The Asian Crisis and Macroeconomic Development: The Impact of Ambiguity [1]

by

Willy Spanjers[2]

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[1] Helpful comments and suggestions by Subrata Ghatak, Paul Levine and Joachim Stibora are gratefully acknowledged.
[2] Address for correspondence: Willy Spanjers, School of Economics, Kingston University, Penrhyn Road, Kingston-upon-Thames, Surrey KT1 2EE, United Kingdom. Email: w.spanjers@kingston.ac.uk

1. Introduction

When casually contemplating the intricacies of improving the standard of living in developing and emerging economies, the terms ‘growth’, ‘uncertainty’ and ‘crisis’ are among the first that come to mind. To improve standards of living, economic growth is a necessity. The outcomes of the policies devised for achieving growth are subject to all kinds of uncertainties. And if things fail to work out as planned, one may end up with a full blown economic crisis. A particularly powerful combination of growth, uncertainty and crisis has been provided by East Asia. After a prolonged period of extraordinarily high growth, in 1997 a sudden and unexpected boot of uncertainty led to the reversal of international financial flows and caused an unprecedented crisis.

The purpose of this paper is to provide a coherent framework in which the main characteristics of growth, uncertainty and crisis are connected. Within this framework, we find that these issues, which were so prominent in East Asia, are consequences of the chosen development strategy. Thus, we identify a fundamental mechanism that relates the high levels of per capita growth in the East Asian countries before the crisis, its fall during the crisis and the more modest growth rates thereafter. We address the question whether or not crises can be prevented in the process of economic development and, if so, whether it is desirable to do so.

The approach of this paper differs from the usual perspective on the East Asian crisis which relates to the well established literature on currency crises. In this literature, different mechanisms that may trigger a currency crisis are identified, often with the intention of developing early warning systems as to when a crisis may be immanent. The different types of mechanisms are distinguished in different “generations” of models. The first generation models follow the seminal paper by Krugman (1979), according to which a currency crisis occurs when the specified dynamics make such a crisis inevitable. The second generation models, in the spirit of Obstfeld (1986, 1996), argue that some crises are not inevitable, but rather the consequence of a self fulfilling prophecy, i.e. of equilibrium selection and coordination problems. More recently, third generation models following Morris and Shin (1998) remove the multiple equilibrium aspects by assuming a lack of common knowledge among investors. In the survey article of Breuer (2005), a fourth generation of models is identified, which focus on institutions and loss of confidence as potential causes.

In many respects, the above mentioned research relates to models of bank runs in the spirit of Bryant (1980) and Diamond and Dybvig (1983), in which bank runs are suboptimal and should be prevented. The desirability of preventing bank runs in a setting with risky assets, however, has recently been challenged by Allen and Gale (1998) and Spanjers (1999/08, Chapter 3). When the likelihood of a bank run is low and its costs are limited, while the opportunity costs of preventing a bank run are high, it is better to accept the occasional occurrence of bank runs, rather preventing them.

In this setting the impact of incalculable risk, also known as Knightian uncertainty or ambiguity, is analyzed by Spanjers (1999/08, Chapter 5). The typical results in the presence of calculable risk are confirmed. But in addition it is found that the updating of ambiguous beliefs regarding returns introduces dynamic inconsistency in the behaviour of investors. When banks choose their reserve policies, it is difficult for them to distinguish between investors being exposed to subjective calculable risk and investors facing ambiguity. If banks wrongly interpret the investors to be exposed to calculable risks when they actually face incalculable ambiguity, the dynamic inconsistency appears to cause investors to “overreact” and “panic” in the face of bad news, unexpectedly causing a bank run.

