Japanese Journal of Political Science 5 (1) 1–22
DOI: 10.1017/S146810990400129X Printed in the United Kingdom © Cambridge University Press 2004

Diversification and Energy Security Risks: The Japanese Case

S. HAYDEN LESBIREL
Associate Professor, Political Science, School of Humanities, James Cook University, Townsville, QLD, 4811
hayden.lesbirel@jcu.edu.au

Abstract

This article explores the relationship between diversification and energy security risks. It uses portfolio theory to conceptualise energy security as an insurance mechanism against disruptions to energy import markets. It provides quantitative measures of systematic and specific risks associated with Japanese energy imports during the period 1970–99. It suggests that Japan's policy of diversification of energy import sources has reduced specific risks, although fundamental changes in the political and economic structure of international energy and, in particular, oil markets have also significantly reduced systematic risks. The article concludes that, despite their limitations, portfolio measures provide a much more theoretically and methodologically robust indicator of energy import security than traditional measures of dependence.

Introduction

Energy security is a continuing concern for nations such as Japan which are heavily reliant on imported energy sources. The ability to be able to secure adequate access at reasonable prices to energy imports to satisfy the needs of the economy has a major impact on Japan's overall security position. It has profound implications for the health of the Japanese socio-economy and the political structures underpinning that economy. Yet, the risks of disruptions in energy markets are many. They include politically and

The author would like to thank Takashi Inoguchi, Robert Keohane, Masaru Kohno, Ken Koyama, Tatsujiro Suzuki and others at a Roundtable on International Political Economy held at the University of Tokyo in 2002 for valuable comments on a draft of this paper. He also benefited from comments from Peter Drysdale, Alexis Dudden and Javed Maswood. He acknowledges the generous assistance provided by the Japan Foundation which enabled him to spend six months as a Japan Foundation Fellow at the University of Tokyo from 2001–02. He also acknowledges the generous assistance from the Institute of Energy Economics and the Osaka School of International Public Policy, University of Osaka for extensive access to their databases during that period.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

market induced disruptions as well as accidents. There is little predictability in the probabilities of these risks, their possible interactions and their cumulative effects. Every policy statement of the Japanese government since the 1970s has stressed Japan's dependence on imported energy sources and the need to manage the risks associated with that structural dependence to ensure Japanese security. Energy security risks matter.

Several observations make an examination of Japanese energy security risks since the 1970s interesting. First, Japan has been able to reduce its overall dependence on imported oil since the 1970s. Second, it has been able to diversify away from the Middle East into the Asia-Pacific as a source of energy imports. Third, Japan's regional dependence on imported energy sources has been heavily concentrated regionally: on the Middle East for oil and LPG, and on the Asia-Pacific for LNG and coal. Fourth, there have been quite significant changes in the regional patterns on import dependence. For example, while Japan was able to reduce its dependence on Middle East oil up till 1985, it has subsequently increased that dependence to a level higher than it was in 1973.

What do these patterns cumulatively mean in terms of Japan's energy security risks? Do they reduce, increase, or leave those risks unchanged? The purpose of this paper is to provide a preliminary quantitative assessment of the impact of these changing dependencies on the energy import security risks which have confronted Japan since the 1970s. It treats energy security as insurance against risks of supply disruptions, and applies portfolio theory to analyse those security risks. The theory explores the relationship between diversification and security risks, and posits that diversification is potentially a useful strategy for reducing security risks. It provides a way of classifying the complex configuration of risks confronting importer nations into systematic (common risks associated with international energy markets) and specific risks (unique risks associated with reliance on specific fuels or regions). Through the use of a single index model, the theory can be applied to obtain a measure of total portfolio risks (systematic plus specific risks) and to explore the effects of diversification on aggregate security risks.

A key conclusion is that overall security risks have declined significantly over the two periods: 1970–84 and 1985–99. The major contributor to that decline was the reduction in systematic risks associated with significant changes in international energy markets. Specific risks have also declined quite markedly over the two periods, suggesting that diversification has also worked to assist in reducing risks. Changes in the risks of relying on oil and Middle East oil in particular have dominated the security risk picture. The results are significant because they provide evidence to suggest that increased Japanese dependence on Middle East oil in total oil imports since the mid 1980s has been associated with a significantly lower risk when compared with the period 1970–84.

The results of the paper have implications beyond simply providing some measures of energy security risks. I contend that portfolio measures of risk provide a better basis than traditional measures, such as dependence ratios, on which to develop indicators for

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

use in energy policy formulation, implementation, and evaluation. Dependence ratios do not take into account risks, or make implicit assumptions about risks. Furthermore, as I will show in the paper, there is not necessarily a consistent relationship between the level of dependence and the level of security risks, either theoretically or empirically. They are inadequate because the relationship between dependence and risks is not explicitly specified. In contrast, portfolio measures explicitly take into account various types of risks and provide a more theoretically informed assessment of the risks of dependence.

The paper attempts to provide a preliminary measure of energy import security risks by applying portfolio theory to examining the effects of diversification on those risks in the Japanese case. While it is important to specify what this paper is about, it is equally important to note what it is not about. First, it does not explore the effects of policy measures such as stockpiling, foreign investment and trade, and ODA on energy security risks. Second, it does not incorporate an investigation of sea-lane security which would also need to be taken into account in any comprehensive analysis of Japanese energy security. Third, it does not explore Japanese energy security in a regional context. This has become more important given increasing reliance on the Middle East by other north-east Asian nations and some concerns about the lack of policy measures, such as stockpiling, in some countries to deal with sudden supply disruptions.[1] Despite these limitations, I contend that the framework developed in the paper can be used as an important conceptual starting point in analysing the nature and impact of those factors on energy security risks.

Japanese diversification patterns: 1970–99

The 1973 Arab–Israeli war and the subsequent oil crisis had a significant impact on Japanese energy policy. In response to increased oil prices and concerns about the availability of oil, Japan institutionalised a policy which had two pillars designed to enhance its energy security over the longer term.[2] The policy sought to reduce dependence on imported oil by diversifying into coal, LNG, and nuclear power. It also aimed to reduce dependence on Middle East oil by diversifying into alternative oil import sources. The Iranian revolution of 1979 and the subsequent Iran–Iraq

[1] For comprehensive analyses on energy issues in Northeast Asia, see Calder, Kent E. (1996), 'Asia's Empty Tank', *Foreign Affairs*, 75(2): 55–69 and Fesharaki, Fereidun (1999), 'Energy and the Asian Security Nexus', *Journal of International Affairs*, 53(1): 85–99.

