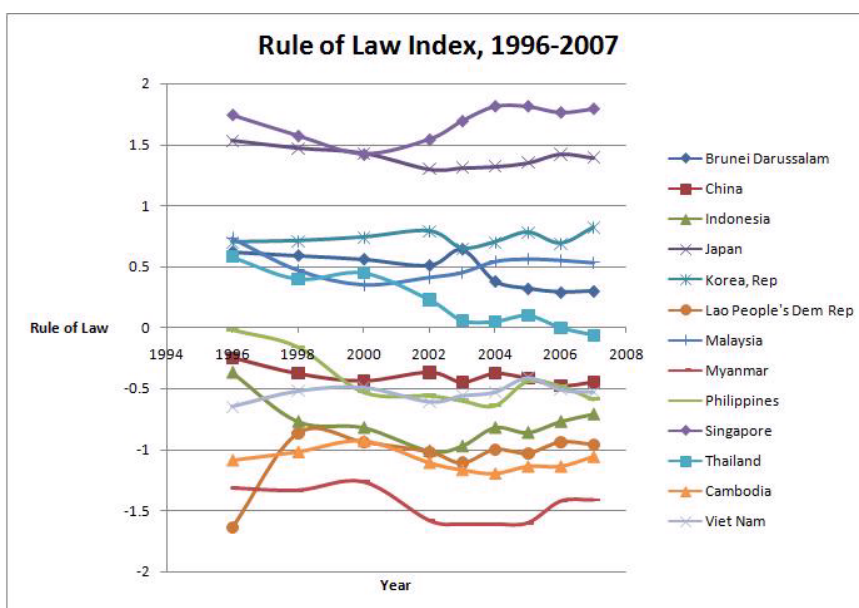


Figure 0-16: Rule of Law Index, 1996-2007, ASEAN+3

as important non-economic factors, then Myanmar's Rule of Law Index¹⁹ (from the Worldwide Governance Indicators, 1996-2007) is also ranked lowest among neighboring countries (see Figure 16).

We also observe that the next least transparent country that does not participate in either of the IMF's public data dissemination standards, Laos, is ranked the third lowest by the expert in terms of its fundamental. Since Laos is not a military-regime country, this might strengthen our hypothesis that economic fundamentals could have affected transparency. Countries that participate in GDDS instead of SDDS are Brunei Darussalam, China, Vietnam and Cambodia. This means that these countries have a low quality of data dissemination and/or may not seek access to international capital market. The fact that Brunei Darussalam and China have relatively high fundamentals will contradict our hypothesis that

¹⁹Rule of Law Index measures the "justness" and political freedom of a society that may affect the economic fundamental of a country.

these countries should have participated more actively in public data dissemination. According to expert opinion, Singapore and Brunei Darussalam are two anomalies in the region, that despite their relatively high fundamentals, remain opaque in terms of its financial issues. In the case of Singapore, it may be related to the strong stance on an authoritarian leadership²⁰. Brunei Darussalam remains opaque because it is a monarchial country and it does not seek international capital market because of a rich oil supply.

These anomalies, therefore, cannot be explained by economic-fundamental reasons, but can be explained by political reasons. Our study in the next section shows that these anomalies could be best explained by the level of democracy. This study suggests that the level of democracy is highly positively correlated with the level of transparency. Brunei Darussalam is a monarchial country. Myanmar, Vietnam and China are considered non-democratic countries, and Singapore and Cambodia are considered semi-democratic countries. Laos is ranked 141 out of 150 (second lowest behind Myanmar) in terms of its democracy in 2008 by the World Audit Democracy. This might explain why Brunei Darussalam, Myanmar, Vietnam, China, Laos and Cambodia remain opaque or do not actively participate in public data dissemination, while Singapore, despite being ranked first in terms of its fundamental, remains relatively opaque.

A compelling argument to draw here is that economic fundamentals, political and economic institutions are endogenous. This is probably why we see that countries such as Myanmar, Cambodia, and Laos, with no or low level of democracy and low Rule of Law (see Figure 16 and Figure 17) tend to be less transparent and have low fundamentals. Suppose we could start from no democracy, which causes less transparency, which then combined with low rule of law causes low fundamental,

²⁰In an economic forum in 2008, Lee Kwan Yew, reiterated Singaporean stance on authoritarian leadership without corruption.

causing even less democracy, and so on. In the case of ASEAN+3, variations in the level of transparency could not be explained by economic fundamentals alone, but also political fundamentals.

0.5.3 Polity, Social-Cultural Factors, and International Pressures

Polity

ASEAN+3 countries are heterogenous in terms of the level of democracy. Differences in the level of democracy among ASEAN+3 countries could affect the level of transparency and the level of political openness as well as attitudes towards regional integration of individual countries. Some countries that are less democratic such as China and Myanmar might be less willing to open up to the regional community. The rank of the central bank transparency of the countries studied in Dincer and Eichengreen (2007) (see Figure 17) correlates positively to the level of democracy (Table 3.9). China being the least democratic country has the lowest level of DE Transparency Index while the semi-democratic countries, namely Singapore and Malaysia, are ranked the second and third least transparent countries after China. Liberal Democratic countries, namely Japan and South Korea, are ranked the second and third most transparent countries. Hence, we see a strong correlation between the level of democracy and the central bank's transparency. Table 3.10 below shows the rank of democracy as indexed by the World Audit Democracy. Except for Thailand and Philippines, the rank of democracy in 2008 by the World Audit Democracy matches the rank of 2005 DE TI index. We show the polity index (democracy minus autocracy index) of the ASEAN+3, except Brunei Darussalam, in Figure 18²¹, which could explain the anomalies of

²¹In the figure, China and Laos do not show because they overlap Vietnam.

transparency among the ASEAN+3 countries. In particular, countries with the lowest polity indexes namely Myanmar, Laos, Vietnam, and China are also the least transparent with regards to their public data dissemination (i.e. IMF's Article IV, SDDS/GDDS). Countries with the highest polity indexes in 2005, namely Japan, Philippines, Korea, Thailand, and Indonesia, are also the most transparent countries according to the DE TI 2005.

Table 9: Level of Democracy of ASEAN+3, Rule of Law of East Asia, Peerenboom

Level of Democracy	Countries
Non-Democratic	China, Hong Kong, Vietnam, Myanmar
Semi-Democratic (soft authoritarian, non-liberal, or electoral democracy)	Singapore, Malaysia, Cambodia
Liberal Democratic	Japan, Taiwan, South Korea

Table 10: WAD's Democracy Index of ASEAN+3 (Source: World Audit Democracy, 2008)

Country	Democracy 2008 (out of 150)	DE TI 2005 Rank
Japan	30	2
South Korea	33	3
Indonesia	70	5
Singapore	74	6
Malaysia	82	7
Thailand	86	4
Philippines	88	1
Cambodia	112	-
China	120	8
Vietnam	126	-
Laos	141	-
Myanmar	150	-
Brunei Darussalam	(Monarchial)	-

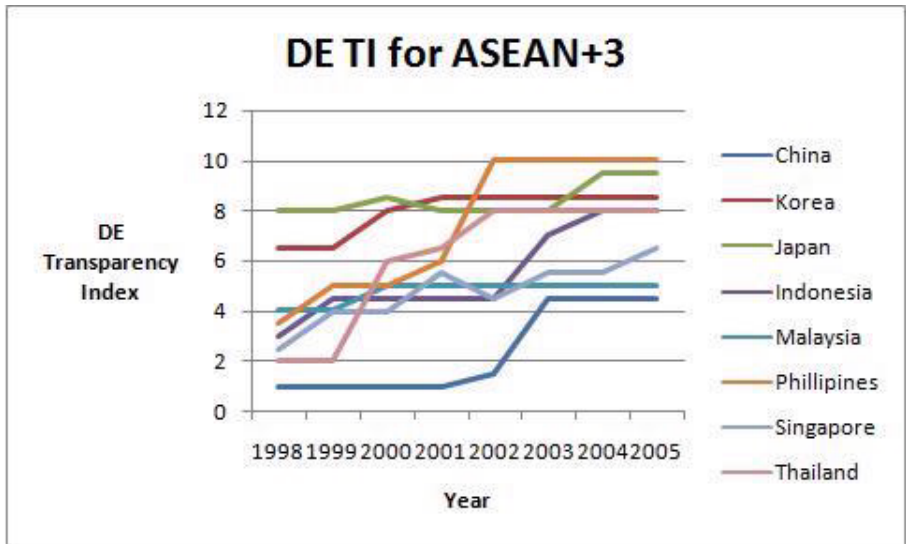


Figure 0-17: DE TI, 1998-2005, for eight ASEAN+3 countries

Social and Cultural Factors: Integration and Collectivist Countries

Social and cultural factors cannot be neglected in explaining the incentives of countries to seek to regional integration. The fact that most of East Asian countries can be considered as collectivist rather than individualistic countries can impede regional integration. This argument relies on historical, social, cultural, and theoretical analysis by Greif (2006). He argues that in collectivist countries, the social structure is segregated, while in individualistic countries, the social structure is integrated. In a segregated social structure, members of a group interact socially and economically only with members of their own group. In an individualistic social structure, members of a group interact socially and economically with members from different groups. Informal institutions are more likely to arise in a collectivist society while formal institutions are more likely to arise in an individualistic society. This difference affects agency relationship, and eventually, the likelihood of a social and economic integration because of the different cultural beliefs institutionalized in these types of societies. The cultural beliefs in a collectivist society mobilize collective punishments, in which an agent is re-hired if

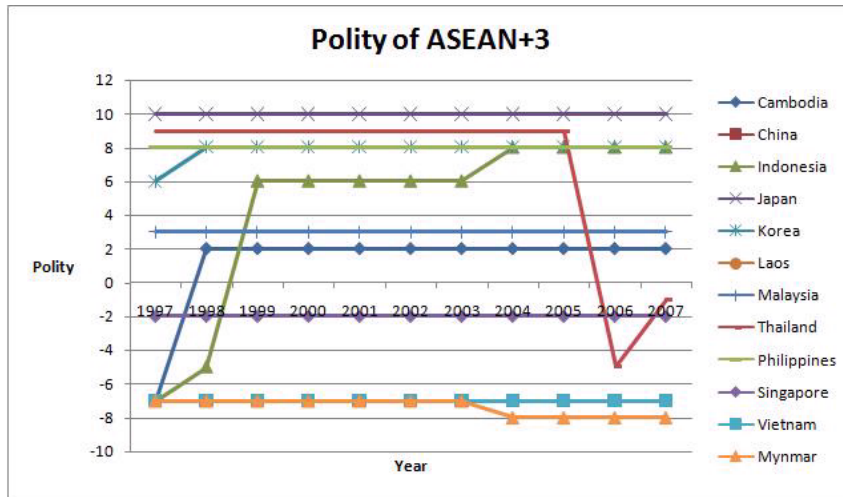


Figure 0-18: Polity of ASEAN+3 (exc.Brunei) (Source: Systemic Peace, Polity IV)

he does not cheat and is not hired by any other member in the society if he does cheat. Members of the group are more likely to be honest in an intra-agency relationship. Collective punishment may not extend to inter-agency relationships, and hence, in order to keep agents from other groups honest, wages must be higher. Hiring a member from the same group is therefore cheaper than hiring a member from a different group. As a result of this, the joint economy among collectivist societies is segregated. The cultural beliefs in an individualistic society do not mobilize collective punishments, while the joint economy among individualistic societies is integrated. In this case, hiring a member from the same group costs the same as hiring a member from a different group. Among collectivist societies, the joint economy is integrated only if collective punishments essentially extend to inter-agency relationships. Moreover, a collectivist society never initiates an inter-agency relationship with an individualistic society.