Spanjers (1998/09) shows that these results also hold for currency crises. In particular, it is shown that the stylized facts of the East Asian crisis match the mechanisms and conclusions of the model. It is argued that the crisis was shaped by a loss of confidence of investors, caused by a combination of perceived incompetence of key policy makers, bad news, and incalculable political risk. In the language of the model, the dynamic inconsistency associated with the incalculable risks wrong-footed central banks, which were not aware of its presence. Investors seemed to “overreact” and to “panic”, reversing international financial flows to an extent that was previously unimaginable. For a comprehensive description of the East Asian crisis see Williamson (2004).

The current paper takes a different approach to the East Asian crisis. Rather than modelling the investment opportunities as high yielding illiquid assets, the analysis is based on different strategies for economic growth and development. It incorporates the impact of globalisation, recognizing the effects of both international financial liberalization and of the internal and external increasing returns to scale that characterize modern production technologies. In particular, the effects of a low technology development strategy are compared to those of a high technology strategy.

In line with modern decision theory, the uncertainty involved in development strategies for emerging countries is understood to include both (calculable) risk and (incalculable) ambiguity in the tradition of Knight (1921) and Keynes (1909/21). Decision making under ambiguity is modelled a by basic version of the approach pioneered by Schmeidler (1982/89). A prominent area of recent economic applications of ambiguity and incalculable risk is monetary policy. Ghatak and Spanjers (2007) discuss the impact of ambiguity on monetary policy rules in transition economies; in a more general monetary policy context applications can be found in e.g. Hansen and Sargent (2003, 2007), Levine and Pearlman (2008) and Spanjers (2008).

In the setting of the current paper we analyse the impact of ambiguity on the decision which development strategy to follow. Here ambiguity can take the form of incalculable political risk or of unpredictable reverses of international financial flows. Our theoretical analysis indicates that risk neutral but ambiguity averse investors and policy makers may be tempted to implement a low technology development strategy in the face of ambiguity, where a high technology strategy would be appropriate.

A brief examination of growth rates of per capita GDP for selected countries from East Asia and other parts of the world illustrates the theoretical argument. This leads to policy recommendations that focus on either reducing incalculable risks or insulating the high technology strategy from its impact. The recommendations not only question the appropriateness of what seems to be a cautious economic development strategy in the selected East Asian countries. It also highlights the importance of reducing the incalculable political risks in the Middle East and in Russia. Regarding the incalculable risk of a reversal of financial flows, a combination of high currency reserves and appropriate reform of the IMF is recommended.

The remainder of the paper is structured as follows. Section 2 discusses agglomeration and cluster effects and describes the basic features of both a low technology and a high technology development strategy. In Section 3 an intuition for ambiguity is provided, along with a basic description of the associated decision-theoretical model. The implications of ambiguity in the presence of decreasing and increasing returns to scale are also discussed. Section 4 focuses on the analysis of the growth rates generated by the two development strategies. In this context the behaviour of risk neutral but ambiguity averse policy makers and investors is discussed and analyzed, followed by a brief examination of the per capita growth rates of selected countries over the period 1975 – 2005. The final section, Section 5, contains policy recommendations.

2. Agglomeration Effects and Development Strategies

The breathtaking development of the Asian "tiger" economies during the past three decades benefited strongly from the process of globalisation. Indeed, the international economy as a whole has been subject to momentous changes, some triggered by globalisation, some fuelling it. Changes in the international institutional structure did much to support global economic integration, but the forces that were released are of a more fundamental nature.

Globalisation can best be understood as a reaction on fundamental changes caused by technological progress. It is the shift from production technologies that exhibit internal and external decreasing returns to scale to technologies that are characterized by internal and external increasing returns to scale that has shaped the ongoing processes of economic globalisation. The "Asian experience" provides an excellent illustration of this.

Of course, external increasing returns to scale in the form of agglomeration and cluster effects were relevant for past processes of economic development. But the reasons for agglomeration were more strongly linked to the proximity to specific resources or the presence of geographical features. Geographical features could provide a location advantage in terms of protection against destruction by wars or in terms of the ease with which a cost effective transportation infrastructure could be provided. For more recent technological progress, agglomeration and cluster effects are no longer linked to exogenously given geographical structures. Rather, they are endogenous results of the choice of location of production sites. This is the distinguishing feature between the "old" and the "new" economic geography, as discussed, amongst others and from different perspectives, in Neary (2001), McCann and Shefer (2005) and Fujita and Mori (2005).