[2] Excellent analyses of Japanese energy policy can be found in Matsui, Kenichi (ed.) (1995), *Enerugii: Sengo 50 Nen no Kenshō* [Energy: A Fifty Year Investigation], Tokyo: Denryoku Shinpōsha; Samuels, Richard (1987), *The Business of the Japanese State: Energy Markets in Comparative and Historical Perspective* (Ithaca: Cornell University Press); and Toiichi, Tsutomu (1994), *Sekiyu – Nihon no Sentaku* [Oil: Japan's Options], Tokyo: Nihon Nōritsu Kyōkai Manejimento Sentaa. A more recent conference also provides important perspectives on Japanese energy security. See James A. Baker III Institute for Public Policy (May, 2000), Conference on 'Japanese Energy Security and Changing Global Energy Markets: An Analysis of Northeast Asian Energy Cooperation and Japan's Evolving Leadership Role in the Region', Held at the James A. Baker III Institute for Public Policy, Rice University.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

war heightened concerns about reliance on Middle East oil and reinforced Japan's determination to develop alternative energy sources to reduce dependence on that region for oil imports.[3]

By the mid 1980s several changes in international energy markets, such as the continued conservation efforts, development of alternative energy, and the discovery of non-Middle East oil (North Sea), weakened considerably OPEC's power over oil supply and pricing. These changes led to significant oil price declines (some have referred to this as the reverse oil shock) and the emergence of a more competitive and transparent international oil market, which included spot and futures markets.[4] While energy security had been the dominate policy goal since 1973, Japan, in response to the changed international oil market conditions, altered its energy policy to giving relatively more weight to other policy goals, such as efficiency, and less weight to security goals than it had in the past.[5]

Table 1 highlights the changing energy import dependence ratios (at five-year intervals) that have occurred over the period 1970–99 in association with these energy market and policy changes. It categorises fuel imports into oil, LNG, LPG, and steaming coal, and categorises regions into Middle East, Asia-Pacific, and others (including Africa, Europe, and South America).

The data reveal considerable fuel diversification. Reliance on imported oil declined from 98% in 1970 to 61% in 1999. However, the rate of decline in oil dependence has declined quite markedly in the period from 1985. Although oil still remains the largest single energy import, Japan has been able to diversify into non-oil imports quite significantly. The bulk of the changing pattern of oil imports has been due to increased dependence on alternative energy imports. The share of steaming coal imports increased from zero to 20%; the LNG import share increased from 1% to 15%; and the LPG import share increased marginally from 1% to 4% over the period.

Japan's regional dependence on total energy imports has also changed quite dramatically. The proportion of Middle East energy imports declined from 85% to 59%, while the share of energy imports from the Asia-Pacific grew to 40%. Australia and East Asia have figured predominantly in this changed import pattern, with import shares from Australia growing from zero to 15%, and import shares from East Asia expanding from 13% to 23% over the period. North American and other imports have figured little in Japan's changing import dependence. These data reveal that, at the aggregate level, the broad story of diversification for Japan revolves around a reduction in oil dependence, and a reduction in Middle East energy dependence.

[3] See Morse, Ronald A. (1985), *Japan and Middle East in Alliance Politics* (Lanham: University Press of America) for an excellent analysis of this period.

[4] van der Linde, Coby (1991), *Dynamic International Oil Markets: Oil Market Developments and Structure 1860–1990* (Dordrecht: Kluwer Academic Publishers) and Frankel, Paul H. (1989) 'The Changing Structure of the Oil Industry', in Robert G. Reed III and Fereidun Fesharaki (eds), *The Oil Market in the 1990s: Challenges for the New Era* (Boulder: Westview Press).

[5] Matsui, *Enerugii.*

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

Table 1. *Japanese energy import patterns*

			1970	1975	1980	1985	1990	1995	1999
By Fuel	Oil		0.98	0.95	0.86	0.73	0.70	0.66	0.61
	LNG		0.01	0.02	0.07	0.12	0.13	0.13	0.15
	LPG		0.01	0.02	0.04	0.05	0.05	0.04	0.04
	Coal		0.00	0.00	0.03	0.10	0.12	0.16	0.20
By Region		Middle East	0.85	0.76	0.66	0.56	0.55	0.57	0.59
		Asia Pacific	0.14	0.21	0.31	0.42	0.43	0.41	0.40
		Australasia	0.00	0.01	0.02	0.08	0.10	0.12	0.15
		East Asia	0.13	0.20	0.27	0.29	0.29	0.26	0.23
		North America	0.01	0.01	0.02	0.05	0.04	0.03	0.02
		Others	0.01	0.03	0.04	0.02	0.02	0.02	0.01
By Fuel/Region	Oil	Middle East	0.85	0.78	0.71	0.70	0.72	0.79	0.86
		Asia Pacific	0.13	0.19	0.25	0.29	0.29	0.21	0.13
		Australasia	0.00	0.00	0.00	0.01	0.01	0.01	0.01
		East Asia	0.13	0.19	0.24	0.23	0.24	0.18	0.11
		North America	0.00	0.00	0.01	0.05	0.04	0.02	0.01
		Others	0.01	0.03	0.04	0.00	0.00	0.01	0.01
	LNG	Middle East	0.00	0.00	0.12	0.08	0.06	0.09	0.18
		Asia Pacific	1.00	1.00	0.88	0.92	0.94	0.91	0.81
		Australasia	0.00	0.00	0.00	0.00	0.09	0.16	0.14
		East Asia	0.00	0.80	0.83	0.88	0.82	0.72	0.65
		North America	1.00	0.20	0.05	0.04	0.03	0.03	0.02
	LPG	Middle East	0.84	0.74	0.82	0.81	0.78	0.79	0.84
		Asia Pacific	0.15	0.24	0.17	0.16	0.22	0.21	0.15
		Australasia	0.05	0.20	0.12	0.12	0.05	0.03	0.05
		East Asia	0.00	0.00	0.03	0.04	0.17	0.18	0.10
		North America	0.10	0.04	0.02	0.00	0.00	0.00	0.00
		Others	0.00	0.01	0.01	0.03	0.00	0.00	0.00
	Coal	Middle East	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Asia Pacific	0.00	0.94	0.89	0.82	0.89	0.91	0.96
		Australasia	0.00	0.66	0.60	0.62	0.70	0.59	0.62
		East Asia	0.00	0.28	0.11	0.11	0.10	0.23	0.28
		North America	0.00	0.00	0.18	0.09	0.09	0.09	0.06
		Others	0.00	0.06	0.10	0.18	0.11	0.09	0.04

Source: Compiled from data from The Energy Data and Modelling Center, Institute of Energy Economics, Japan.

A more disaggregated examination of energy fuel dependence by fuel and by region (regional dependence on total imports by fuel) reveals rather different dimensions to Japan's diversification story. The share of Middle East oil imports to total oil imports, after declining from 85% in 1970 to 70% in 1985, increased to 86% by 1999. Japan now relies on Middle East oil slightly more than it did in 1970 and markedly more than

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

it did in 1973 (78%). During the period 1970–90, the share of Asia-Pacific oil (mainly from East Asia) increased from 13% to 29%, after which it declined to 13% by 1999. Japan was able to diversify away from Middle East oil until 1985, but that trend reversed subsequently. These data cumulatively suggest that, while Japan has been able to reduce its dependence on imported oil over the period, it has simultaneously increased its dependence on Middle East oil as a proportion of total oil imports since the mid 1980s.