Different types of societies can therefore affect the likelihood of an integration. The Genoese and Maghribis are constrained by the same technology, environment,

and organizational problems, but the Maghribis' collectivist society leads to social and economic segregation while Genoese individualistic society leads to social and economic integration. With this evidence, we argue that it is easier for an individualistic society of the European countries to integrate than it is for a collectivist society of the East Asian countries. Furthermore, Greif argues that collectivist societies might be inefficient in the long-run because a collectivist system creates a gap between profitability and efficiency of an inter-agency relationship while an individualistic system does not. Formal institutions, which may spur growth, are also more likely to be established under an individualistic system than under a collectivist system. This is supported by the fact that most under-developed countries are collectivist while most developed countries are individualistic. However, this argument may not take into account the fact that the level of development of a country might change the type of society, as people tend to be more individualistic as they move from low-technology to high-technology societies. Video games, for example, could replace playgrounds where children play together. Hence, social institution is endogenous to the level of development. There are also cases in which a collectivist society is better than an individualistic society. This is, for example, the case in times of war. Moreover, individuals could behave differently under different circumstances. For example, some societies might be very collectivist with respect to family matters, but might be very individualistic with respect to work matters. The issue of identity is also important to consider. If individuals could consider themselves as citizens of the world rather than citizens of their home countries, global integration would be more likely to take place. Social and cultural heritages could therefore affect the tendencies to integrate.

International Pressures

Another barrier could be the oppositions from other international organizations, including the IMF, WTO, and the World Bank. The main reasons for their oppositions are the double standard that it may create and moral hazard, as countries may become more lenient towards their neighbors (Jeon, 2002).

0.5.4 Some Facts about Transparency and Development Level in ASEAN+3

There has been evidence that transparency and development level, defined by the GDP per capita, are endogenous. Geraats (2008) shows that transparency depends on the monetary regime. Moreover, transparency is positively correlated with the level of past inflation, the level of development and the GDP per capita in the same year but is negatively correlated with the level of subsequent inflation. Dincer and Eichengreen (2007) show that transparency is determined by the exchange rate regime and GDP per capita, but transparency index also affects inflation persistence, output variability, inflation variability, which might in turn affect the level of GDP per capita. Our study shows that economic fundamentals and the level of development could affect qualities of economic institutions. If transparency and the level of development are co-determined, it may mean that the emerging country region of East Asia will never be successful in establishing an institutionalized regional financial arrangement. East Asian emerging countries with low GDP per capita might not choose transparency, though it also depends on other economic and non-economic factors, such as polity. While a country is trapped under no regional economic cooperation, development could become worse, creating a vicious cycle between non-transparency and low level of development.

In order to test the relationship between transparency and the level of devel-

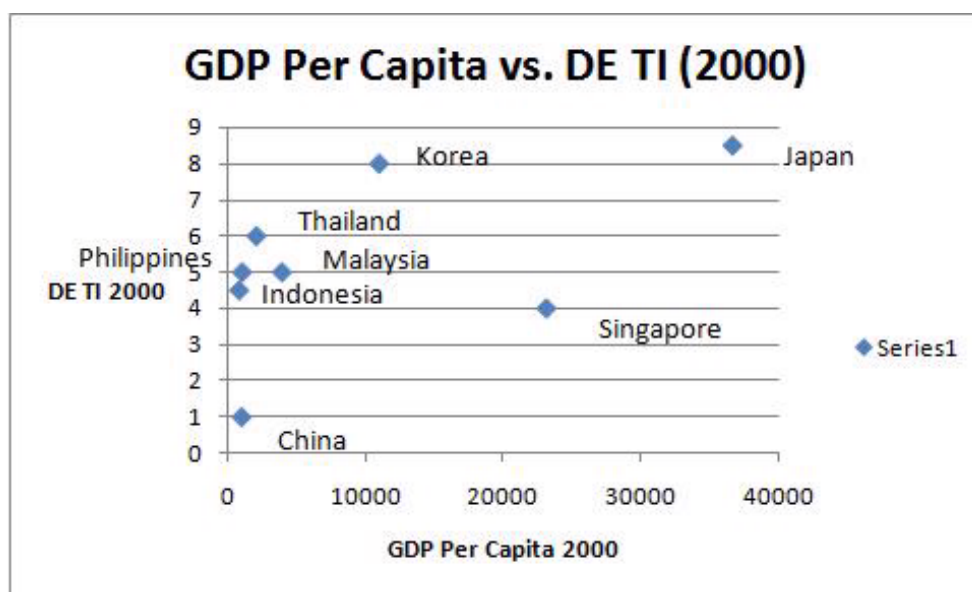


Figure 0-19: GDP Per Capita vs. DE TI (2000) for eight ASEAN+3 countries

opment, we take Dincer and Eichengreen’s Transparency Index that includes eight ASEAN+3 countries. To test for the endogeneity, we plot the relationship in both directions. We show a strong positive correlation between GDP per capita in 2000 and DE Transparency Index in 2000, although this correlation disappears as we forward the dependent variables, which means that GDP per capita in some specific year does not affect the level of transparency a few years later (see Figure 19). This suggests that the level of development does tend to increase transparency, which is consistent with our empirical study. We are also interested to know whether transparency has a positive impact on real GDP per capita growth in these countries. The data suggests that transparency is negatively correlated with GDP per capita growth from 2000 to 2006 (see Figure 20). This is counterfactual to what might have been predicted. One possible explanation is the convergence argument, that high-GDP-per-capita countries tend to grow less rapidly than low-GDP-per-capita countries. Hence, this observation might just signal that high levels of

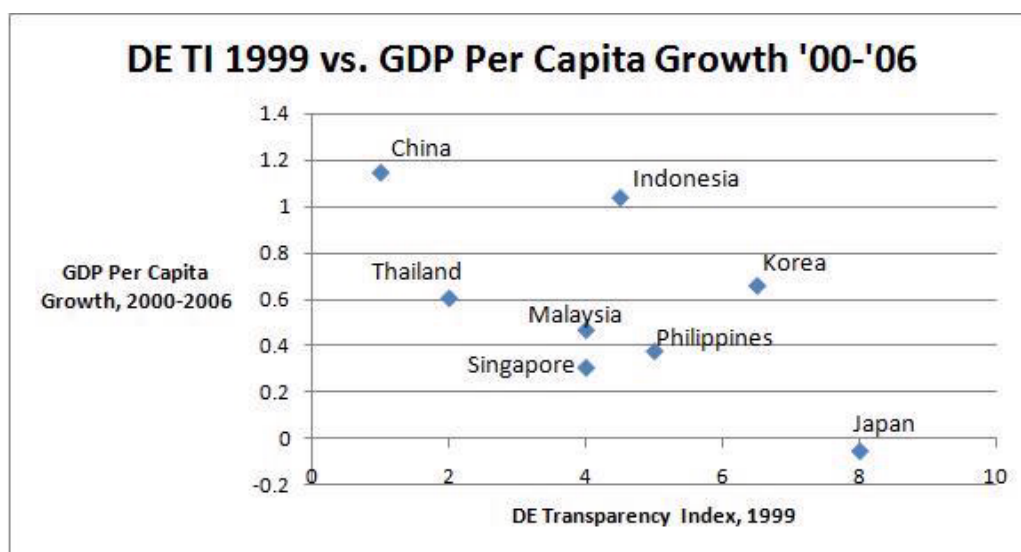


Figure 0-20: DE TI 1999 vs. GDP Per Capita Growth '00-'06 for eight ASEAN+3 countries

transparency are associated with more developed countries. Another explanation could be that the time lag is longer for transparency to bring positive impact. A more comprehensive study on this could explain the phenomenon.

0.6 Policy Issues

This paper has shown both theoretically and empirically that fundamentals could affect the level of transparency of partially informed agents including, the ASEAN+3 countries. Countries with higher levels of fundamentals are more closely associated with higher levels of transparency than countries with lower or intermediate levels of fundamentals. The evidence is, however, weak in the eight-RFA-country study, which includes China, Singapore, Malaysia, Japan, South Korea, Philippines, and Indonesia. We compare the DE transparency index of these countries and their economic fundamentals, and find many anomalies. China, Brunei Darussalam, Malaysia and Singapore, which have relatively high fundamentals have rel-

atively low levels of transparency with respect to their ASEAN+3 neighbors. Neither the exogenous nor the endogenous transparency model could explain this. A more convincing explanation is the level of democracy of these countries. China is considered to be one of the least democratic countries among its ASEAN+3 neighbors along with Myanmar. Malaysia and Singapore are semi-democratic. Korea and Japan, democratic countries, have high levels of transparency. Hence, economic fundamentals do not always explain variations in the quality of economic institutions. In the case of ASEAN+3, political biases, such as the level of democracy, seem to explain a lot of the variation in the level of transparency. The empirical study of this paper has also shown that regional bias, worldwide time bias and occurrence-of-crisis bias play significant roles in determining the qualities of economic institutions. The policy implication of this is that non-economic fundamentals could affect the quality of economic institutions. Politics, for example, influence economic outcomes because economic policy decisions are made not only by economists (if at all), but also by politicians. Regional integration requires not only compatible economic fundamentals, but political fundamentals. Social and cultural heritages could also play a role.

What we are called to do now is determine how to resolve the non-economic factors that impede regional financial integration while strengthening the economic factors, and recognize the need for greater integration in the midst of the 2007 global financial crisis and the recovery from the 1997-1998 Asian financial crisis. Immediate calls for action include changing how the Sino-Japan war is portrayed in textbooks in Japan, to hold dialogues to discuss issues on China's nuclear weapons, and to have open discussions regarding the U.S. military presence in Japan whenever it is appropriate. In December 2008, 32 Asian countries, including Australia, held the Bali Democracy Forum, at the initiative of Indonesia, which recently underwent a political reform towards democracy, to discuss issues on democracy

in Asia (Soesastro, 2008). As our eight-RFA-country study suggests, the level of democracy seems to be very much connected to the level of transparency of their central banks. Hence, open discussions on democracy are ways to increase openness and could encourage regional integration among Asian countries. Making different political systems of the ASEAN+3 countries more compatible with each other could also be important for regional integration. For example, how democratic countries of the ASEAN+3 could work with a military-regime country of Myanmar must be well-understood, otherwise dialogues with Myanmar might not work.

Another explanation for the slow progress towards institutionalizing the regional financial arrangement is asymmetric bargaining power, in particular the gigantic and disproportionately large power of China. China's population, geography, natural resources, international reserves and trade surplus have made it enormously powerful compared to its neighbors. Decision-making processes and the bargaining process must be resolved before we can expect China and other powerful countries, as well as less dominant countries to seek to institutionalize regional financial arrangement and other regional integration measures. One policy action to resolve asymmetric bargaining power is to decrease the payoff for China at the threat point by acting more antagonistically in the bargaining stage, thus making cooperation with China more beneficial for other less powerful ASEAN+2 countries. Higher levels of GDP per capita of the less powerful countries could have increased their payoffs at the threat point, thus increasing their payoffs from bargaining. However, none of these threats seem to be rational. The power of China is so omnipresent that none of the smaller countries will rationally commit to end their relationship with China. Increasing the levels of GDP per capita of the smaller countries cannot take place in an instant. In other words, changing the threat points is not a simple solution. Financial crisis, however, could decrease

the payoffs at the threat point of all of the ASEAN+3 countries, which could make a game feasible for a set of lower feasible payoffs. A more compelling solution is a coalitional analysis. Currently, ASEAN+3 is being expanded to ASEAN+6 to include Australia, New Zealand and India, which some speculate is an effort to reduce the power of China. Some economists argue that including India in the ASEAN+3 is salient. Consensus-based decision-making rather than population- or size-based voting rights could also help to avoid China's domination of the process. A more representative voice from the smaller countries, and not only Japan and China, should be considered in the case of a disagreement or no consensus.

On a more positive note, positive shocks such as the financial crisis should bring East Asian countries towards greater regional cooperation, ending the period of reservation among some of the East Asian countries. This is evident in the growing bilateral and multilateral swap agreements among ASEAN+3 countries even beyond the Chiang Mai's Initiatives. China and Indonesia made an agreement on three-year bilateral currency swap amounting to CNY100 billion - IDR175 trillion at the end of March, 2009, which allows Indonesia to import Yuan-denominated Chinese goods and avoid a bilateral trade transacted in U.S. dollar. Other countries that made a bilateral currency swap agreement with China include South Korea, Malaysia, Hongkong, Belarus and Argentina. The lack of international support for an institutionalized regional financial arrangement or even an Asian Monetary Fund because of the moral hazard and double standard arguments is not really well-founded. The issue of moral hazard is less likely to arise. In fact, because reputation effects are more salient in a smaller community, which could be referred to as the localization of information (Dixit, 2004) or diminishing anonymity (Greif, 2006), countries have more incentives to behave well. Also, trust-based or reputation- or relation-based institution with collective punishment system that is better sustained in a small community might be cheaper than formal,

rule-based institution without collective punishment system that is more likely to erect in a large community.