The agglomeration and cluster effects related to external increasing returns to scale are driven by direct and indirect positive externalities of production. Such synergy effects may range from the efficient use of local physical infrastructure to the availability of a pool of skilled labour. But they may also relate to the ease with which communication may take place, improving the functioning of financial markets and facilitating cooperation in research and development. The success of the financial centres of, for example, New York, London and Hong Kong is an illustration of how powerful agglomeration and cluster effects can be for financial markets. Silicon Valley is an example of their potential impact in the area of research and development. Many more examples can be found that illustrate the potential advantages of geographically concentrating the production of specific sectors.

When contemplating which path to follow for developing their economies, policy makers are aware of the importance of external increasing returns to scale. But there still are trade-offs to be made, as strategies that aim to exploit external economies of scale may have disadvantages in other respects.

For simplicity, we consider only two proto-typical economic development strategies: a low technology strategy and a high technology strategy. As indicated below, these development strategies differ with respect to internal and external economies to scale, financial requirements, governmental policies, and vulnerability to calculable and incalculable risks. The government chooses which policy to pursue with the instruments available to them.

Low technology strategy

The first development strategy is of a more traditional nature and focuses on established low technology sectors, of which agriculture is an important example. Such technologies typically have either decreasing internal returns to scale or relatively small optimal sizes. They tend not to rely on elaborate and expensive physical infrastructure of traffic, utilities and communication networks and make modest demands on the non-physical infrastructure, including the judiciary and educational systems.

Although they may produce for foreign markets, these low technology sectors are relatively independent of globalization. Their economic success is only moderately linked to the speed and direction of the liberalisation of international trade. The low level of technology also reduces the need for protection of intellectual property rights and makes the impact of their violation on technology transfer an issue of secondary importance. The tried and tested technologies do not involve significant levels of calculable or incalculable technological risk. Similarly, the modest financial requirements of developing these sectors reduce both the importance of financial liberalisation and the impact of volatility of international financial markets.

The impact of the decreasing external returns to scale of the low technology development strategy is not restricted to the economic sphere. It also has consequences for the economic geography and the role of the government. Because of the decreasing external returns to scale, the clustering of economic activity tends to be counter-productive. The more geographically concentrated production is, the higher the average costs of production will be, all else being equal. In a decentralized economic system, the uncoordinated individual decision making will tend to result in a geographically even distribution of economic activity. So disparities in geographical patterns of economic growth and income will tend to be small and there will not be a tendency towards excessive migration pressures. This greatly reduces the need for regional income re-distribution or for elaborate regional economic policies.

As a consequence, the low technology development strategy does not require a strong and efficient political governance structure. The services a government may provide are, from an economic perspective, not overly important. There is no strong need for enhancing human capital through education or for providing a relatively up-to-date infrastructure. Nor is there a need for the regional redistributing of income or for regional development policies. The relative insulation from the effects of globalisation also reduce the need for a competent and forward looking foreign policy on trade and other issues. Finally, the low dependence on financial resources and foreign technologies reduce the reliance on international investors and the need to pay attention to their nervousness regarding various forms of political risks.

High technology strategy

For a development strategy that focuses on the adoption and development of high technology production processes the opposite holds. These processes, which often are knowledge intensive, show the increasing internal returns to scale that are normally associated with research and development. High technology sectors also have increasing external returns to scale, partially because of their reliance on a well-developed physical and non-physical infrastructure. The demands on physical infrastructure relate to swift and reliable connections with the rest of the world, both physically through roads, railways, harbours and airports, and virtually through modern information and communication technologies. The need for experts requires the presence of a high quality merit-based education system. There is a need for well-connected and internationally recognized universities and research institutes that are able and willing to communicate relevant scientific progress to the local industry.