The share of LNG from the Asia-Pacific (which has dominated total imports over the period) generally declined over the period from 100% to 81%. The East Asian share declined from 88% in 1985 to 65% in 1999. Middle East imports, after declining to 6% in 1990, grew to 18% in 1999, while Australian imports increased from zero in 1985 to 14% in 1999. Japan has diversified LNG imports away from East Asia into the Middle East and Australia during the 1990s.

Imports from the Middle East have dominated Japan's LPG imports. They declined from 84% in 1970 to 78% in 1990, but increased to 84% by 1999. Import shares from the Asia-Pacific increased, after increasing from 15% in 1970 to 22% in 1990, but declined to 15% by 1999. The shares of LPG imports from Australia have declined from 20% in 1975 to 5% in 1999. East Asian shares have increased over the period, but showed declines from 1995. Like oil and LNG, the proportion of LPG imports from the Middle East declined but then grew over the period, but at different rates and at different times.

The dependence on the Asia-Pacific for coal has dominated Japan's total coal imports more than the regional dependence on any other energy fuel import. The share from the Asia–Pacific declined from 94% in 1975 to 82% in 1985 and then increased to 96% by 1999. Also in contrast to other fuels, the import share of coal from other regions figured prominently from 1975, but declined to 4% by 1999. Within the Asia–Pacific, changing import shares revolved around Australia and East Asia. Shares of North American coal have declined since 1980. In contrast to other energy imports, the diversification of coal imports has revolved around changing dependencies within the Asia–Pacific.

This descriptive analysis of changing import diversification reveals two broad observations. At the aggregate level, Japan has diversified considerably with respect to fuel out of oil into non-oil imports, and with respect to region out of the Middle East into the Asia–Pacific. At a more dissagregated level, Japan still has remained quite heavily dependent particular regions, the Middle east for oil and LPG, and the Asia–Pacific for LNG and coal. Within the Asia–Pacific, Japan's imports of LNG are dominated by East Asian imports, while imports of coal are dominated by Australian imports. Yet, there have been quite important changes in the pattern of energy import dependencies both across and within regions.

The complex patterns of Japan's aggregate and changing dependence over the period raise a broader set of questions about the relationship between diversification and energy security. For instance, have the diversification effects of Japan's overall fuel and regional diversification away from the Middle East enhanced energy security?

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

What implications did the consistently high concentration of fuel imports by region have for security? Has the increasing dependence on Middle East oil and LPG since 1985 weakened Japan's energy security? What implications has the increasing dependence on the Asia-Pacific for LNG and coal had on energy security? Finally, what do these overall patterns and trends tell us about Japanese energy security more cumulatively? To provide some answers to these questions, it is necessary to explore the nature of energy security risks, and to explore theoretically the relationship between diversification and security risks.

Energy security and insurance against risks

Security is a primary concern of all states. Indeed, some observers have argued that it is only when security is achieved that other lesser national goals can be pursued. States are concerned about military security. But, they are also concerned about non-military dimensions of security such as economic and environmental security.[6] Disruptions to energy imports can represent a major threat to nations that have few domestic resources and rely heavily on external supplies of energy sources. Threats to energy supplies can influence adversely social and economic orders, and the ideologies, institutions and political and economic coalitions underpinning the state. Hence, states take energy security seriously.[7]

Defining security is no easy task. It has to deal with a variety of threats. While the nature of these threats may be reasonably well understood, the probabilities, potential interactions between them, and the possible cumulative severity of them is less often understood. Notions that are often included in analyses of security include: freedom from harmful threats, a capacity to survive, and an ability not to sacrifice core values. Survival is often regarded to be the bottom line of security. Security is not an absolute concept; there is no such thing as absolute security. It is a relative concept. It is only possible to be relatively free from harmful threats, to have a relative ability to survive, or to be relatively free from having to sacrifice core values.[8]

Energy security, like the concept of security itself is a contestable concept. Rather than seeking to define energy security comprehensively and while acknowledging different conceptions of it, I stress the notion of *insurance against risks*. An important aspect of energy security is the relative ability to insure against the risks of harmful energy import disruptions in order to ensure adequate access to energy sources to sustain acceptable levels of social and economic welfare and state power both

[6] For en excellent review article on the non-military aspects of security, see Baldwin, David A. (1996) 'Security Studies and the End of the Cold War', *World Politics*, 48(1): 117–141.

[7] For a comprehensive examination of the security, including the economic security issue, see Buzan, Barry (1991), *People, States and Fear: An Agenda for International Security Studies in the Post-cold War Era*, Second Edition (Boulder: Lynne Rienner Publishers).

[8] Ibid., Introduction.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

domestically and internationally.[9] The relative strength of an insurance cover will influence both the likelihood and consequences of being targeted by supplier nations.

In principle, nations that have to rely heavily on international markets for energy imports face a multitude of possible disruptions to the availability of energy. Disruptions can be thought of broadly as any events that lead to imbalances between supply and demand in international energy markets. These imbalances can occur as a result of political, market and accidental events, or a combination of them. In this section, I highlight briefly the character of these possible risks with particular reference to oil.[10]

Politically induced disruptions can occur due to several reasons. On the supply side, a *force majeure* disruption can be thought of as a disruption which occurs as a result of an inability of a producer country to export energy resources due to either internal or external political problems. This might happen as a result of such things as: domestic political unrest, and war-related damage to production, distribution, and transportation facilities. Supply disruptions can also occur due to policy changes in a group of producer countries, such as those acting as a cartel, which lead to deliberate restrictions for political and strategic ends.[11] Disruptions can also occur on the demand side of the market through embargo restrictions. Rather than supplier nations not being able or willing to supply energy resources, embargoes are when consumer nations restrict their purchases of energy imports from particular countries to achieve political and other objectives. Such embargoes (providing consumer countries follow them and supplier countries cannot get around them) effect a disruption in energy markets (reduction in available imports), from the demand side of the market.[12]

Energy importing nations not only worry about politically induced disruptions; they also worry about market induced disruptions, which can also represent a risk to energy security. Such disruptions can occur when investment in surge (excess refining) capacity becomes insufficient for an adequate margin of excess capacity in order to cater for sudden surged in demand. Shortages can also occur due to an ineffectiveness of information regimes. For example, producers might anticipate that supply is growing faster than demand, and become concerned that oil prices may fall. In an attempt to keep prices from falling, producers may restrict supply. But, given a lack of information

[9] Bohi, Douglas R. and Michael A. Toman (1996), *The Economics and Energy Security* (Dordrecht: Kluwer Academic Publishers) and Keohane, Robert O. and Joseph Nye (1989), *Power and Interdepedence*, Second Edition (Glenview, IL: Scott, Foresman).