An institution is needed to resolve asymmetric informational issues by providing ways to write contracts between borrowing and lending countries, to initiate concerted efforts for better economic outcomes, and to provide checks and balances for more healthy economies. A regional institution could better resolve the issue of asymmetric information because countries are closer together. A regional institution could also be more prompt in helping countries in trouble. Some studies also suggest that a punishment system is more effective in a smaller group because of localization of information and diminishing anonymity.

One of the prominent issues of institutions is that often, an institution defined more broadly as a set of rules, organizations, beliefs, norms, and implied behaviors, has multiple equilibria (Greif, 2006) or is indeterminate. In the case of a weak financial and economic institution, one of the multiple outcomes is crisis. This highlights the importance of a good financial and economic institution, which can be achieved by establishing a strong regional financial arrangement. A regional institution is also needed to enable the East Asian region to come out strongly as a rising star in a new global financial system. Moreover, we can expect that greater financial integration among ASEAN+3 countries in the midst of the recovery from the Asian financial crisis and the 2007 global financial crisis, which would be likely improve the fundamentals of these countries, will lead to greater transparency. Greater transparency might arise not because of reputation effects, but because of improved fundamentals.

Because of the endogeneity of economic institutions, political institutions, social institutions, and other non-economic factors, the issue of establishing an institution such as an Asian regional financial arrangement must be approached from many angles. A lot of times, policies can not be generalized across countries or cases. It

might be, for example, that in response to external threats or troubled times, people behave more adversely towards one another, instead of behaving cooperatively. Hence, each case may be unique. The case of the 2007 global financial crisis that could be explained by the absence of proper regulation on data disclosure is a special case of the endogenous transparency model with reputation effects, in which pressures to be transparent may make investment banks and credit rating agencies disclose information, but at poor quality.

This study also highlights the importance of a two-way academic study: how economic incentives could help to break the entrenched reservation and introduce new ways to establish a political relationship among East Asian countries and how political factors influence economic decisions.

0.7 Conclusion

This paper seeks an explanation for the slow progress of institutionalizing the regional financial arrangement that started right after the Asian Financial Crisis in order to safeguard countries against another crisis. We start with a theoretical analysis on information and coordination. We have shown that for strategic complementary investments, given asymmetric common knowledge in which each country knows its own fundamental but not the others and the precision of public information is exogenous, high transparency about a country's fundamental can be detrimental to the level of investment of that country if the fundamental is intermediate and if there is a high probability that the low-level investment equilibrium is played in the case of multiple equilibria. Low precision of public information may therefore be preferable in order to avoid a multiplicity of equilibria, in which the low-level investment equilibrium is played. Hence, not only might countries with low fundamental be averse to transparency, but also countries with intermediate

fundamentals.

We also present a model as an extension to this paper, namely a model with endogenous precision of public information. The difficulty of endogenizing the precision of public information lays in the fact that agents often do not reveal the precision of public information, thus making it difficult to derive expectations of the fundamentals given private and public information. In a simple model of endogenous transparency, in which there are two possible levels, transparent and non-transparent, the only countries that adopt non-transparency are those countries with the lowest fundamentals or the *lemon cars*. The endogenous transparency model is hence more powerful than the exogenous transparency model because without any regulation on the adoption of transparency, countries will choose transparency because of the reputation effects and adverse selection biases.

We conduct an empirical study to test the theoretical hypothesis above that economic fundamentals could affect the level of transparency of central banks controlling for non-economic fundamentals. We show that higher inflation, higher ratio of broad money to foreign exchange reserves, and higher ratio of current account balance to nominal GDP could decrease the level of transparency of central banks. Structural fundamentals rather than macroeconomic fundamentals could explain more variation in transparency of central banks. Moreover, higher GDP per capita (or higher level of development), more flexible exchange rate arrangement and full democracy relative to full autocracy could increase the level of transparency. Countries located in Southern Africa, North America, Australia and New Zealand, and Northern Europe tend to have significantly higher levels of transparency than Eastern Africa to different degrees. Countries affected by the Asian, Mexican and Russian crises in the late 1990s and early 2000s have relatively higher levels of transparency, most probably because of international pressures. In general, all countries experience an upward trend in transparency over time. This empirical

study shows us that transparency of central banks and economic fundamental are co-determined, and thus, fundamentals and institutions are endogenous.

We apply our theoretical analysis to determine whether aversion to transparency because of low fundamentals could cause failures to integrate. What we find is that the level of democracy seems to explain more variations of transparency among ASEAN+3 countries than do the economic fundamentals. An interesting observation is that in the case of worldwide study, polity is not the main factor in explaining variations in the transparency of central banks, while in the ASEAN+3 study, it is. This shows that after controlling for regional-specific biases, the political factor becomes prevalent, at least in the case of ASEAN+3. Singapore, Malaysia, and China, who have relatively strong fundamentals, have low transparency, which can be explained by their semi-democratic or non-democratic governments. Hence, we argue that economic factors only play a small role in the non-cooperation among East Asian countries. Rather it is the non-economic factors, including political issues of democracy, security issues surrounding China's nuclear weapons, military issues, including US presence in Japan, and the reluctance of the Japanese government in educating its citizens about the Sino-Japan war that are more dominant in explaining the non-cooperation among East Asian countries. In fact, we argue that economic incentives should bring countries towards greater integration and offset non-economic disincentives towards integration.

APPENDICES

Appendix 1: Proof Lemma 1

Proof. $E(\theta_j|x_j^i, z_j) = \int_0^1 \theta_j f(\theta_j|x_j^i, z_j) d\theta_j = \int_0^1 \theta_j \frac{f(\theta_j, x_j^i, z_j)}{f(x_j^i, z_j)} d\theta_j.$

$$f(\theta_j, x_j^i, z_j) = f(x_j^i, z_j|\theta_j) f(\theta_j) = f(x_j^i|\theta_j) f(z_j|\theta_j) f(\theta_j) =$$

$$\frac{1}{\sigma_x \sqrt{2\pi}} \exp\left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2}\right) \frac{1}{\sqrt{2\pi \frac{1}{P_j}}} \exp\left(-\frac{(z_j - \theta_j)^2}{2 \frac{1}{P_j}}\right) (1)$$

$$f(x_j^i, z_j) =$$

$$\int_0^1 f(\theta_j, x_j^i, z_j) d\theta = \int_0^1 \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2}\right) \frac{1}{\sqrt{2\pi \frac{1}{P_j}}} \exp\left(-\frac{(z_j - \theta_j)^2}{2 \frac{1}{P_j}}\right) d\theta_j$$

$$= \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \int_0^1 \exp\left(-\frac{1}{2}\left(\frac{(x_j^i - \theta_j)^2}{\sigma_x^2} + P_j(z_j - \theta_j)^2\right)\right) d\theta_j$$

$$= \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \int_0^1 \exp\left(-\frac{1}{2}\left(\frac{1}{\sigma_x^2}(x_j^{i2} - 2x_j^i\theta + \theta_j^2) + P_j(z_j^2 - 2\theta_j z_j + \theta_j^2)\right)\right) d\theta_j$$

$$= \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \int_0^1 \exp\left(-\frac{1}{2}\left(\theta_j^2\left(\frac{1}{\sigma_x^2} + P_j\right) - 2\theta_j\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right) + \frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2\right)\right) d\theta_j$$

$$= \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \int_0^1 \exp\left(-\frac{1}{2}\left(\frac{1}{\sigma_x^2} + P_j\right)\left(\theta_j^2 - \frac{2\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)\theta_j}{\left(\frac{1}{\sigma_x^2} + P_j\right)} + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)\right) d\theta_j$$

$$= \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \int_0^1 \exp\left(-\frac{1}{2}\left(\frac{1}{\sigma_x^2} + P_j\right)\right)$$

$$\left(\left(\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2 - \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right) d\theta_j$$

$$= \left(\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)\right) \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \exp\left(-\frac{1}{2}\left(\frac{1}{\sigma_x^2} + P_j\right)\right)$$

$$\left(-\left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)$$

$$\int_0^1 \frac{1}{\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)} \exp\left(-\frac{1}{2}\left(\frac{\left(\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)\right) d\theta_j$$

$$f(\theta_j|x_j^i, z_j) =$$

$$\frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \exp\left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2}\right) \exp\left(-\frac{(z_j - \theta_j)^2}{2 \frac{1}{P_j}}\right)$$

$$\left(\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)\right) \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \exp\left(-\frac{1}{2}\left(\frac{1}{\sigma_x^2} + P_j\right)\right)$$

$$\left(-\left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right) \int_0^1 \frac{1}{\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)} \exp\left(-\frac{1}{2}\left(\frac{\left(\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)\right) d\theta_j$$

$$\begin{aligned}
& \int_0^1 \frac{1}{\sqrt{2\pi(\frac{1}{\sigma_x^2} + P_j)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{(\frac{x_j^i}{\sigma_x^2} + z_j P_j)}{(\frac{1}{\sigma_x^2} + P_j)}}{\frac{1}{(\frac{1}{\sigma_x^2} + P_j)}} \right) \right) d\theta_j = 1 \\
\mathbb{E}(\theta_j | x_j^i, z_j) &= \frac{\int_0^1 \theta_j \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \exp \cdot \left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2} \right) \exp \cdot \left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P_j}} \right)}{\left(\sqrt{2\pi(\frac{1}{\sigma_x^2} + P_j)} \right) \frac{1}{(2\pi)\sigma_x \sqrt{\frac{1}{P_j}}} \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j \right) \right)} d\theta_j \\
& \quad \left(-\frac{(\frac{x_j^i}{\sigma_x^2} + z_j P_j)}{(\frac{1}{\sigma_x^2} + P_j)} \right)^2 + \frac{x_j^{i2} + P_j z_j^2}{(\frac{1}{\sigma_x^2} + P_j)} \int_0^1 \frac{1}{\sqrt{2\pi(\frac{1}{\sigma_x^2} + P_j)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{(\frac{x_j^i}{\sigma_x^2} + z_j P_j)}{(\frac{1}{\sigma_x^2} + P_j)}}{\frac{1}{(\frac{1}{\sigma_x^2} + P_j)}} \right) \right) d\theta_j \\
&= \int_0^1 \theta_j \frac{1}{\sqrt{2\pi(\frac{1}{\sigma_x^2} + P_j)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{(\frac{x_j^i}{\sigma_x^2} + z_j P_j)}{(\frac{1}{\sigma_x^2} + P_j)}}{\frac{1}{(\frac{1}{\sigma_x^2} + P_j)}} \right) \right) d\theta_j \\
(\theta_j | x_j^i, z_j) &\sim N\left(\frac{(\frac{x_j^i}{\sigma_x^2} + z_j P_j)}{(\frac{1}{\sigma_x^2} + P_j)}, \frac{1}{(\frac{1}{\sigma_x^2} + P_j)}\right) \blacksquare
\end{aligned}$$

Appendix 2: Proof of Corollary 1

Proof. A uniform distribution in \mathfrak{R} is proxied by a normal distribution with mean 0 and precision σ_θ^2 as $\sigma_\theta^2 \rightarrow \infty$.