Given the global character of high-technology sectors, embracing globalisation is crucial for this development strategy. It requires governments to accept and implement global treaties on trade and on intellectual property rights. As high technology sectors typically produce for international markets, trade liberalisation and an internationally level playing field are important for the success of the strategy, despite the efforts of some governments to protect their domestic markets in an effort to grow national champions in specific sectors. Furthermore, the importance of international cooperation in research and development make the adherence to treaties on intellectual property rights crucial, as this is a pre-requisite both for the exchange of knowledge and ideas and for the transfer of technology.

Financial liberalisation and openness are also important for a high technology oriented development strategy. Not only does this strategy require a substantial amount of financial resources, which some countries may find difficult to accumulate through domestic savings. The high levels of calculable and incalculable risk make it sensible and efficient to use the risk-sharing opportunities of the international financial system. This risk sharing leads to an increased dependence on international financial flows, both in the form of portfolio investment and in the form of foreign direct investment.

A disadvantage of the geographical clustering caused by a high technology development strategy is that it creates disparities between regions within the country that may be difficult to manage. These disparities can include differences in income, employment, access to education, health services, local infrastructure, and individual freedoms. The disparities of such dual economy tend to lead to migration and self-selection effects that re-enforce existing differences. Left to its own devices, uncoordinated individual decision making is likely to result in an economic and social structure that is full of tensions that can easily get out of control.

Therefore, apart from the economic requirements, a high technology development strategy requires a strong, competent government, which is capable of devising and implementing policies that reduce tensions and bridges the internal divide. The government must efficiently supply the appropriate infrastructure within the agglomerations, provide adequate education and create an environment in which internationally mobile experts feel comfortable and well at ease. It needs to engage in development strategies for the regions of the country that are not part of the successful clusters and implement a regional redistribution of income. It must direct internal migration flow in ways that support the growth and development of clusters, rather than hamper it.

There also will be a need to build consensus for and conduct a foreign and trade policy that embraces the process of globalisation, e.g. by skilfully negotiating and adhering to international, regional and bilateral trade treaties. Given the reliance of the high technology development strategy on international finance, there is a need for providing a transparent and stable governance structure. International investors' nervousness with respect to political risk needs to be taken seriously, as a reversal of financial flows may have catastrophic effects on the success of the development strategy.

Given the different requirements the two development strategies make on the government, weak and instable governments may be justified in their preference for following isolationist impulses and for setting unambitious targets for economic growth and development. Their weakness creates an environment in which an ambitious high-technology development strategy would suffer from the political and policy risks and, therefore, would be inappropriate. Strong, competent and stable governments, on the other hand, may well be encouraged to embrace globalisation and the chances it offers for achieving the high growth rates that are associated with a high technology oriented development strategy.

The main characteristics of the two development strategies are illustrated in the diagrams in the next section. Before turning to the graphical analysis, the intricacies of decision making under the uncertainties involved in the two development strategies are discussed.

3. Political Risk and Ambiguity

When speaking about uncertainty, economists almost without exception refer to calculable risk. This reflects the usefulness of the separation of beliefs from the evaluation of outcomes that characterizes the subjective expected utility approach. The possibility of such a separation on the basis of an objective axiomatic foundation was convincingly shown by Savage (1954) and Anscombe and Aumann (1963). On the basis of their work one can easily be led to believe that for all practical purposes uncertainty can be represented by subjective probability distributions. The refutation of the "Sure Thing Principle" by the thought experiment in Ellsberg (1961) would seem nothing but one of many irrelevant oddities and paradoxes. In reality, it shows a systematic aversion for situations in which probabilities are unknown and, therefore, risks are incalculable.