[10] This discussion of possible threats to the interruption of oil supplies is based heavily of the following excellent analyses: Horsnell, Paul (May, 2000), 'The Probability of Oil Market Disruptions: With an Emphasis on the Middle East', paper presented to a conference on 'Japanese Energy Security and Changing Global Energy Markets'; and Sokolsky, Richard and Ian Lesser (2000), 'Threats to Western Energy Supplies: Scenarios and Implications', in Richard Sokolsky, Stuart Johnson, and F. Stephen Larrabee (eds), *Persian Gulf Security: Improving Allied Military Contributions* (Santa Monica, CA: Rand).

[11] Maull, Hans (1980), 'Oil and Influence: The Oil Weapon Examined', in Gregory Treverton (ed.), *Energy and Security* (Montclair, NJ: Published for the International Institute for Strategic Studies by Gower and Allanheld, Osmun).

[12] Phillips, James A. (1990), *Can the Embargo on Iraq Succeed?* (Washington, DC: The Heritage Foundation.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

about supply and demand, they may cut production more than is actually needed to prevent price reductions. In short, they over-react to expectations about price declines. In response, consumers may become concerned that shortages will emerge, and might start to build up stocks, thereby putting upward pressure on demand. In this way, asymmetric information can create an over-reaction to expected market changes on both supply and demand sides of the market, and can lead to disruptions.[13]

A final source of disruption in international energy markets is that due to accidents. In contrast to politically and market induced disruptions, they are often thought of as being devoid of human agency. Accidents can occur at different stages of the drilling, production, and supply stages at production facilities, pipelines, and vessels transporting energy resources. They can also occur on the demand side at loading facilities and in transporting fuels from ports to power plants where energy fuels are used.

The various risks to energy imports cannot always be neatly categorised into these different boxes. Market and politically induced threats to energy supplies can interact with each other and may or may not exacerbate disruptions in oil markets. For instance, a *force majeure* disruption in one country may pose a significant threat to supplies where there is a lack of excess global surge capacity and where other nations are not willing, nor able to cover for those losses. On the other hand, a group of producer countries seeking to work in concert with each other may pose little threat to supplies where there are internal differences within the grouping and where alternative substitutes are in plentiful supply.

In sum, there are several important features about possible disruptions in international energy markets. First, there is a multiplicity of possible causes that can lead disruptions. They can arise when international energy markets become politicised, but they can also arise from within the market itself and from random accidents. Second, they can occur not only on the supply side, but also on the demand side of the market. Third, there can be complex interactions between political and market disruptions which may or may not magnify the effects of those disruptions. Finally, disruptions can occur simultaneously from one or more suppliers. Ensuring energy security is no trivial task when the probability of disruptions and possible interactions between them are potentially so uncertain.

Portfolio theory and diversification

Diversification is one common response to deal with the complex range of risks of possible disruptions to energy imports and to attempt to ensure energy import security. The idea of diversification is a potentially very powerful one in understanding the risks of energy market disruptions. It is often portrayed by the expression: 'Don't put all your eggs in the one basket'. In its simplest form, it suggests that diversification can enhance energy security by reducing the risks of market disruptions. For example, by relying on

[13] Horsnell, 'The Probability of Oil Market Disruptions'.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

one country for energy imports, an importer risks loosing all its imports if that supplier, for whatever reason, is unable to supply that energy. In contrast, by relying on several countries for energy, an importer can, in principle, reduce the risks of disruptions. Even if one supplier is unable to deliver energy supplies, the importer nation would still have a good chance of obtaining some energy supplies. Hence, diversification aims to spread dependence and to reduce the risks of disruptions in energy markets.

Portfolio theory can help in providing a more rigorous investigation of the risks associated with dependence.[14] It is useful for investigating choices between more or less risky assets (sources of imported energy supply). While the theory was developed for application in financial markets, it can assist in thinking about the relationship between diversification and energy security risks. The theory categorises the various risks of disruptions to energy markets into systematic risk and specific risk. *Systematic risk* is often called non-diversifiable risk. It is defined as the risks that affects the international energy market as a whole. To some extent, the fortunes of energy importers move with overall changes in energy markets. Systematic risk typically affects a relatively large number of suppliers and, therefore, a large proportion of the market. For instance, a shortage of world surge capacity in a situation where demand for energy is increasing rapidly will generally lead to increased import prices for all consumers alike. Political change, such as the nationalisation of resource production capacity previously controlled by internationally owned firms or the collective use of oil as a strategic weapon, which affects many supplier nations, may similarly affect the fortunes of all energy importers.

In contrast, *specific risk* (which is also called unsystematic or diversifiable risk) is defined as the risks of disruptions due to conditions that are more unique or specific to individual suppliers. Unlike systematic risk, specific risk derives from events that are not related to general movements in international markets. Hence, they normally affect a smaller number of suppliers. For instance, a particular country, because of, say, a natural disaster, might have fewer resources to develop excess capacity, even though there may well be a global excess capacity situation. Various forms of political unrest, such as labour strikes, ethnic conflict, demonstrations, and terrorism, might be prevalent comparatively in a particular nation, and that may affect from time to time the ability of that nation to supply exports. An accident at a refinery in a particular nation would also constitute a specific risk. Reliance on such a nation for energy imports exposes an importing country to those more unique risks.

The theory can be used to explore the risks of individual assets comprising a portfolio and the aggregate risk of a portfolio of assets. A key conclusion is that diversification can enhance security by reducing the risks of unexpected supply

[14] Good overall treatments of portfolio theory can be found in Elton, Edwin J. and Martin J. Gruber (1984), *Modern Portfolio Theory and Investment Analysis*, Second Edition (New York: John Wiley & Sons) and Dobbins, Richard, Stephen F. Witt, and John Fielding (1994), *Portfolio Theory and Investment Management* (Cambridge, MA: Blackwell Publishers).

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

disruptions or price increases. The risks of imports from any one country can be very different from the risks of a combination of imports from different countries (portfolio). Most dramatically, the risk associated with a combination of two or more imports may be less than the risk associated with either of those imports themselves.

The extent to which diversification reduces supply risk will be determined by the nature and extent of market and political relationships between the sources of supply. I highlight this using the example of price changes as a measure of risk, and considering how diversification can reduce risks given different co-variances between the costs of imports.

Let us start with two extreme cases. Assume that a country only imports one type of fuel from two supplier countries. Furthermore, assume the prices of imports from those two countries co-vary in a perfectly negatively way. This means that when the price of one import increases, the price of the other declines by the same amount because, say, one country sees this as an opportunity to increase its market share or because it wishes to strengthen political relations with the importer nation. Under these conditions, diversification can reduce risks significantly. This is because the good outcome (price decrease) cancels out the bad one (price increase). Now, let us assume that the prices of the same two imports co-vary in a perfectly positive way. This means that when the price of one import increases, the price of the other increases by the same magnitude because, say, those suppliers are part of a well-organised cartel and have agreed to work together for political and strategic ends. Under these conditions, diversification will not reduce risk. This is because the bad outcome (price increase) is not cancelled out by a good outcome (price decrease).