$$\begin{aligned}
\mathbb{E}(\theta_j | x_j^i, z_j) &= \int_{-\infty}^{\infty} \theta_j f(\theta_j | x_j^i, z_j) = \int_{-\infty}^{\infty} \theta_j \frac{f(\theta_j, x_j^i, z_j)}{f(x_j^i, z_j)} d\theta_j. \\
f(\theta_j, x_j^i, z_j) &= f(x_j^i, z_j | \theta_j) f(\theta_j) = f(x_j^i | \theta_j) f(z_j | \theta_j) f(\theta_j) = \\
& \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp \cdot \left(-\frac{\theta_j^2}{2\sigma_\theta^2} \right) \frac{1}{\sigma_x \sqrt{2\pi}} \exp \cdot \left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2} \right) \frac{1}{\frac{1}{P} \sqrt{2\pi}} \exp \cdot \left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P}} \right) \\
f(x_j^i, z_j) &= \int_{-\infty}^{\infty} f(\theta_j, x_j^i, z_j) d\theta_j = \\
& \int_{-\infty}^{\infty} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp \cdot \left(-\frac{\theta_j^2}{2\sigma_\theta^2} \right) \frac{1}{\sigma_x \sqrt{2\pi}} \exp \cdot \left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2} \right) \frac{1}{\sqrt{2\pi\frac{1}{P}}} \exp \cdot \left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P}} \right) d\theta_j \\
&= \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \int \exp \cdot \left(-\frac{1}{2} \left(\frac{(x_j^i - \theta_j)^2}{\sigma_x^2} + P_j (z_j - \theta_j)^2 + \frac{\theta_j^2}{\sigma_\theta^2} \right) \right) d\theta_j \\
&= \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \int \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} (x_j^{i2} - 2x_j^i \theta_j + \theta_j^2) + P(z_j^2 - 2\theta_j z_j + \theta_j^2) + \frac{\theta_j^2}{\sigma_\theta^2} \right) \right) d\theta_j \\
&= \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \int \exp \cdot \left(-\frac{1}{2} \left(\theta_j^2 \left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2} \right) - 2\theta_j \left(\frac{x_j^i}{\sigma_x^2} + z_j P_j \right) + \frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2 \right) \right) d\theta_j \\
&= \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \int \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2} \right) \left(\theta_j^2 - \frac{2(\frac{x_j^i}{\sigma_x^2} + z_j P_j)\theta_j}{(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2})} + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2})} \right) \right) d\theta_j \\
&= \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \int \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2} \right) \right)
\end{aligned}$$

$$\begin{aligned}
& \left(\left(\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 - \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right) d\theta_j \\
&= \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2} \right) \right. \\
& \quad \left. \left(- \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right) \right) \int \exp \cdot \left(-\frac{1}{2} \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 \right. \\
& \quad \left. \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \exp \cdot \left(\frac{-\theta_j^2}{2\sigma_\theta^2} \right) \exp \cdot \left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2} \right) \exp \cdot \left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P_j}} \right) \right. \\
& \quad \left. \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2} \right) \right) \left(- \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 + \right. \right. \\
& \quad \left. \left. \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right) \right) \int_{-\infty}^{\infty} \exp \cdot \left(-\frac{1}{2} \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 \right. \\
& \quad \left. \frac{\left(\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)}\right)^2}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right) d\theta_j = 1 \\
& \quad \int_{-\infty}^{\infty} \exp \cdot \left(-\frac{1}{2} \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 \right) d\theta_j = 1 \\
& \quad \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \exp \cdot \left(\frac{-\theta_j^2}{2\sigma_\theta^2} \right) \exp \cdot \left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2} \right) \exp \cdot \left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P_j}} \right) \\
& \quad \frac{P_j^{1/2}}{(2\pi)^{\frac{3}{2}} \sigma_x \sigma_\theta} \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2} \right) \right) \left(- \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right) \\
& \quad \left(\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 \\
& \quad \int_{-\infty}^{\infty} \theta_j \exp \cdot \left(-\frac{1}{2} \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right)^2 \right) d\theta_j \\
& \quad \left(\theta_j | x_j^i, z_j \right) \sim N \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)}, \frac{1}{\left(\frac{1}{\sigma_x^2} + P_j + \frac{1}{\sigma_\theta^2}\right)} \right) \\
& \quad \text{As } \sigma_\theta^2 \rightarrow \infty, \left(\theta_j | x_j^i, z_j \right) \sim N \left(\frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j\right)}{\left(\frac{1}{\sigma_x^2} + P_j\right)}, \frac{1}{\left(\frac{1}{\sigma_x^2} + P_j\right)} \right). \blacksquare
\end{aligned}$$

Appendix 3: Proof of Proposition 1

Proof. Denote:

$$F_1(x^*(z_i), \theta^*(z_i); z_i) =$$

$$\theta_i + \left(1 - \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp \cdot \left(\frac{-u^2}{2\sigma_x^2} \right) du \right) \left(1 + \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp \cdot \left(\frac{-u^2}{2\sigma_x^2} \right) du \right) - 1 = 0$$

$$F_2(x^*(z_i), \theta^*(z_i); z_i) =$$

$$\left(w_{x_i} x_i + w_{z_i} z_i \right) + \left(1 - \int_{-\infty}^{\theta(z_i^*)} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp \cdot \left(-\frac{(u - E(\theta_{-i} | x_i, z_i))^2}{2\sigma_\theta^2} \right) du \right) +$$

$$\left(\int_{-\infty}^{\theta(z_i^*)} \frac{1}{\sigma_\theta \sqrt{2\pi}} \exp\left(-\frac{(u-E(\theta_i|x_i, z_i))^2}{2\sigma_\theta^2}\right) du\right) \left(1 - \int_{-\infty}^{x^*(z_i)} \frac{1}{\sigma_{\bar{x}} \sqrt{2\pi}} \exp\left(-\frac{(u-E(x_i^{-i}|x_i, z_i))^2}{2\sigma_{\bar{x}}^2}\right) du\right) - 1 = 0$$

$$F(x(z_i), z_i) = [F_1(x(z_i), z_i), F_2(x(z_i), z_i)]'$$

Transform the distributions of θ_i and x_i^{-i} into standard normal distributions:

$$\left(\frac{\theta_i - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta} | x_i, z_i\right) \text{ is normally distributed with mean 0 and variance 1,}$$

$$\left(\frac{\theta_i + \varepsilon_i^{-i} - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_{\bar{x}}} | x_i, z_i\right) \text{ is normally distributed with mean 0 and variance 1.}$$

We can re-write $F_2(x^*(z_i), \theta^*(z_i); z_i)$ as:

$$F_2(x^*(z_i), \theta^*(z_i); z_i) = (w_{x_i} x_i + w_{z_i} z_i) + \left(1 - \int_{-\infty}^{\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right) + \left(\int_{-\infty}^{\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right) \left(1 - \int_{-\infty}^{\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right) - 1 = 0$$

$F_1(x^*(z_i), \theta^*(z_i); z_i)$ and $F_2(x^*(z_i), \theta^*(z_i); z_i)$ are continuously differentiable with respect to $x(z_i)$, $\theta(z_i)$, and z_i .

Using the Implicit Function Theorem, the determinant of the Jacobian of

$$F(x(z_i), \theta(z_i); z_i) \neq 0.$$

$$\begin{aligned} |D_{x, \theta} F(x(z_i), \theta(z_i); z_i)| = & \\ & \left[2 \frac{1}{\sigma_\theta} \frac{1}{\sigma_x} \Phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) \right] \\ & - \left[1 + 2 \frac{1}{\sigma_x} \Phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \right] \left[w_{x_i} \left(1 + \frac{1}{\sigma_\theta} \phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right)\right) \right. \\ & \left. \Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) - w_{z_i} \left(\frac{1}{\sigma_{\bar{x}}} \Phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) \phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right)\right) \right], \end{aligned}$$

$$\text{where } \sigma_\theta = \frac{1}{\frac{1}{\sigma_{\bar{x}}^2} + P}, \sigma_{\bar{x}} = \frac{1}{\frac{1}{\sigma_x^2} + P} + \sigma_x^2.$$

$$|D_{x, \theta} F(x(z_i), \theta(z_i); z_i)| \neq 0.$$

$$\begin{pmatrix} \frac{dx(z_i)}{dz_i} \\ \frac{d\theta(z_i)}{dz_i} \end{pmatrix} = \begin{pmatrix} -\frac{1}{|D_{x, \theta} F(x(z_i), \theta(z_i); z_i)|} \left((-1) \left(1 + 2 \frac{1}{\sigma_x} \Phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \right) \right. \\ \quad \left. \left(w_{z_i} \left(\frac{1}{\sigma_{\bar{x}}} \phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \Phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) + \right. \right. \right. \\ \quad \left. \left. \left. 1 + \frac{1}{\sigma_\theta} \phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) \Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \right) \right) \right) \\ -\frac{1}{|D_{x, \theta} F(x(z_i), \theta(z_i); z_i)|} \left\{ \left[-2 \frac{1}{\sigma_x} \Phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \right] \right. \\ \quad \left[\left(w_{z_i} \left(\frac{1}{\sigma_{\bar{x}}} \phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \Phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) + \right. \right. \right. \\ \quad \left. \left. \left. + \frac{1}{\sigma_\theta} \phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) \Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \right) \right] \right\} \end{pmatrix} \quad \blacksquare$$

Appendix 4: Proof of Proposition 2

Proof. Denote:

$$F_1(\mathbf{x}^*(z_i), \theta^*(z_i); z_i) = \theta_i + \sum_{j=1}^{K-1} \frac{(K-1)!}{(K-1-j)!j!} \left(1 - \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left(-\frac{u^2}{2\sigma_x^2}\right) du\right)^j$$

$$\left(1 + \int_{-\infty}^{x(z_i^*) - \theta_i} \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left(-\frac{u^2}{2\sigma_x^2}\right) du\right)^{K-1-j} - 1 = 0$$

$$F_2(\mathbf{x}^*(z_i), \theta^*(z_i); z_i) = (w_{x_i}^i x_i + w_{z_i} z_i) + \left(1 - \int_{-\infty}^{\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right)$$

$$\sum_{j=0}^{K-2} \frac{(K-2)!}{(K-2-j)!j!} \left(1 - \int_{-\infty}^{\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right)^j$$

$$\left(\int_{-\infty}^{\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right)^{K-2-j} + \left(\int_{-\infty}^{\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right)$$

$$\sum_{j=1}^{K-2} \frac{(K-2)!}{(K-2-j)!j!} \left(1 - \int_{-\infty}^{\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right)^j$$

$$\left(\int_{-\infty}^{\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du\right)^{K-2-j} - 1 = 0$$

$F_1(\mathbf{x}^*(z_i), \theta^*(z_i); z_i)$ and $F_2(\mathbf{x}^*(z_i), \theta^*(z_i); z_i)$ are continuously differentiable with respect to $\mathbf{x}(z_i)$, $\theta(z_i)$, and z_i .