In the Ellsberg Paradox choices need to be made between bets with known probabilities and bets with unknown probabilities. For this purpose, consider an urn containing 90 balls. The colours of the balls are blue, red or yellow. The urn contains 30 blue balls; the remaining 60 balls are red or yellow in an unknown proportion. In the first instance, the choice is offered between two bets, B_1 and B_2. B_1 pays £ 100 if the ball drawn from the urn is blue, and nothing otherwise. Similarly, B_2 pays £ 100 if the ball is yellow. When faced with the choice between B_1 and B_2, B_1 is typically chosen, implying that the subjective probability of a blue ball exceeds that of a yellow ball.

<table>
<tr><td></td><td>Blue</td><td>Red</td><td>Yellow</td></tr>
<tr><td>Number of balls</td><td>30</td><td colspan="2">60</td></tr>
<tr><td>B_1</td><td>£100</td><td>£0</td><td>£0</td></tr>
<tr><td>B_2</td><td>£0</td><td>£0</td><td>£100</td></tr>
<tr><td>B_3</td><td colspan="2">£100</td><td>£0</td></tr>
<tr><td>B_4</td><td>£0</td><td colspan="2">£100</td></tr>
</table>

Next the bets B_3 and B_4 are considered, where B_3 pays £100 if the ball is either blue or red and nothing if it is yellow. B_4 pays £ 100 if the ball is either red or yellow. Once again, faced with a choice between B_3 and B_4, the bet with the known probabilities, B_4, is chosen. So the subjective probability of {either a red or a yellow ball} exceeds that of {either a blue or a red ball}. This implies that the subjective probability of a blue ball must be less than the subjective probability of a yellow ball, contradicting the result of the first comparison. Therefore, the decision maker cannot have been a subjective expected utility maximizer.

Compelling as thinking of the Ellsberg Paradox as an irrelevant oddity may seem, it misses the point. The difference between (calculable) risk and (incalculable) ambiguity, as discussed in an early stage by Knight (1921) and Keynes (1909/21), is more than a mirage. It is this fundamental difference that is reflected in the Ellsberg Paradox. What is more, after the work by Schmeidler (1982/89) the type of solution proposed by Ellsberg (1961) can no longer be criticized as "ad hoc". Rather, Schmeidler provided it with a decision-theoretic foundation as solid as that of the subjective expected utility approach.

Uncertainty: Risk and Ambiguity

So what exactly is meant by incalculable risk or ambiguity? Perhaps the clearest explanation is provided by Keynes (1937). Keynes states:

> "By 'uncertain' knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty [...]. The sense in which I am using the term is that [...] there is no scientific basis on which to form any calculable probability whatever. We simply do not know."
> [pp. 113-114]

Keynes than continues to discuss its implications

> "Now a practical theory of the future [...] has certain marked characteristics. In particular, being based on so flimsy a foundation, it is subject to sudden and violent changes. The practise of calmness and immobility, of certainty and security, suddenly breaks down. New fears and hopes will, without warning, take charge of human conduct. The forces of disillusion may suddenly impose a new conventional basis of valuation. All these pretty, polite techniques, made for a well-panelled board room and a nicely regulated market are liable to collapse. At all times vague panic fears and equally vague and unreasoned hopes are not really lulled, and lie but a little way below the surface."
> [pp. 114-115]

To him, these implications are not without consequences for economic theory

> "[T]he fact that our knowledge of the future is fluctuating, vague and uncertain, renders wealth a peculiarly unsuitable subject for the methods of the classical economic theory. This theory might work very well in a world in which economic goods are necessarily consumed within a short interval of their being produced. But it requires, I suggest, considerable amendment if it is to be applied to a world in which the accumulation of wealth for an indefinitely postponed future is an important factor; and the greater the proportionate part played by such wealth accumulation the more essential does such amendment become."
> [p. 113]

When facing the decision between a low technology development strategy and a strategy that focuses on high technology, policy makers face various forms of (calculable) risk and of (incalculable) ambiguity. Some of the ambiguity is inherent in the development and implementation of high technology processes, as the country may not have had the opportunity to gain experience with them. Indeed, the lack of relevant past experience on the basis of which to form reasonable (subjective) probability estimates is what Knight (1921) considers the basic cause of ambiguity.