There are a range of intermediate examples where the co-variances between prices of imports lie between these two extreme examples. Assume that there is a general tendency for prices of energy imports to be negatively correlated (but not in all situations). Under these conditions, diversification can help to reduce risks as there will be more times when the good and bad effects cancel each other out. Now assume that there is a general tendency for prices of energy imports to be positively correlated (but not in all situations). Under these conditions, diversification will only help in reducing risks to a lesser extent as there will be fewer times when the good and bad outcomes cancel each other out.

Based on this discussion, we can now explore the relationship between diversification and specific and systematic risk. Diversification has the potential to reduce specific risk quite significantly where events that effect supply are uniquely related to individual supplier nations and are not affected by general trends in the international markets. As it is unlikely that events that cause unsystematic risk are likely to all occur at the same time, diversification can mitigate potential ups and downs of both supply and price in the market. In contrast, diversification cannot eliminate systematic risk as the costs of imports tend to move to a large extent with common movements in the international markets. Systematic risk is the 'unavoidable' risks left after diversification — a well-diversified portfolio would only have unavoidable risk

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

remaining. Hence, diversification cannot reduce systematic risks or the risks associated with general movements in international markets.

A single index model, which explores the relationship between the variation in import prices and the variation in a world energy import price index (WEIPI) can be used to provide a measure of systematic and specific risks.[15] The model is specified as:

$$P_i = \alpha_i + \beta_i WP_m + \varepsilon_i$$

where P_i is the import price of security i;
WP_m is the WEIPI;
α_i and β_i are parameters; and
ε_i is the error.

The model uses the variation in import prices as a measure of the risk of disruptions to energy imports. It is possible to use estimates of energy supply disruptions focussing on political crises and accidents, such as the Exxon Valdez oil spill, when thinking about energy security risks.[16] However, as I have defined disruptions as imbalances between both supply and demand, supply disruptions are not an adequate measure of disruptions in energy markets for two reasons. The first is that the impact of supply disruptions on energy markets can be significantly different. For example, similarly large supply disruptions may lead to more or less sustained price increases depending on the levels of surge capacity and the availability of alternative sources of imports. The second is that energy importers are not only worried about politically induced supply disruptions; they are also worried about market induced disruptions, which can lead to supply shortages and can affect adversely energy security as well.[17] Hence, the variance in energy import prices are a more appropriate measure of the risk of disruptions in international energy markets, because prices reflect the interaction of both the supply and demand sides of the market.

The model regresses fuel import prices against an index which seeks to provide an overall measure of variations in world energy import prices. Casual observation of energy import prices reveals that when overall international energy prices increase, most import prices for countries would tend to increase, and when market prices fall, most energy import prices would tend to decrease. This suggests that one reason the cost of assets (imports) might be correlated is because of a common response to changes in international energy markets. Hence, a useful measure of this correlation might be to relate the costs of energy imports to a WEIPI index, which is calculated by multiplying

[15] See Sharpe, W.F. (1963), 'A Simplied Model for Portfolio Analysis', *Management Science*, 9: 277–293 and Cohen, K.J. and G.A. Pogue (1967), 'An Empirical Evaluation of Alternative Portfolio Selection Models', *Journal of Business*, 44: 166–193 for good examinations of single index models.

[16] Cook, John S. and Charles P. Shirkey (March, 1989), 'A Review of Valdez Oil Spill Market Impacts', United States Energy Information Administration, <www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/1989/valdez/valdez.html>

[17] See Horsnell, 'The Probability of Oil Market Disruptions'.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

energy import prices of major countries, weighted by the share of particular energy imports to total imports of those major countries.

The model generates two statistics of particular importance to the analysis. The first is a beta (β) estimate which provides a measure of systematic risk. The beta is a measure of the change in price of Japanese energy imports that is associated with a change in the world fuel import prices. For instance, a positive beta of 0.90 would imply a 90% increase in Japanese import prices for every unit increase in world energy import prices. It tells us the extent to which fuel import prices change with common price responses in international fuel import prices. It offers a measure of systematic risk, because it measures the sensitivity of fuel import prices to overall changes in international energy markets.

The second statistic of special interest is the error (ε) estimate which offers an indication of specific risk. The error is a measure of the variation in the price of fuel imports unexplained by overall price changes in international markets that effect the fortunes of all energy importers. The value for the error provides an indication of the overall extent to which actual fuel import prices deviate from the values predicted from the model based on the world price of imports. It provides a measure of specific risk because it measures the extent to which idiosyncratic or specific factors affect the price of fuel imports from particular suppliers, independently of overall changes in world energy markets.

The *risk* (variance in the fuel import cost) of *energy asset i* is defined as:

$$\sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma_{i\varepsilon}^2$$

where σ_m^2 is the variance of WP_m

$\sigma_{i\varepsilon}^2$ is the variance of ε_i

$\beta_i^2 \sigma_m^2$ provides a measure of systematic (non-diversifiable) risk for asset *i*, and $\sigma_{i\varepsilon}^2$ provides a measure of specific (diversifiable) risk for asset *i*.

The *systematic risk of the portfolio* is:

$$\beta_p^2 = \sigma_m^2 \sum_{i=1}^{n} X_i^2 \beta_i^2$$

where β_p is the systematic risk of the portfolio;

X_i is the market value invested in asset *i*; and

β_i is risk of asset *i*.

The *specific* (diversifiable) *risk* of the *portfolio* is:

$$\sigma_{p\varepsilon}^2 = \sum_{i=1}^{n} X_i^2 \sigma_{i\varepsilon}^2$$

where $\sigma_{p\varepsilon}^2$ is the specific risk of the portfolio;

X_i is the market value invested in asset *i*; and

$\sigma_{i\varepsilon}^2$ is the specific risk of asset *i*.

The *total portfolio risk* can be measured by adding the systematic and specific risk.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

Japanese energy import diversification and energy security risks

Concerns about energy security have been around much longer than attempts to use portfolio theory in order to analyse energy security risks.[18] Nonetheless, there have been some attempts in the literature to quantify the security risks of energy imports. Neff (1997), in a thoughtful analysis, applied portfolio theory to analyse security risks in the Asia-Pacific. Using a mean-variance approach, he observed that the correlation co-efficients for oil supplies from selected Middle East producers during the 1990 Gulf War crisis were negative, so that other suppliers were able to compensate for the loss of oil supplies from Iraq and Kuwait. He argued that specific supply risks of relying on Middle East oil can be reduced by a suitably diversified portfolio. He concluded by examining the relationship between factors, such as investment, contracting and inventories, and systematic risk.[19]

The importance of this approach has also been reflected recently in Japanese energy policy making. The Ministry of Economy, Trade and Industry (METI), in its Energy Security Working Group Report of 2000, sought to offer a quantitative analysis of security risks. The analysis examined the risks of energy supplies, the optimal energy supply structure, and how to minimise risk given changing technological conditions. Of particular import for this paper was the analysis which related import shares to country risk indicators to generate a risk matrix. Using the supply risks for oil as a benchmark (1.000), it found the risks of LNG (1.941) were higher than for oil, coal (0.317) and nuclear (0.026). While the analysis only made it to the appendix and while it acknowledges the limitations of using country risk indicators as measures of supply risk, it suggests the increasing policy importance of seeking to provide some quantification of energy security risks.[20]

This paper seeks to build on those earlier studies in several ways. First, it attempts to generate a quantitative estimate of both systematic and specific risk and, therefore, overall portfolio risk from the single index model, rather than attempting to measure risks using the mean-variance and other approaches. There are benefits in using single index models in terms of ease of calculating the enormous number of co-variances which are required for mean-variance approaches. Second, it uses price volatility as a measure of risk, rather than relying on supply variances and country risk indicators. As I argued above, variation in prices is a better measure of risk as it takes into account both supply and demand sides of the market. Third, it develops an index of world energy import prices to provide an indicator of changes in international energy prices. This provides a better measure than simply using oil price data. Finally, it

[18] The unrivalled source for understanding oil security concerns historically is Yergin, Daniel (1991), *The Prize: The Epic Quest for Oil, Money and Power* (New York: Simon & Schuster).