Using the Implicit Function Theorem, the determinant of the Jacobian of

$$F(\mathbf{x}(z_i), \theta(z_i); z_i) \neq 0.$$

$$|D_{x, \theta} F(\mathbf{x}(z_i), \theta(z_i); z_i)| =$$

$$\left[(K-1) \frac{1}{\sigma_\theta} \frac{1}{\sigma_x} \Phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right)^{K-2} \Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right)^{K-2} \phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right) \right] -$$

$$\left[1 + (K-1) \frac{1}{\sigma_x} \Phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right)^{K-2} \phi\left(\frac{x^*(z_i) - \theta(z_i)}{\sigma_x}\right) \right] \left[w_{x_i} \left(1 + \frac{1}{\sigma_\theta} \phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right)\right) \right.$$

$$\Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right)^{K-2} - w_{z_i} (K-2) \left(\frac{1}{\sigma_{\bar{x}}} \Phi\left(\frac{\theta(z_i^*) - (w_{x_i} x_i + w_{z_i} z_i)}{\sigma_\theta}\right)\right)$$

$$\left. \Phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \phi\left(\frac{(x^*(z_i) - z_i) w_{z_i}}{\sigma_{\bar{x}}}\right) \right],$$

$$\text{where } \sigma_\theta = \frac{1}{\frac{1}{\sigma_\theta^2} + P}, \sigma_{\bar{x}} = \frac{1}{\frac{1}{\sigma_x^2} + P} + \sigma_x^2.$$

$$|D_{x, \theta} F(\mathbf{x}(z_i), \theta(z_i); z_i)| \neq 0.$$

$$\begin{pmatrix} \frac{dx(z_i)}{dz_i} \\ \frac{d\theta(z_i)}{dz_i} \end{pmatrix} =$$

$$\left(
\begin{aligned}
& -\frac{1}{|D_{x,\theta}F(x(z_i),\theta(z_i);z_i)|}(-)(1+(K-1)\frac{1}{\sigma_x}\Phi(\frac{x^*(z_i)-\theta(z_i)}{\sigma_x})^{K-2}\phi(\frac{x^*(z_i)-\theta(z_i)}{\sigma_x})) \\
& \quad (w_{z_i}((K-2)\frac{1}{\sigma_{\bar{x}}}\phi(\frac{(x^*(z_i)-z_i)w_{z_i}}{\sigma_{\bar{x}}})) \\
& \quad \Phi(\frac{\theta(z_i^*)-(w_{x_i}x_i+w_{z_i}z_i)}{\sigma_\theta})\Phi(\frac{(x^*(z_i)-z_i)w_{z_i}}{\sigma_{\bar{x}}})^{K-3}+ \\
& \quad 1+\frac{1}{\sigma_\theta}\phi(\frac{\theta(z_i^*)-(w_{x_i}x_i+w_{z_i}z_i)}{\sigma_\theta})\Phi(\frac{(x^*(z_i)-z_i)w_{z_i}}{\sigma_{\bar{x}}})^{K-2})) \\
& -\frac{1}{|D_{x,\theta}F(x(z_i),\theta(z_i);z_i)|}\{[-(K-1)\frac{1}{\sigma_x}\Phi(\frac{x^*(z_i)-\theta(z_i)}{\sigma_x})^{K-2}\phi(\frac{x^*(z_i)-\theta(z_i)}{\sigma_x})] \\
& \quad [w_{z_i}((K-2)\frac{1}{\sigma_{\bar{x}}}\phi(\frac{(x^*(z_i)-z_i)w_{z_i}}{\sigma_{\bar{x}}})) \\
& \quad \Phi(\frac{\theta(z_i^*)-(w_{x_i}x_i+w_{z_i}z_i)}{\sigma_\theta})\Phi(\frac{(x^*(z_i)-z_i)w_{z_i}}{\sigma_{\bar{x}}})^{K-3}+ \\
& \quad 1+\frac{1}{\sigma_\theta}\phi(\frac{\theta(z_i^*)-(w_{x_i}x_i+w_{z_i}z_i)}{\sigma_\theta})\Phi(\frac{(x^*(z_i)-z_i)w_{z_i}}{\sigma_{\bar{x}}})^{K-2})]\}
\end{aligned}
\right) \blacksquare$$

Appendix 5: Strategic Complements. Numerical Example.

We use *Excel* as first approximations that give us critical values at three-decimal working precision. Then, we use *Mathematica* to compute these critical values using the results we have from the first approximations to at least six-decimal working precision. The function used in *Mathematica* is "FindRoot" to solve simultaneous non-linear equations: $F(x(z_i), \theta(z_i); z_i) = 0$. (Proofs are omitted).

Example of *Mathematica* Programming: $z=-1, P=.0001, \frac{1}{\sigma_x}=1$

F1 = theta - (CDF[NormalDistribution[], (xstar - theta)/((1/1)^(1/2))])^(2)

F2 = ((1/(.0001 + 1))*xstar + (.0001/(.0001 + 1))*-1) +

(1 - CDF[NormalDistribution[], (theta - ((1/(.0001 + 1))*

xstar + (.0001/(.0001 + 1))*-1))/((1/(.0001 + 1))^(1/2))] +

(CDF[NormalDistribution[], (theta - ((1/(.0001 + 1))*

xstar + (.0001/(.0001 + 1))*-1))/((1/(.0001 + 1))^(1/2))]*)

(1 - CDF[NormalDistribution[], ((xstar + 1)*

(.0001/(.0001 + 1)))/(((1/(.0001 + 1)) + (1/1)^(1/2))] - 1

FindRoot[{F1 == 0, F2 == 0}, {{theta, .25}, {xstar, .25}}]

{theta -> 0.250042, xstar -> 0.250147}

Appendix 6: Consistency of Numerical Examples with Proposition 1

For $K=3$, we evaluate the derivatives of the critical values with respect to the public signal, $(\frac{d}{dz_i}\theta^*(z_i), \frac{d}{dz_i}x^*(z_i))$, using the formulae we derive in Proposition 1 to prove the local existence of $x^*(z_i)$ and $\theta^*(z_i)$ at the simulated critical values x^* and θ^* . We show that these derivatives are negative and at these simulated critical values, these derivatives are consistent with the graphs we plot on the simulated critical values against public signals. (Proofs are omitted).

Appendix 7: Proof of Lemma 3

Proof. Note: $x \sim N(\mu, \sigma^2)$, $\frac{f(x, x=[a,b])}{f(x=[a,b])} = \begin{cases} \frac{\frac{1}{\sigma} \phi(\frac{x-\mu}{\sigma})}{\Phi(\frac{b-\mu}{\sigma}) - \Phi(\frac{a-\mu}{\sigma})}, & \text{for } x=[a,b]. \\ 0, & \text{everywhere else.} \end{cases}$

We can write the conditional distribution $\frac{f(\theta_j, x_j^i, z_j, \theta_j=[a,b])}{f(x_j^i, z_j, \theta_j=[a,b])}$ as $\frac{f(\theta_j, \theta=[a,b]|x_j^i, z_j)f(x_j^i, z_j)}{f(x_j^i, z_j, \theta_j=[a,b])}$.

From Lemma 1:

$$\frac{f(\theta_j, \theta_j=[a,b]|x_j^i, z_j)f(x_j^i, z_j)}{f(x_j^i, z_j, \theta_j=[a,b])} = \left[\frac{\frac{1}{\sqrt{2\pi \frac{1}{\sigma_x^2 + P_j}}} \exp\left(-\frac{1}{2} \left(\frac{\theta_j - \frac{x_j^i}{\sigma_x} + P_j z_j}{\frac{1}{\sigma_x^2 + P_j}}\right)^2\right)}{\int_a^b \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2}\right) \frac{1}{\sqrt{2\pi(\frac{1}{P_j})}} \exp\left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P_j}}\right) d\theta_j} \int_a^b \frac{1}{\sigma_x \sqrt{2\pi}} \exp\left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2}\right) \frac{1}{\sqrt{2\pi(\frac{1}{P_j})}} \exp\left(-\frac{(z_j - \theta_j)^2}{2\frac{1}{P_j}}\right) d\theta_j} \right] =$$

$$\begin{aligned}
& \frac{1}{\sqrt{2\pi \frac{1}{\sigma_x^2 + P_j}}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) \\
& \int_0^1 \frac{1}{\sigma_x \sqrt{2\pi}} \exp \cdot \left(-\frac{(x_j^i - \theta_j)^2}{2\sigma_x^2} \right) \frac{1}{\sqrt{2\pi \left(\frac{1}{P_j} \right)}} \exp \cdot \left(-\frac{(z_j - \theta_j)^2}{2 \frac{1}{P_j}} \right) d\theta_j \\
& \frac{(\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)) \frac{1}{(2\pi) \sigma_x \sqrt{\frac{1}{P_j}}} \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j \right) \left(-\left(\frac{\frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)}{\int_a^b \frac{1}{\sqrt{2\pi \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{\frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j \right)}}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) d\theta_j} \\
& \frac{1}{\sqrt{2\pi \frac{1}{\sigma_x^2 + P_j}}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{\frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) \left(\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right) \right) \frac{1}{(2\pi) \sigma_x \sqrt{\frac{1}{P_j}}} \\
& \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j \right) \left(-\left(\frac{\frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right) \right) \\
& \int_0^1 \frac{1}{\sqrt{2\pi \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j \right)}{\left(\frac{1}{\sigma_x^2} + P_j \right)}}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) d\theta_j \\
& \frac{(\sqrt{2\pi} \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)) \frac{1}{(2\pi) \sigma_x \sqrt{\frac{1}{P_j}}} \exp \cdot \left(-\frac{1}{2} \left(\frac{1}{\sigma_x^2} + P_j \right) \left(-\left(\frac{\frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)^2 + \frac{\frac{x_j^{i2}}{\sigma_x^2} + P_j z_j^2}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)}{\int_a^b \frac{1}{\sqrt{2\pi \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{\left(\frac{x_j^i}{\sigma_x^2} + z_j P_j \right)}{\left(\frac{1}{\sigma_x^2} + P_j \right)}}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) d\theta_j} \\
& \frac{1}{\sqrt{2\pi \frac{1}{\sigma_x^2 + P_j}}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{\frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) \\
& \int_a^b \frac{1}{\sqrt{2\pi \left(\frac{1}{\left(\frac{1}{\sigma_x^2} + P_j \right)} \right)}} \exp \cdot \left(-\frac{1}{2} \left(\frac{\theta_j - \frac{\frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j \right)}}{\frac{1}{\sigma_x^2 + P_j}} \right)^2 \right) d\theta_j
\end{aligned}$$

This random variable $(\theta_j | x_j^i, z_j, \theta_j = [a, b])$ has a doubly truncated normal distribution with the probability density function taking the form of:

$$\frac{\frac{1}{\sqrt{2\pi\sigma_x^2}} \exp\left(-\frac{1}{2}\left(\frac{\theta_j - \mu}{\sigma_x^2}\right)^2\right)}{\int_a^b \frac{1}{\sqrt{2\pi\sigma_x^2}} \exp\left(-\frac{1}{2}\left(\frac{\theta_j - \mu}{\sigma_x^2}\right)^2\right) d\theta_j} \text{ and } a \leq x \leq b \text{ (Johnson, Kotz, and Balakrishan, 1994),}$$

and with the expected conditional value of:

$$\begin{aligned} \mathbb{E}(\theta_j | x_j^i, z_j, \theta_j = [a, b]) &= \int_a^b \theta_j \frac{f(\theta_j, \theta_j = [a, b] | x_j^i, z_j) f(x_j^i, z_j)}{f(x_j^i, z_j, \theta_j = [a, b])} d\theta_j \\ &= \int_a^b \theta_j \frac{\frac{1}{\sqrt{2\pi \frac{1}{\frac{1}{\sigma_x^2} + P_j}}} \exp\left(-\frac{1}{2}\left(\frac{\theta_j - \frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2} + P_j}\right)^2\right)}{\int_a^b \frac{1}{\sqrt{2\pi \left(\frac{1}{\sigma_x^2} + P_j\right)}} \exp\left(-\frac{1}{2}\left(\frac{\theta_j - \frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2\right) d\theta_j} d\theta_j \end{aligned}$$

Rewriting the conditional probability density function:

$$\begin{aligned} f(\theta_j | x_j^i, z_j, \theta_j = [a, b]) &= \frac{\frac{1}{\sqrt{2\pi \frac{1}{\frac{1}{\sigma_x^2} + P_j}}} \exp\left(-\frac{1}{2}\left(\frac{\theta_j - \frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2} + P_j}\right)^2\right)}{\int_a^b \frac{1}{\sqrt{2\pi \left(\frac{1}{\sigma_x^2} + P_j\right)}} \exp\left(-\frac{1}{2}\left(\frac{\theta_j - \frac{x_j^i}{\sigma_x^2} + z_j P_j}{\left(\frac{1}{\sigma_x^2} + P_j\right)}\right)^2\right) d\theta_j} \\ &= \frac{\frac{1}{\sqrt{\frac{1}{\sigma_x^2} + P_j}} \phi\left(\frac{\theta_j - \frac{x_j^i}{\sigma_x^2} + P_j z_j}{\sqrt{\frac{1}{\sigma_x^2} + P_j}}\right)}{\Phi\left(\frac{b - \frac{x_j^i}{\sigma_x^2} + z_j P_j}{\sqrt{\frac{1}{\sigma_x^2} + P_j}}\right) - \Phi\left(\frac{a - \frac{x_j^i}{\sigma_x^2} + z_j P_j}{\sqrt{\frac{1}{\sigma_x^2} + P_j}}\right)}. \end{aligned}$$