Another source of ambiguity, which is most relevant for developing and emerging economies, is political uncertainty. It is easy to imagine how changes in the confidence of international investors in the behaviour and stability of governments can lead to unpredictable reactions of international financial markets. It may lead investors, seemingly without proper regard for the unchanged fundamentals, to radically change their valuation of assets or reverse long standing financial flows. In similar ways incalculable risk may affect the behaviour of other decision makers directly or indirectly involved in the implementation of the chosen development strategy.

To develop an intuition for how the impact of (incalculable) ambiguity on the decision process may differ from that of (calculable) risk, we compare both situations below. For this purpose we consider a variation of the familiar risk premium, which equals the difference between the expected value of a random variable and the certain value which leads to an outcome the decision maker considers as equally good. It is compared with an overall uncertainty premium, which also takes ambiguity into account. The difference between the two premiums reflects the impact of ambiguity.

The Risk Premium

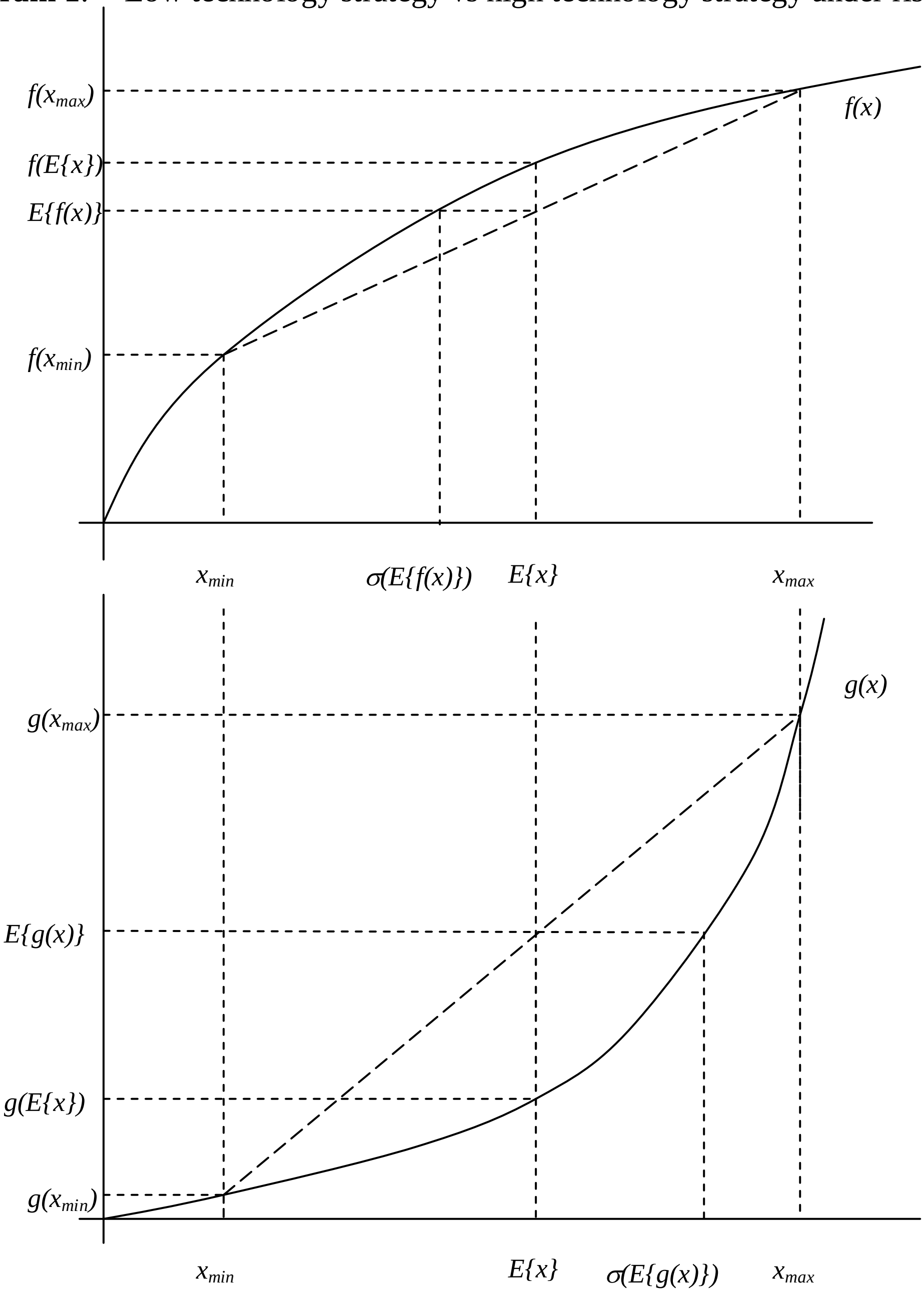
When one has found a way to make incalculable risk, i.e. ambiguity, calculable, defining the counterpart of a risk premium is a straight forward task. Focusing on the effect of ambiguity by considering a risk neutral decision maker was done in Spanjers (1999/08, Section 8.4). The same approach is followed in this paper to analyse the impact of ambiguity on the evaluation of the two development strategies outlined above.