[19] Neff, Thomas L. (December, 1997), 'Improving Energy Security in Pacific Asia: Diversification and Risk Reduction for Fossil and Nuclear Fuels', Paper commissioned by Pacific Asia Regional Energy Security Project.

[20] Sōgō Shigen Enerugii Chōsa Kai (2000), 'Sōgō Bukai, Enerugii Sekyuritei Wākingu Gurūpu' (Tokyo: Shigen Enerugii Chō).

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

covers a 30-year period from 1970–99 rather than focussing on limited time periods of analysis. This will allow for a preliminary assessment of how risks have changed over time.

The analysis covers oil, LNG, LPG, and steaming coal imports. Data on the prices, quantities, and origin of imports of these energy imports were collated from published sources. Data for both uranium and enriched uranium imports and prices were not available from published sources to the extent they could be used in the statistical analysis. Missing values, because of a lack of either import price or quantity data were deleted from the data set. In most cases, these appeared to represent small amounts of imports from countries which seemed to only trade with Japan in energy commodities on a one-off or irregular basis. As a result, it is not expected that missing values will bias the data set in any meaningful way.

The construction of the WEIPI only included oil and steaming coal imports from selected countries. It would have been ideal to develop the index from a large number of countries for all energy imports. However, this was not possible because of inadequate world energy trade data. For instance, the IEA has not published LNG import prices by countries for a consistent time period. In order to cater for these data limitations, I constructed the WEIPI for the period 1970–99 from data for crude oil and steaming coal import quantities and prices for France, Germany, Italy, Japan, UK, and US. I calculated the index by multiplying each country's energy import prices by their share in total imports of the six nations.

The use of only crude oil and coal for a limited set of countries can be justified on two grounds. The first is that oil, LPG, and LNG import prices tend to be highly correlated with each other. Coal import prices are less correlated with other energy import prices. Hence, this will reduce the bias associated with the omission of LNG and LPG import data from the index, as changes in LNG and LPG prices will be reasonably well captured in changes in oil prices. The second is that oil and steaming coal imports of these countries represent about 50% of world trade. As these are major importers, they are likely to have a large influence on the determination of world import prices, and, therefore, be a reasonable overall measure of those prices. Despite these limitations, the use of limited set of countries and fuels provides a reasonable basis upon which to generate the WEIPI.

The examination spans a 30-year period from 1970–99 and, therefore provides a comprehensive analysis of the impact of diversification on the systematic and specific risks of energy imports. In this analysis, I break the period into two sub-periods: 1970–84 and 1985–99. The justification for this periodisation is two-fold. The first relates to the impact of the fundamental changes which had taken place in international oil markets. Higher oil prices during the 1970s and 1980s had encouraged the development of alternative sources of energy and new oil fields such as the North Sea. This weakened the ability of OPEC to set oil prices. In response, Saudi Arabia's changed its oil export policy in 1985–86 to cease acting as OPECs swing producer. Subsequently, the international oil market became more competitive and transparent, including the development of

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

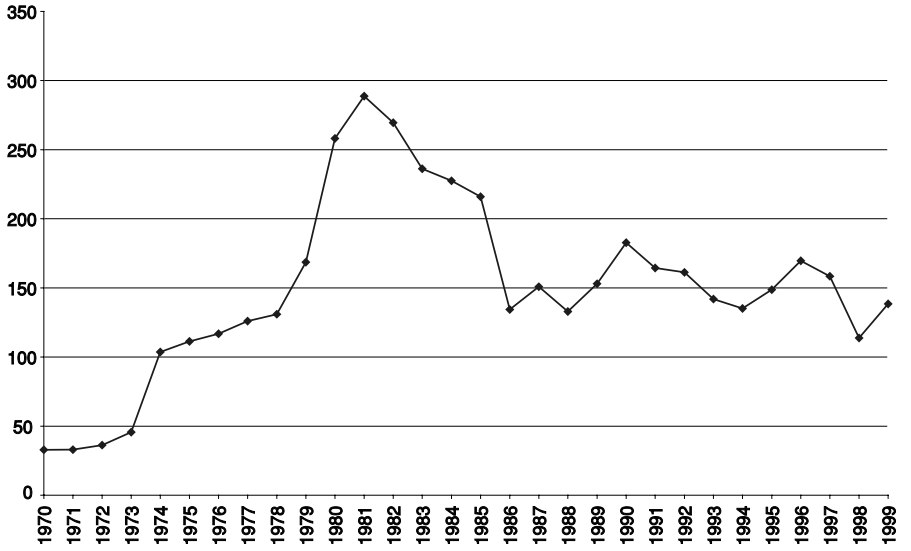


Figure 1 The World Energy Import Price Index (WEIPI)

spot and futures oil markets.[21] These developments had a significant impact on world energy import prices. As Figure 1 highlights, although the WEIPI had been declining since 1981, the fall was much sharper in 1985.[22] Furthermore, the WEIPI has remained significantly lower and less variable since 1985.

The second justification relates to Japan's response to those changes in international oil markets. The market response to these changes led to a significant change in the rate and pattern of diversification. The policy response to this domestic market response came later in the early 1990s when METI (formerly MITI) announced a change in energy policy to giving more balance between policy goals, such as security and efficiency. Table 2 shows this trend using Herfindahl indices.[23] A higher index implies more concentration; a lower index, the converse. It shows categorically that diversification by energy imports, by region, and within both the Middle East and the Asia-Pacific all consistently dropped from 1970–85, but then all remained consistently stable in the subsequent period to 1999. This reinforces the justification for the suggested periodisation.

Table 3 highlights the key results of the analysis. For the period 1970–84, the total portfolio risk was 5259.27 for fuel and 3050.55 for fuel combined with region. The

[21] See van der Linde, *Dynamic International Oil Markets*.

[22] For a good discussion of falling oil prices in the mid-1980s, refer to Adelman, Morris A. (1986), 'Comments and Discussion of Lessons from the 1986 Oil Price Collapse', *Brookings Papers on Economic Activity*, 2: 272–276.