This conditional probability density function is the probability function of a truncated normal distribution of

$$\theta_j | x_j^i, z_j \sim N\left(\mu, \sigma^2\right), \text{ where } \mu \text{ be } \frac{\frac{x_j^i}{\sigma_x^2} + P_j z_j}{\frac{1}{\sigma_x^2} + P_j} \text{ and } \sigma^2 = \frac{1}{\left(\frac{1}{\sigma_x^2} + P_j\right)}.$$

The expectation and variance of a random variable with a truncated normal distribution is given by:

$$\begin{aligned} \mathbb{E}(\theta_j | x_j^i, z_j, \theta_j = [a, b]) &= \mu + \frac{\phi\left(\frac{a-\mu}{\sigma}\right) - \phi\left(\frac{b-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right) - \Phi\left(\frac{a-\mu}{\sigma}\right)} \sigma \\ \text{Var}(\theta_j | x_j^i, z_j, \theta_j = [a, b]) &= \sigma^2 \left[1 + \frac{\left(\frac{a-\mu}{\sigma}\right)\phi\left(\frac{a-\mu}{\sigma}\right) - \left(\frac{b-\mu}{\sigma}\right)\phi\left(\frac{b-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right) - \Phi\left(\frac{a-\mu}{\sigma}\right)} - \left(\frac{\phi\left(\frac{a-\mu}{\sigma}\right) - \phi\left(\frac{b-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right) - \Phi\left(\frac{a-\mu}{\sigma}\right)}\right)^2 \right]. \quad \blacksquare \end{aligned}$$

Appendix 8: Eijffinger-Geraats Transparency Questionnaire (Eijffinger-Geraats, 2006)

(1) Political Transparency: refers to openness about policy objectives. This comprises a statement of the formal objectives of monetary policy, including an explicit prioritization in case of potentially conflicting goals, and quantitative targets. Political transparency is enhanced by institutional arrangements, like central bank independence and central bank contracts, because they ensure that there is no undue influence or political pressure to deviate from states objectives.

(a) Is there a formal statement of the objective(s) of monetary policy, with an explicit prioritization in case of multiple objectives?

No formal objective(s)=0.

Multiple objectives without prioritization=1/2.

One primary objective, or multiple objectives with explicit priority=1.

(b) Is there a quantification of the primary objective(s)?

No=0.

Yes=1.

(c) Are there explicit institutional arrangements or contracts between the monetary authorities and the government?

No central bank, contract or other institutional arrangements=0.

Central bank without explicit instrument independence or contract=1/2.

Central bank with explicit instrument independence of central bank contract (although possibly subject to an explicit override procedure)=1.

(2) Economic transparency: focuses on the economic information that is used for monetary policy. This includes the economic data the central bank uses, the policy models it employs to construct economic forecasts or evaluate the impact of its decisions, and the internal forecasts the central bank relies on. The latter are particularly important since monetary policy actions are known to take effect only

after substantial lags. So, the central bank's action are likely to reflect anticipated developments.

(a) Is the basic economic data relevant for the conduct of monetary policy publicly available? The focus is on the release of data for the following five variables: money supply, inflation, GDP, unemployment rate and capacity utilization.

Quarterly time series for at most two out of the five variables=0.

Quarterly time series for three or four out of the five variables=1/2.

Quarterly time series for all five variables=1.

(b) Does the central bank disclose the formal macroeconomic model(s) it uses for policy analysis?

No=0.

Yes=1.

(c) Does the central bank regularly publish its own macroeconomic forecast?

No numerical central bank forecasts for inflation and output=0.

Numerical central bank forecasts for inflation and/or output published at less than quarterly frequency=1/2.

Quarterly numerical central bank forecasts for inflation and output for the medium term (one to two years ahead),specifying the assumption about the policy instrument (condition or unconditional forecasts)=1.

(3) Procedural transparency: is about the way monetary policy decisions are taken. It involves an explicit monetary policy rule or strategy that describes the monetary policy framework, and an account of the actual policy deliberations and how the policy decision was reached, which is achieved by the release of minutes and voting records.

(a) Does the central bank provide an explicit policy rule or strategy that describes its monetary policy framework?

No=0.

Yes=1.

(b) Does the central bank give a comprehensive account of policy deliberation (or explanation in case of a single central banker) within a reasonable amount of time?

No, or only after a substantial lag (more than 3 weeks)=0.

Yes, comprehensive minutes (although not necessarily verbatim or attributed) or explanation (in case of a single central banker), including a discussion of backward and forward-looking argument=1.

(c) Does central bank disclose how each decision on the level of its main operating instrument or target was reached?

No voting record, or only after substantial lag (more than eight weeks)=0.

Non-attributed voting records=1/2.

Individual voting records, or decision by single central banker=1.

(4) Policy transparency: means a prompt announcement of policy decisions. In addition, it includes an explanation of the decision and a policy inclination or indication of likely future policy actions. The latter is relevant because monetary policy actions are typically made in discrete steps; a central bank may be inclined to change the policy instrument, but decide to wait until further evidence warrants moving a full step.

(a) Are decisions about adjustments to the main operating instrument or target promptly announced?

No, or after a significant lag=0.

Yes, at the latest on the day of implementation=1.

(b) Does the central bank provide an explanation when it announces policy decision?

No=0.

Yes, when policy decisions change, or only superficially=1/2.

Yes, always and including forward-looking assessment=1.

(c) Does the central bank disclose an explicit policy inclination after every policy meeting or an explicit indication of likely future policy actions (at least quarterly)?

No=0.

Yes=1.

(5) Operational Transparency: concerns the implementation of the central bank's policy actions. It involves a discussion of control errors in achieving the operating instrument or target set in the policy decision, and (unanticipated) macroeconomic disturbances that affect the transmission of monetary policy from instrument to outcome.

(a) Does the central bank regularly evaluate to what extent its policy operating targets (if any) have been achieved?

No, or not very often (at less than annual frequency)=0.

Yes, but without providing explanation for significant deviations=1/2.

Yes, accounting for significant deviations from target (if any); or (nearly) perfect control over main operating instrument/target=1.

(b) Does the central bank regularly provide information on (unanticipated) macroeconomic disturbances that affect the policy transmission process?

No, not very often=0.

Yes, but only through short-term forecasts or analysis of current macroeconomic development (at least quarterly)=1/2.

Yes, including a discussion of past forecast error (at least annually)=1.

(c) Does the central bank regularly provide an evaluation of the policy outcome in light of its macroeconomic objective?

No, or not very often (at less than annual frequency)=0.

Yes, but superficially=1/2.

Yes, with an explicit account of the contribution of monetary policy in meeting the objectives=1.

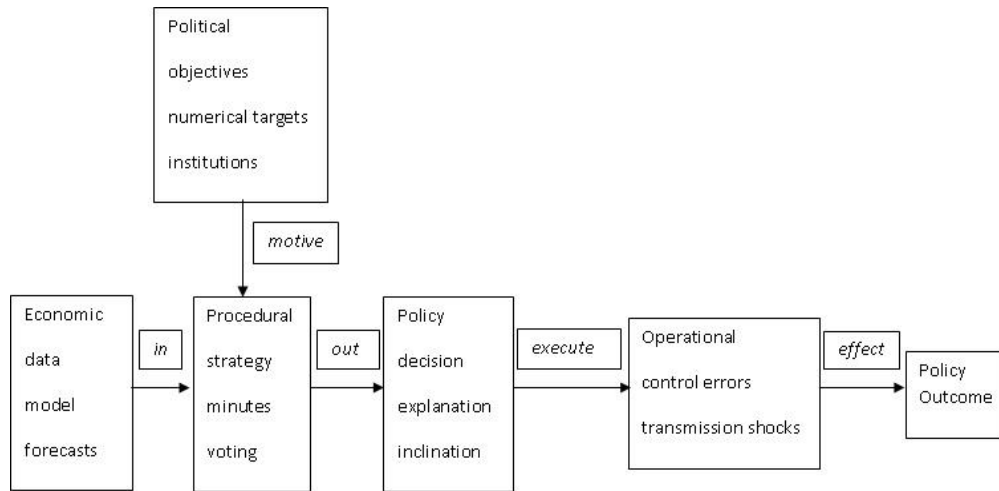


Figure 0-21: Eijffinger-Geraats Transparency Index Framework (Eijffinger, Geraats, 2006)

Appendix 9:

Regression 1: (original)

$$\begin{aligned} DETI_{i,t} = & \alpha + \beta_1 GDPPERCAP_{i,t-1} + \beta_2 (GDPPERCAP_{i,t-1})^2 + \\ & \beta_5 EXREGIME_{i,t-1} + \beta_6 INFLATION_{i,t-1} \\ & \beta_3 UNEMPLOYMENT_{i,t-1} + \beta_4 (UNEMPLOYMENT_{i,t-1})^2 + \\ & \beta_7 RESERVE_{i,t-1} + \beta_8 (RESERVE_{i,t-1})^2 \\ & \beta_9 RER_{i,t-1} + \beta_{10} (RER_{i,t-1})^2 \\ & \beta_{11} DCAGDP_{i,t-1} + \beta_{12} (DCAGDP_{i,t-1})^2 \\ & + I(POLITY_{i,t-1}) + I(REGION_i) + I(CRISIS) + I(YEAR_t) \end{aligned}$$

where:

GDPPERCAP=GDP Per Capita

UNEMPLOYMENT=unemployment rate

EXREGIME=exchange rate arrangement

INFLATION=inflation

RESERVE=the ratio of broad money to foreign exchange reserves

RER=Real Exchange Rate appreciation (-)/ depreciation (+)

DCAGDP= the ratio of current account balance to nominal GDP

I(POLITY)=indicator variable on polity (-10=most autocratic, +10=most democratic)

I(REGION)=indicator variable on region (1-19)

I(CRISIS)=1 if country is in crisis in the last 8 years (1998-2005), =0 otherwise

I(YEAR)=indicator variable on year (1998-2005)

Command in STATA

xi: xtmixed deti laggedgdppercapita laggedgdppercapitasq laggedexchanger-
atearrangement laggedinflation laggedunemployment laggedunemploymentsq lagge-
dreserves laggedreservessq laggeddcagdp laggeddcagdpsq laggedrealexchangerate
laggedrealexchangeratesq i.laggeddemocracy i.region i.crisis i.year ||countryid:

Output

Mixed-effects REML regression Number of obs = 584

Group variable: countryid Number of groups = 75

Obs per group: min = 4

avg = 7.8 max = 8

Table 11: Regression 1

DETI _t	Coeff.	z	P> z
GDPPERCAPITA _{t-1}	.0000951	2.13	.033
GDPPERCAPITASQUARED _{t-1}	-1.21e-09	-1.92	.055
EXREGIME _{t-1}	.1472609	3.31	.001
INFLATION _{t-1}	-1.770036	-3.81	.000
UNEMPLOYMENT _{t-1}	-7.828995	-1.96	.050
UNEMPLOYMENTSQ _{t-1}	31.99875	2.82	.005
RESERVES	-.1904879	-3.27	.001
RESERVESSQUARED	-.0074515	3.43	.001
DCAGDP	-1.618754	-2.04	.041
DCAGDPSQUARED	-2.547012	-.87	.384
RER	-.9492929	-2.67	.008
RERSQUARED	.5864727	1.72	.085

Table 12: Regression 1, cont.

I(POLITY2)	1.81039	1.24	.213
I(POLITY3)	.6309463	.42	.673
I(POLITY4)	.5742103	.42	.672
I(POLITY5)	1.135863	.82	.412
I(POLITY6)	1.598662	1.14	.254
I(POLITY7)	2.049721	1.37	.17
I(POLITY8)	2.157456	1.35	.176
I(POLITY9)	-.8091402	-.54	.587
I(POLITY11)	-.4876156	-.33	.742
I(POLITY12)	.4857216	.34	.738
I(POLITY13)	.3988954	.16	.876
I(POLITY14)	3.008728	2.01	.044
I(POLITY15)	.90332224	.67	.503
I(POLITY16)	1.17243	.87	.382
I(POLITY17)	1.43272	1.07	.285
I(POLITY18)	1.291813	.96	.336
I(POLITY19)	1.069359	.79	.428
I(POLITY20)	1.86272	1.37	.172

Table 13: Regression 1, cont.