Consider a risk neutral decision maker who faces two possible outcomes for the amount of financial resources available for implementing the development strategy. This amount is either low, x_{min}, or high, x_{max}. The valuation of the two strategies is depicted in Diagram 1.

In Diagram 1 we have two indirect production functions. The function f depicts the output of a low technology development strategy as a function of the financial resources available. It is an *indirect* production function. It implicitly incorporates the equilibrium of the interactions between both private sector and political decision makers for an overall amount of available financial resources x. This equilibrium comprises behaviour in all relevant aspects under the assumption that the low technology strategy is followed. Similarly, the function g is an indirect production function depicting the output when a high technology strategy is pursued and financial resources x are available.

The ratio of probabilities with which the financial resources x_{min} and x_{max} are obtained corresponds to the ratio of the distance between x_{max} and $E\{x\}$ to the distance between x_{min} and $E\{x\}$. The loss in average output caused by the risk regarding the availability of

Diagram 1: Low technology strategy vs high technology strategy under risk



financial resources, as compared to the output that would be obtained if the average financial resource was available with certainty, is obtained on the vertical output axis as

$$f(E\{x\}) - E\{f(x)\}.$$

If the return for the risk-neutral investors is proportional to output generated, the risk has a negative effect on returns when the low technology strategy is followed. This is the direct analogue of the expected utility of a risk averse investor for an investment strategy with has a linear indirect production function.

The same expected output could have been obtained when financial resources of $\sigma(E\{f(x)\})$ would be available with certainty, the counter part of the certainty equivalent in for a risk averse investor. Similarly, we obtain the analogue of the risk premium for the low technology strategy as

$$E\{x\} - \sigma(E\{f(x)\}),$$

reflecting loss due to the risk, expressed as a reduction in available financial resources.

The lower panel of Diagram 1 depicts the high technology strategy. Its indirect production function has increasing returns to scale. As before, the impact of risk on the investors' return is obtained as the difference between the output for the average financial resources available and the average of the risky output, i.e.

$$g(E\{x\}) - E\{g(x)\}.$$

Since the indirect production function has increasing returns to scale the average return of the high-technology strategy exceeds the return of the average of the available financial resources.

Denoting the analogue of the certainty equivalent of the high technology strategy by $\sigma(E\{g(x)\})$, we obtain

$$E\{x\} - \sigma(E\{g(x)\})$$

as the (negative) equivalent reduction in available financial resources due to risk, i.e. the equivalent gain in available financial resources due to risk. Therefore, the presence of risk increases the average return of the risk neutral investors in the same way as risk increases the expected utility of a risk loving investor.