[23] This index is a traditional measure of market concentration. It is calculated by the sum of the squares of market shares controlled by supplier countries by region and fuel source.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

Table 2. *Herfindahl indices of Japanese energy imports*

	1970	1975	1980	1985	1990	1995	1999
By Energy Import	0.26	0.18	0.17	0.10	0.11	0.12	0.10
By Region	0.74	0.62	0.51	0.41	0.40	0.41	0.42
By Middle East Imports	0.30	0.23	0.24	0.15	0.17	0.18	0.15
By Asia–Pacific Imports	0.96	0.34	0.25	0.14	0.15	0.13	0.16

Source: Compiled from data from The Energy Data and Modelling Center, Institute of Energy Economics, Japan.

dominant component of total risk was systematic risk; 95% for fuel and 97% for fuel combined with region. The largest contribution to systematic risk was oil (4947.49) and, more specifically, oil from the Middle East (2612.22). This reflects the weight of oil and oil from the Middle East in total energy imports over the period. Japan achieved considerable diversification during the period (see Tables 1 and 2) which is reflected in the specific risks for both fuel and fuel combined with region, both being extremely low compared with the systematic risks that the country faced. The variation in the WEIPI for the period was 4350.48, and provides evidence that the significant increases in world energy import prices, the impacts of which were not easily avoidable, swamped any diversification effects that Japan was able to achieve.

The security risk picture changed dramatically in the period 1985–99. Total portfolio risk for fuel declined significantly from 5259.27 to 305.84, and for fuel combined with region from 3055.55 to 175.10. The largest contributor to this decline in overall portfolio risk was the decline in systematic risk. For fuel, systematic risk declined from 5019.63 to 209.41, and for fuel combined with region, it declined from 3050.55 to 132.03. This reflected declining betas. The sensitivities of Japanese energy import prices by fuel and by fuel combined with region all declined in the period 1985–99. This also crucially reflected the profound changes that had taken place in international oil and energy markets since the mid 1980s, particularly the weakened power of OPEC to set oil prices. Over the period, the variation in the WEIPI declined from 4350.48 to 307.59. Japan faced an external environment in which the political economy of international energy markets, as reflected in world energy import prices, was much more stable over the period (see Figure 1).

Specific risk also declined compared with the earlier period. For fuel, it declined from 239.88 to 96.43. For fuel combined with region, it declined from 80.04 to 43.07. The major contributor to the decline in specific risk was the reduction in specific risk for oil and for oil from the Middle East. For oil, it declined from 235.84 to 86.23. For Middle East oil, it declined from 64.76 to 33.90. Interestingly, the specific risks for alternative energy fuel imports from non-Middle East regions generally increased over the two periods. However, these increases were small in relation to the decreases in specific risks for oil and Middle East oil.

Japan's strategy of diversifying out of oil into non-oil imports has had quite a large impact on reducing specific risks. Even though Japan's dependence on Middle East oil

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

Table 3. *Measures of security risks*

Category	Fuel	NOBS	Period	$\sigma_m^2 X_i^2 \beta_i^2$ Systematic (a)	$X_i^2\ \varepsilon_i^2$ Specific (b)	Portfolio (a + b)	β_i	ε_i	X_i	σ_m^2
Fuel	Oil	272	1970–84	4947.49	235.84		1.23	17.71	0.87	4350.48
	LNG	47	1970–84	49.88	1.50		1.45	16.55	0.07	4350.48
	LPG	140	1970–84	22.24	2.54		1.43	31.87	0.05	4350.48
	Coal	59	1970–84	0.01	0.00		0.20	5.67	0.01	4350.48
	β_{pf}		1970–84	5019.63	239.88	5259.51				
	Oil	298	1985–99	196.91	86.23		1.14	13.27	0.70	307.59
	LNG	90	1985–99	10.50	3.35		1.02	10.06	0.18	307.59
	LPG	158	1985–99	2.00	6.80		1.17	37.79	0.07	307.59
	Coal	104	1985–99	0.00	0.05		0.08	4.37	0.05	307.59
	β_{pf}		1985–99	209.41	96.43	305.84				
Region By Fuel										
Asia–Pacific	Oil	67	1970–84	303.49	12.93		1.23	16.68	0.22	4350.48
	LNG	39	1970–84	37.72	1.15		1.41	16.17	0.07	4350.48
	LPG	55	1970–84	0.60	0.05		1.35	25.98	0.01	4350.48
	Coal	38	1970–84	0.01	0.00		0.20	4.74	0.01	4350.48
Middle East	Oil	127	1970–84	2612.22	64.76		1.23	12.73	0.63	4350.48
	LNG	8	1970–84	0.75	0.01		1.73	11.85	0.01	4350.48
	LPG	64	1970–84	13.14	0.94		1.35	23.78	0.04	4350.48
Others	Oil	78	1970–84	2.57	0.21		1.24	23.19	0.02	4350.48
	LPG	21	1970–84	0.00	0.00		1.77	30.35	0.00	4350.48
	Coal	21	1970–84	0.00	0.00		0.20	5.31	0.00	4350.48
	β_{pr}		1970–84	2970.51	80.04	3050.55				
Asia–Pacific	Oil	119	1985–99	11.48	3.46		1.16	11.21	0.17	307.59
	LNG	71	1985–99	8.70	2.10		1.02	8.79	0.16	307.59
	LPG	64	1985–99	0.08	0.27		1.27	41.14	0.01	307.59
	Coal	75	1985–99	0.00	0.04		0.09	4.64	0.04	307.59
Middle East	Oil	138	1985–99	110.61	33.90		1.13	10.98	0.53	307.59
	LNG	19	1985–99	0.09	0.06		1.00	14.41	0.02	307.59
	LPG	83	1985–99	1.06	3.23		1.06	32.39	0.06	307.59
Others	Oil	41	1985–99	0.01	0.01		1.23	17.90	0.00	307.59
	LPG	11	1985–99	0.00	0.00		1.18	54.16	0.00	307.59
	Coal	29	1985–99	0.00	0.00		0.07	3.42	0.00	307.59
	β_{pr}		1985–99	132.03	43.07	175.10				

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

rebounded from the mid 1980s, this has not had the effect of increasing specific risk of increased reliance on imported oil from that region, contrary to the officially stated concerns of energy policy makers in Japan.[24] More careful analysis is required here, but one reason might be that Japan has diversified significantly within the Middle East since the 1970s, although that diversification remained constant since 1985 (see Table 2). This may very well provide further evidence to substantiate Neff's (1997: 15) claim that the specific risk of relying on Middle East oil can be reduced by an appropriately diversified portfolio within the Middle East.

It is also interesting to note that specific risk has also declined significantly despite relatively high levels of concentration of fuel imports by region. As Table 1 highlights, during the 1990, close to or over 80% of all fuel imports came from specific regions, and this reflected in the high Herfindahl ratio during that period (see Table 2). This suggests the importance of not only considering the risks from any one region, but also evaluating the combination of risks from different sources in analysing total specific risks. While Japan's energy fuel imports remain highly concentrated by region, the risks associated with that reliance on a combination of regional import markets is clearly less than those associated with any of those regional imports by themselves. High regional concentrations of imports do not necessarily correlate with high overall specific portfolio risk.