I(REGION2)	-.0291694	-.02	.985
I(REGION3)	1.173495	.69	.489
I(REGION4)	2.729856	1.17	.241
I(REGION5)	2.044812	1.1	.272
I(REGION6)	.1462903	.09	.931
I(REGION7)	1.582003	1.04	.297
I(REGION8)	6.991754	2.91	.004
I(REGION9)	9.479348	4.04	.000
I(REGION10)	.9970283	.54	.588
I(REGION11)	.8201153	.44	.663
I(REGION12)	2.481032	1.57	.116
I(REGION13)	.6670308	.44	.658
I(REGION14)	2.251013	1.29	.196
I(REGION15)	1.110306	.76	.445
I(REGION16)	1.50119	1.04	.297
I(REGION17)	4.024274	2.69	.007
I(REGION18)	1.660637	.99	.322
I(REGION19)	4.242221	1.77	.077

Table 14: Regression 1, cont.

I(CRISIS)	1.84758	2.67	.008
I(YEAR1999)	.1863427	1.13	.191
I(YEAR2000)	.5014312	3.49	.000
I(YEAR2001)	.8610037	5.7	.000
I(YEAR2002)	1.245093	8.03	.000
I(YEAR2003)	1.355135	8.18	.000
I(YEAR2004)	1.608896	9.25	.000
I(YEAR2005)	1.777133	9.85	.000
CONSTANT	-.4946193	-.27	.786

Note: the coefficients on unemployment become insignificant when we run the regression with orthogonalized independent variables.

Appendix 10:

Regression 2: (without unemployment)

$$\begin{aligned} DETI_{i,t} = & \alpha + \beta_1 GDPPERCAP_{i,t-1} + \beta_2 (GDPPERCAP_{i,t-1})^2 + \\ & \beta_3 EXREGIME_{i,t-1} + \beta_4 INFLATION_{i,t-1} + \\ & \beta_5 RESERVE_{i,t-1} + \beta_6 (RESERVE_{i,t-1})^2 \\ & \beta_7 RER_{i,t-1} + \beta_8 (RER_{i,t-1})^2 \\ & \beta_9 DCAGDP_{i,t-1} + \\ & + I(POLITY_{i,t-1}) + I(REGION_i) + I(CRISIS) + I(YEAR_t) \end{aligned}$$

where:

GDPPERCAP=GDP Per Capita

EXREGIME=exchange rate arrangement

INFLATION=inflation

RESERVE=the ratio of broad money to foreign exchange reserves

RER=Real Exchange Rate appreciation (-)/ depreciation (+)

DCAGDP= the ratio of current account balance to nominal GDP

I(POLITY)=indicator variable on polity (-10=most autocratic, +10=most democratic)

I(REGION)=indicator variable on region (1-19)

I(CRISIS)=1 if country is in crisis in the last 8 years (1998-2005), =0 otherwise

I(YEAR)=indicator variable on year (1998-2005)

Command in STATA

xi: xtmixed deti laggedgdppercapita laggedgdppercapitasq laggedexchanger-
atearrangement laggedinflation laggedreserves laggedreservessq laggeddcagdp i.democracy

i.region i.crisis i.year ||countryid:

Output

Mixed-effects REML regression Number of obs = 649

Group variable: countryid Number of groups = 84

Obs per group: min = 3

avg = 7.7 max = 8

Table 15: Regression 2

DETI _t	Coeff.	z	P> z
GDPPERCAPITA	.0000927	2.28	.022
GDPPERCAPITASQUARED _{t-1}	-1.13e-09	-1.89	.058
EXREGIME _{t-1}	.135508	3.18	.001
INFLATION _{t-1}	-1.109903	-2.8	.005
RESERVES _{t-1}	-.1280636	-2.62	.009
RESERVESSQ _{t-1}	.0057443	2.95	.003
RER _{t-1}	-.5990215	-2.25	.025
RERSQ _{t-1}	.2293227	1.81	.071
DCAGDP	-1.412857	-2.03	.043

Table 16: Regression 2, cont.

I(POLITY2)	1.746504	1.32	.188
I(POLITY3)	.6491689	.47	.636
I(POLITY4)	.6046694	.5	.620
I(POLITY5)	.7552114	.62	.536
I(POLITY6)	1.649546	1.31	.189
I(POLITY7)	.5422832	.42	.672
I(POLITY8)	-.015514	-.01	.991
I(POLITY9)	.8847709	.70	.487
I(POLITY10)	.059738	.04	.966
I(POLITY11)	.7273669	.58	.561
I(POLITY12)	.3430782	.26	.795
I(POLITY13)	.9518903	.42	.677
I(POLITY14)	1.54668	1.23	.217
I(POLITY15)	.4281239	.36	.722
I(POLITY16)	1.039057	.87	.386
I(POLITY17)	1.081071	.90	.367
I(POLITY18)	1.33227	1.11	.267
I(POLITY19)	1.374387	1.14	.253
I(POLITY20)	2.190003	1.80	.072

Table 17: Regression 2, cont.

I(REGION2)	.1182925	.1	.918
I(REGION3)	2.146925	1.71	.087
I(REGION4)	.7293044	.59	.554
I(REGION5)	.9859309	.68	.494
I(REGION6)	-.2552168	-.2	.839
I(REGION7)	1.085502	1.02	.305
I(REGION8)	5.63735	2.81	.005
I(REGION9)	8.449721	4.33	.00
I(REGION10)	.1538443	.14	.891
I(REGION11)	.7773641	.60	.546
I(REGION12)	1.678207	1.45	.147
I(REGION13)	.4677368	.44	.662
I(REGION14)	1.520336	1.18	.239
I(REGION15)	.3537219	.36	.720
I(REGION16)	.9762814	1	.318
I(REGION17)	3.135058	2.91	.004
I(REGION18)	1.100708	.88	.377
I(REGION19)	3.180414	1.58	.113

Table 18: Regression 2, cont.

I(CRISIS)	1.436086	2.42	.016
I(YEAR1999)	.1742855	1.29	.196
I(YEAR2000)	.4526542	3.32	.001
I(YEAR2001)	.8289379	5.87	.000
I(YEAR2002)	1.20015	8.26	.000
I(YEAR2003)	1.319378	8.8	.000
I(YEAR2004)	1.575402	10.09	.000
I(YEAR2005)	1.698822	10.48	.000
CONSTANT	-.2845945	-.21	.837

Note: all the results of this regression remain robust when we run the regression with orthogonalized independent variables.

Appendix 11: Chronology of Asian Regional Financial Arrangement (1997-2009) (Source: Minister of Finance, Japan; Soesastro, 2008; Jeon, 2002)

1997-1998: Asian financial crisis

August - September 1997: Asian Monetary Fund was proposed by Japan.

December 1997: The 1st ASEAN+3 Summit was held in Kuala Lumpur, Malaysia.

April 1999: The 1st ASEAN+3 Finance Ministerial meeting was held in Manila, Philippines.

November 28, 1999: The 3rd ASEAN+3 Summit was held in Manila, Philippines. Leaders agreed to enhance "self-help and support mechanism in East Asia".

May 6, 2000: The 2nd ASEAN+3 Finance Ministerial meeting was held in Chiang Mai, Thailand. Finance ministers agreed to promote the Chiang Mai Initiatives Bilateral Swap.

May 15, 2004: The 4th ASEAN+3 Finance Ministerial meeting was held in Jeju, Korea. Finance ministers agreed to explore the ways of enhancing its effectiveness of the Chiang Mai Initiatives. Sixteen BSA were already made totalling to US\$36.5 billion. Asian Bond Market Initiatives were initiated. Based Capital Accord was agreed.

May 4, 2005: The 8th ASEAN+3 Finance Ministerial meeting was held in Istanbul, Turkey. Finance ministers agreed to take the following measures to enhance the effectiveness of the Chiang Mai Initiatives: 1. integration and enhancement of ASEAN+3 economic surveillance into the Chiang Mai framework; 2. clear definition of the swap activation process and the adoption of a collective decision-making mechanism; 3. significant increase on the size of swaps from 1 to 2 billion; 4. improvement of the drawdown mechanism.

May 4, 2006: The 9th ASEAN+3 Finance Ministerial meeting was held in

Hyderabad, India. A more advanced framework of regional liquidity support was envisaged (that was later called the Chiang Mai Initiatives Multilateralization).

May 5, 2007: The 10th ASEAN+3 Finance Ministerial meeting was held in Kyoto, Japan. Finance ministers unanimously agreed that a self-managed reserve pooling arrangement was an appropriate way to implement the Chiang Mai Initiative Multilateralization.

May 4, 2008: The 11th ASEAN+3 Finance Ministerial meeting was held in Madrid, Spain. Finance ministers agreed to transform Chiang Mai Initiatives into a much stronger Chiang Mai Initiatives Multilateralization. China-Japan-Korea would be responsible to 80% of the fund while the rest of the ASEAN countries would be responsible to the rest of the fund.

October 25, 2008: The 7th Asia-Europe meeting was held in Beijing. A US\$80 billion regional, multilateral fund based on the Chiang Mai Initiatives Multilateralization was created and expected to become active in May 2009.

November 20, 2008: A technical-group meeting was held in Manila, Philippines, to discuss the details of the new self-managed reserve pooling arrangement.

November 28, 2008: A Deputy Finance Ministerial meeting was held in Hakone, Japan, to discuss the details of the new self-managed reserve pooling arrangement.

December 10, 2008: Bali Democracy Forum was held in Bali to discuss issues on democratization in Asia. Thirty two countries, including Australia, attended the forum.

December 13, 2008: A Trilateral Summit of China, Japan, and Korea was held in Fukuoka. The three countries reiterated their commitment to strengthening the Chiang Mai Initiatives Multilateralization. The summit was seen as a development to the long-time reservation among these countries.

December 15, 2008: ASEAN+3 may expand the reserve pool to US\$120 billion from US\$80 billion.

February 18, 2008: ADBI kicked off studies to expand Asian Bond Market.

February 19, 2008: ASEAN+3 Finance Ministerial meeting was held in Phuket, Thailand. Ministries of Finance advanced in expanding the reserve pool to US\$120 billion from US\$80 billion.

Appendix 12: Vulnerability Data 2003

Brunei	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER	
1997						
1998	-0.1078678			-0.004414	0.01713	
1999	0.06612423		7.890	-0.004156	0.04697	
2000	0.01286849		13.262	0.108984073	0.015581	0.09481
2001	-0.024246	0.439196564	11.052	0.034404957	0.00596	0.16053
2002	-0.0054092	0.347399855	10.207	0.043436498	-0.023151	-0.0461
2003	0.03922199	0.469490357	10.257	0.034153412	0.003	-0.0024
2004	0.10396216	0.510447945	12.011	0.063831582	0.008142	-0.0399
2005		0.630796496	11.193	0.034521993	0.012445	0.07255
2006			11.879	-0.008906487	0.001223	-0.0936
2007			10.378	0.086383038		
2008						
2009						

*M2="Broad Money" line 59

Source: IFS

Figure 0-22: Vulnerability Data 2003: Brunei Darusallam

Cambodia	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER	
1997		-0.07141975				
1998	0.05	-0.05583414		0.027978046	0.148066	-0.034
1999	0.126	-0.05286247		0.16594689	0.040077	-0.017
2000	0.084	-0.03773757		0.17717726	-0.00792	0.079
2001	0.077	-0.02191771	0.96525625	0.04190629	-0.00601	0.032
2002	0.068	-0.02514948	0.94815267	0.131183581	0.03225	-0.007
2003	0.087	-0.05017572	1.02749899	0.262260249	0.012105	0.024
2004	0.103	-0.03436136	1.12808953	0.447524352	0.039375	-0.001
2005	0.132	-0.05754868	1.26639165	0.194837683	0.056506	-0.001
2006	0.108	-0.04609108	1.48556008	0.548447936	0.047117	-0.027
2007	0.101	-0.0578459	1.56210362	0.782290957	0.058539	-0.042
2008						
2009						

Source: IFS

Figure 0-23: Vulnerability Data 2003: Cambodia

Indonesia	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER
1997		-0.03621799	4.61101023		
1998	-0.131262	0.034400294	3.1676362	0.332185702	0.583869 0.1065
1999	0.00791007	0.037256278	3.44894992	-0.554921849	0.204891 -0.2512
2000	0.04919684	0.05517755	2.7316062	0.221741895	0.037184 0.3498
2001	0.03643	0.043593936	2.97872519	0.207327519	0.11504 -0.0005
2002	0.04500063	0.038391216	3.19240899	0.160393597	0.118785 -0.2195
2003	0.04779931	0.034079058	3.22917063	0.192213629	0.06586 -0.0915
2004	0.05031546	0.006324709	3.18402285	0.31115285	0.06243 0.0606
2005	0.05692401	0.000983446	3.69204004	0.210018699	0.104526 -0.0095
2006	0.05510442	0.029267705	3.72890126	0.12066019	0.131101 -0.1626
2007	0.06316534	0.024669478	3.18576216	0.224050659	0.064072 0.0094
2008					
2009					

Source: IFS

Figure 0-24: Vulnerability Data 2003: Indonesia

Laos	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER
1997		-0.366	1.37377708		
1998	0.04	-0.151	1.80551968	0.150071478	0.909802 -0.1373
1999	0.073	-0.089	2.00837862	-0.079705786	1.284195 -0.2045
2000	0.058	-0.005	1.97506473	0.291985264	0.250846 -0.1063
2001	0.058	-0.05	2.0643198	0.070110602	0.07812 0.1014
2002	0.059	0.002	1.72488068	-0.111547183	0.106315 0.0334
2003	0.058	-0.032	1.94106075	-0.001954166	0.154887 -0.1321
2004	0.069	-0.074	2.22525359	0.152225678	0.104626 -0.0785
2005	0.073	-0.068	2.20909608	0.231312955	0.071655 -0.0011
2006	0.083	0.014	2.2125366	0.064954639	0.068023 -0.1276
2007	0.075	0.026	1.96376289	0.336036013	0.045224 -0.0515
2008					
2009					

*M2="Money"+"Quasi Money", line 34+35
Source: IFS

Figure 0-25: Vulnerability Data 2003: Laos

Malaysia	%Real GDP	DCA/GDP	M2/Reserve, IPS	Bank Lending Growth	Inflation	%RER
1997		-0.08197235	3.61182682			
1998	-0.0735934	0.127836769	3.05245614	0.005901582	0.053	-0.0581
1999	0.06137608	0.159241332	2.90048209	-0.00079518	0.027	-0.0054
2000	0.08858822	0.090499134	3.29485671	0.072543792	0.015	0.0181
2001	0.00518	0.078535568	3.23138423	-0.053948842	0.014	0.0139
2002	0.05391074	0.071294586	3.02547924	0.025646771	0.018	-0.0022
2003	0.05788346	0.121423888	2.55857979	0.067191737	0.01	0.0126
2004	0.06783321	0.120877464	2.13368038	0.065052677	0.015	0.0114
2005	0.05332119	0.144558799	2.33344861	0.09122038	0.03	-0.0011
2006	0.05774601	0.156887984	2.47617811	0.068399065	0.036	-0.0692
2007	0.06346611	0.149037295	2.38586795	0.092466003	0.02	-0.0561
2008						
2009						

Source: IFS

Figure 0-26: Vulnerability Data 2003: Malaysia

Myanmar	%Real GDP	DCA/GDP	M2/Reserve, IPS	Bank Lending Growth	Inflation	%RER
1997		-0.00234278	205.00486			
1998	0.05773181	-0.0018737	227.81967	0.348513051	0.514876	-0.3576
1999	0.10916152	-0.00080588	341.214777	0.207941705	0.184007	-0.1146
2000	0.06234815	-0.00054168	549.535018	0.416249887	-0.00109	0.0902
2001	0.11344	-0.0002929	424.711599	0.561835281	0.21101	-0.1197
2002	0.12025794	0.000107483	527.147552	0.461883914	0.570747	-0.4022
2003	0.13839851	-1.42923E-05	499.084973	-0.438615321	0.365899	-0.315
2004		6.72969E-05	565.360141	0.255847658	0.045343	-0.0602
2005			577.8042	0.331039258	0.093685	0.0272
2006			482.666656	0.143570773	0.199966	-0.1827
2007				0.21800696	0.350245	-0.2748
2008						
2009						

*M2="Money Plus Quasi Money", line 35

Source: IFS

Figure 0-27: Vulnerability Data 2003: Myanmar

Philippines	%Real GDP	DCA/GDP	M2/Reserve, IPS	Bank Lending Growth	Inflation	%RER
1997		-0.07167279	3.61291888			
1998	-0.0057673	0.022658107	3.14278121	-0.057002687	0.092659	-0.0919
1999	0.03396352	-0.03891953	2.53841815	-0.020223678	0.059471	-0.0045
2000	0.04008271	-0.03316081	2.17452435	0.052963599	0.039501	0.2334
2001	0.034	-0.02468658	2.19572767	-0.006509106	0.068	-0.0101
2002	0.05537718	-0.0037372	2.35441494	0.003500617	0.029963	0.0188
2003	0.04915419	0.00370769	2.26876205	0.029153346	0.034545	0.0346
2004	0.05000437	0.01886135	2.55100557	0.095296574	0.059754	-0.019
2005	0.04831344	0.019339485	2.42740819	-0.000108426	0.076285	-0.094
2006		0.043546456	2.54268079	0.095599438	0.062404	-0.1004
2007		0.039238552	2.21057853	0.058902014	0.028042	-0.157
2008					-1	
2009						

*M2="Narrow Money" +"Quasi Money", line 59

Source: IFS

Figure 0-28: Vulnerability Data 2003: Philippines

Singapore	%Real GDP	DCA/GDP	M2/Reserve, IPS	Bank Lending Growth	Inflation	%RER
1997		0.175660851	1.03170245			
1998	-0.014	0.220249742	1.28933309	0.063764396	-0.00268	0.0091
1999	0.072	0.171	1.35925026	-0.033670189	0.000167	0.0251
2000	0.101	0.116	1.23076626	0.054294128	0.013616	0.06
2001	-0.024	0.129	1.29148643	0.125748756	0.00997	0.0884
2002	0.042	0.123	1.26249994	-0.087178553	-0.00391	-0.0432
2003	0.035	0.226	1.19005999	0.028265763	0.005079	-0.0034
2004	0.09	0.162	1.1251612	0.043793919	0.016625	-0.0298
2005	0.073	0.186	1.13702221	0.024044568	0.004251	0.0487
2006	0.082	0.211	1.25522168	0.047530279	0.01021	-0.0584
2007	0.077	0.232	1.26717352	0.173246976	0.02078	-0.0531
2008						
2009						

Source: IFS

Figure 0-29: Vulnerability Data 2003: Singapore

Thailand	%Real GDP	DCA/GDP	M2/Reserve, IPS	Bank Lending Growth	Inflation	%RER
1997		-0.03	3.50823838			
1998	-0.105	0.113	4.49438566	-0.080376496	0.080722	-0.2703
1999	0.044	0.1	3.80367001	-0.151823372	0.003039	0.0404
2000	0.048	0.082	3.63304516	-0.128803879	0.015673	0.1753
2001	0.022	0.044	3.66488516	-0.066503549	0.01637	0.034
2002	0.053	0.037	3.27627062	0.123395497	0.006208	-0.0148
2003	0.07	0.032	3.46920469	0.064020855	0.018002	-0.0783
2004	0.062	0.017	3.12928119	0.112639298	0.027683	-0.0142
2005	0.045	-0.044	3.09588598	0.079796149	0.045415	0.0389
2006	0.052	0.01	2.89957622	0.045368594	0.046419	-0.1334
2007	0.05	0.063		0.047858203	0.022283	-0.0588
2008					0.054726	0.0235
2009						

Source: IFS

Figure 0-30: Vulnerability Data 2003: Thailand

Vietnam	%Real GDP	DCA/GDP	M2/Reserve, IPS	Bank Lending Growth	Inflation	%RER
1997		-0.05988756	3.34120328			
1998	0.058	-0.04132188	3.68194451	0.191	0.072662	0.0698
1999	0.048	0.041283376	3.43769052	0.458	0.04117	-0.0088
2000	0.068	0.036346948	4.49510927	0.342	-0.0171	0.0882
2001	0.069	0.021374184	5.04806178	0.232	-0.00432	0.0733
2002	0.071	-0.01736482	5.18459317	0.255	0.03831	-0.0009
2003	0.073	-0.04925058	4.22248034	0.324	0.032201	0.0064
2004	0.078	-0.02110785	4.79147608	0.394	0.077583	-0.0392
2005	0.084	-0.01062423	4.79490521	0.349	0.082815	-0.0367
2006	0.082	-0.00269815	4.29425756	0.229	0.073863	-0.0304
2007	0.085	-0.09848637		0.49794864	0.088946	-0.052
2008					0.243963	-0.1206
2009						

*M2="Money" + "Quasi Money", line 34+35

Source: IFS

Figure 0-31: Vulnerability Data 2003: Vietnam

China	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER
1997		0.037478799		0.028068	
1998	0.078	0.030110069	8.46089095	0.200208943	-0.00845 0.0241
1999	0.076	0.019218751	9.1811912	0.120922355	-0.01408 0.0366
2000	0.084	0.017199059	9.66398039	0.10951006	0.002553 0.0308
2001	0.083	0.013216661	8.87084749	0.135970084	0.004634 0.0235
2002	0.091	0.024362154	7.67742333	0.279879297	-0.00765 0.0237
2003	0.1	0.027836858	6.54865632	0.194983345	0.011568 0.011
2004	0.101	0.035454072	4.97861813	0.08791278	0.03885 -0.0116
2005	0.104	0.068780522	4.50627166	0.106711107	0.018206 -0.01
2006	0.117	0.089419624	4.14187404	0.162545749	0.01464 -0.0155
2007	0.119	0.110133093	3.60885663	0.176357113	0.047543 -0.0815
2008					
2009					

Source: IFS

Figure 0-32: Vulnerability Data 2003: China

Japan	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER
1997		0.02441728	20.5312585		
1998	-0.021	0.027191393	24.5539188	0.020888144	0.006664 -0.103
1999	0	0.023536668	21.409	-0.014058261	-0.00332 -0.094
2000	0.028	0.027334408	15.699	-0.019312013	-0.00712 0.171
2001	0.002	0.023249571	12.698	-0.419255664	-0.00758 0.189
2002	0.003	0.027441616	12.219	-0.077654884	-0.00895 -0.068
2003	0.015	0.029755073	9.609	-0.039256361	-0.00249 -0.084
2004	0.027	0.035949782	8.017	-0.022554409	-8.4E-05 -0.002
2005	0.019	0.03897966	7.204	0.032317457	-0.00274 0.175
2006	0.02	0.03985459	6.822	-0.003283984	0.002415 0.038
2007	0.024	0.04652768	6.707	-0.001660311	0.000582 -0.015
2008			6.70740748		

*M2=M2 (Period Average)

Source: IFS

Figure 0-33: Vulnerability Data 2003: Japan

Korea	%Real GDP	DCA/GDP	M2/Reserve, IPS Bank Lending Growth	Inflation	%RER
1997		-0.028933738	11.106		
1998	-0.069	0.100406163	7.26	0.089	0.075 -0.329
1999	0.095	0.052702403	5.82	0.162	0.008 -0.0419
2000	0.085	0.026770474	4.468	0.167	0.023 0.12324
2001	0.038	0.01695938	4.51	0.117	0.041 0.02638
2002	0.07	0.009350563	4.456	0.171	0.028 -0.1073
2003	0.031	0.019665331	3.263	0.087	0.035 -0.0067
2004	0.047	0.037417421	2.985	0.021	0.036 -0.1397
2005	0.042	0.018697569	3.359	0.077	0.028 -0.0166
2006	0.051	0.005904509	3.439		0.022 -0.0716
2007	0.05	0.006184963	3.284		0.025 0.00981
2008					0.047 0.33219
2009					

Source: IFS

Figure 0-34: Vulnerability Data 2003: Korea

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