The results imply that positive betas do not necessarily mean that diversification cannot assist in reducing specific risk. All the betas are positive, indicating that changes in all the prices of Japanese imports move in ways that are correlated positively with common movements in international energy prices. However, there are variations in the betas for different types of energy imports by fuel and by fuel combined with region. For instance, the betas in the period 1985–99 were oil (1.14), LNG (1.02), LPG (1.17), and coal (0.08), suggesting that oil, LNG, and LPG import prices are more correlated with each other than they are with coal import prices. These variations open up possibilities for reducing specific risks through diversification. For example, by diversifying into LNG and coal (both have betas less than oil), it is possible to reduce the risks of oil supply disruptions and price increases, no matter how they occur. It should be noted, however, that the magnitude of those risk reductions will be significantly less than a case where co-variances are negatively correlated.

Conclusions and implications

An empirical investigation of Japanese energy import security risks supports the major contentions generated by portfolio theory about the nature and management of those risks. Diversification has been a useful strategy for reducing specific security risks as it spread the risks of dependence across different fuels and different regions supplying those fuels. Even though the co-variances between energy import prices have been positive, variations in their magnitudes opened up the scope for specific

[24] See Sōgō Shigen Enerugii Chōsa Kai (2000), 'Report of the Energy Security Working Group'.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

risk reduction through diversification. However, given the structure of co-variances, diversification by itself has not been able to reduce specific risks below the level of systematic risk.

These quantitative conclusions help to interpret the impact of Japan's diversification policy on the complex patterns of changing energy import dependence ratios over the last three decades. Japan was confronted by very high levels of systematic risk, high during the turbulent, politicised oil market conditions of the 1970s and early 1980s. Japan was caught in a position of being heavily reliant on imported oil, particularly from the Middle-east. In response Japanese energy policy was directed to diversifying away from oil and Middle East oil. Since the mid 1980s, Japan's systematic security risks have declined markedly. International oil markets have become less politicised, and market conditions have become less volatile. But Japan's policy of diversification during the 1970s and early 1980s started to have important impacts on specific risk in the period since the mid 1980s. While movement into alternative energy sources outside the Middle East was associated with some increased specific risks, the impact of movement away from oil has resulted in a substantial net reduction in specific risks, despite Japan once again increasing its dependence on Middle East oil over the period.

The results of the analysis have broader policy implications for the comparative utility of different indicators in energy policy processes. Dependence ratios are used commonly in Japan and other nations heavily reliant on imported energy in energy policy making and implementation processes.[25] These ratios provide a measure of the amount (quantities or economic values) of the relevant item (say, imports) that one is interested in, expressed as a %age of the total amount of that item. While there are an enormous number of dependency ratios which can be calculated, two particular ratios figure prominently in discussions of Japanese energy policy: oil import dependence and Middle East oil dependence.

While these measures provide one indication of the concentration or spread of imports by fuel category and by fuel and region category combined, by themselves they say very little about the risks of dependence. For instance, oil import dependence ratios are measured as the share of imported oil to total energy imports. The numerator says little explicit about the relative risks of relying on different sources of oil, and, indeed, assumes that those relative risks are the same. The denominator reveals virtually nothing explicit about the relative risks of 'other' fuel imports, such as LPG and coal. The interaction between the numerator and the denominator (the ratio itself), fails to inform us about the relative risks of oil versus other imports.

The continued use of dependency ratios may be due to habit or custom. Once indicators are developed, they tend to get used even when policy makers become aware of their limitations. It may also be due to policy politics. The selection of numbers in the policy process matters — it is political because some measures are used while others

[25] Kendell, James M. (1998), 'Measures of Oil Import Dependence', in US Energy Information Administration, *Issues in Midterm Analysis and Forecasting*, DOE/EIA 0607(98).

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

are not. They are crucial in demonstrating the wisdom of preferred policy choices and mobilising political support for those choices.[26] For example, Japan continually has used Middle East oil dependence ratios as a key rationale for seeking to maintain public support for nuclear power at the national level, and in seeking to persuade local communities to accept nuclear plants. Whatever the reason, the results of this analysis show that the continued use of Middle East oil dependency ratios as a justification of energy security policies can increasingly be seen as a 'red-herring'.

Dependence ratios provide an inadequate measure in understanding and managing energy security because they do not explicitly take into account the multiplicity of risks of adverse disruptions in international energy markets. In contrast, portfolio approaches provide a better indicator of energy import security risks on both theoretical and methodological grounds. Theoretically, they explicitly specify and categorise different security risks and specify the relationship between diversification and those risks. Methodologically, they provide ways of measuring those different types of risk and assessing their relative importance in overall risk. Such estimates can be used in the formulation, implementation and evaluation stages of the policy process.

The policy implications for energy security are crucial. Not taking into account risk explicitly and accurately can lead to policy prescriptions, which might potentially be costly. Changed levels of dependence may or may not mean changed levels of risk. For example, reducing dependence on a particular source of energy import might actually reduce security if the risks of increasing dependence on another supplier are higher. Similarly, increasing strategic stockpiles might be more costly than a combination of diversification and strengthening diplomatic and trade relations in a situation where systematic risks are relatively low in relation to specific risks, and are expected to remain low. Theoretically informed assessments of risk provide more scope for explicitly targeted policy responses to ensuring energy security.

While the approach adopted in this article has provided a useful preliminary assessment of energy import security risks, there are at least two methodological limitations to the analysis. The first is the analysis measures risks *ex-post*. It would be useful to conduct an analysis of the risks *ex-ante*, as subjective perceptions can and do play a crucial role in understanding risks. Such an analysis might define risk as the chance that the supply and price of energy might be different from that expected, and lead to the development of measures of expected energy security risks based on that definition of subjective risk. A second, and related limitation, is that the analysis assumes that international oil markets are operating under reasonably competitive conditions. It does not take into account explicitly the risks when the market fails, such as when a country might be targeted by a set of oil producers to change its international policy position. It would be interesting to seek to model more carefully the extent to

[26] For an excellent discussion of the use of numbers in the policy process, see Stone, Deborah (1997), *Policy Paradox: The Art of Political Decision Making* (New York and London: W.W. Norton).

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press

which diversification worked in enhancing energy security in the face of attempted or actual use of threats.

Despite these limitations, portfolio analysis provides an important new way of assessing quantitatively security risks. METI has taken a first step in using this framework in the energy policy formulation process in Japan. Measures that explicitly take into account risks should ultimately not be relegated to the appendices of energy policy reports. As energy importers will continue to confront security risks, it is those measures that do not account adequately for risk that should be pushed into appendices. It is hoped that this paper will stimulate further research into this technique and, in doing so, help provide a better basis upon which to design appropriate policies to deal with energy security risks.

https://doi.org/10.1017/S146810990400129X Published online by Cambridge University Press