Evaluating Ambiguity: The Choquet Expected Value

The above discussion does not answer the question which strategy is preferred by a risk neutral investor or policy maker. The decision depends on the level of output or, in a dynamic context, the level of growth that is obtained for the competing strategies. This issue is addressed below in the discussion of Diagram 3 in Section 4. But first we turn our attention to the impact of ambiguity, which is depicted in Diagram 2.

Before we can sensibly discuss the impact of ambiguity on the evaluation of the outcomes of the different development strategies, we have to describe the way in which ambiguity enters the trade-offs made by a decision maker.

In the case of risk, a decision maker is assumed to maximize his expected utility, i.e. the expected value of the von Neumann-Morgenstern utility index u over the outcomes of the random variable described by the pair $(p;y)$, where p describes the probabilities and y the outcomes for the states of nature. The decision maker's expected utility function is now obtained as

$$U(p;y) = E_p\{u(y)\}.$$

When the decision maker is risk-neutral, as in the case we considered above, the von Neumann-Morgenstern utility index is a linear increasing function and the expected utility function U is equivalently represented by taking the expected value of y, i.e. to

$$E_p\{y\}.$$

When considering decision making under ambiguity, the situation is more complex. The beliefs of the decision maker are no longer described by a vector of probabilities and, therefore, it is no longer possible to take an expected value of the von Neumann-Morgenstern utility index over the state-contingent outcomes y.

In the simple case of two possible outcomes, each associated with one specific state of nature, the decision maker's ambiguous beliefs can be represented by the plausible lower bounds he places on the probability that the financial resources equal y_{min} and the probability that they are y_{max}. In particular, the assumption is abandoned that the sum of these lower bounds on the probabilities equals one. Therefore, this representation is more general than that of by a (subjective) probability distribution. In the context of this simple example, the available financial resources will be either y_{min} or y_{max} as before.

An example of the first method to specify of such beliefs assumes that the probability that the available financial resources will be y_{min} is at least 0.25, whereas the probability of y_{max} is at least 0.5. Or, to put it differently, the decision maker considers all probability distributions in the range from

$$0.25 \leq \Pr\{y = y_{min}\} \leq 0.5 \qquad \text{with} \qquad \Pr\{y = y_{max}\} = 1 - \Pr\{y = y_{min}\}$$

to be plausible.

Now that we have stated how the decision maker's ambiguous beliefs can be represented, the next question is how they can be used to evaluate outcomes.

Obviously, there are many different ways in which a decision maker may choose to evaluate this kind of vague or "fuzzy" beliefs. As a general rule, however, it seems plausible to expect the decision maker to act cautiously, i.e. pessimistically. In the presence of a multitude of equally plausible probability distributions, this can be achieved by considering the lowest expected utility value that is compatible with one of the probability distributions that is considered to be plausible. The extreme version of this is the "Hurwicz Principle" (see Hurwicz, 1951, and Arrow and Hurwicz, 1972), and its result is known as the **maxmin value** for the **multiple priors model** axiomized by Schmeidler and Gilboa (1989). Here the decision maker chooses his actions $z \in Z$ to maximize the minimum value of his expected utility over the set of admissible "prior" probability distributions P, i.e.

$$\max_{z \in Z} [\ \min_{p \in P} E_p\{u(x(z))\}\ ].$$

An alternative approach would be to order the possible outcomes in a decreasing sequence with respect to the values they generate for the von Neumann-Morgenstern utility index u. Now one assigns the first, i.e. highest, utility value the minimum probability with which it is obtained. Next, one assigns the minimum remaining probability to the second utility value in the sequence etc. This leads to the **Choquet expected value** of the von Neumann-Morgenstern utility index as axiomized by Schmeidler (1982/89).[3]

So how do these two approaches apply to our example? When following the maxmin approach, it is obvious that the higher the probability associated with y_{min} is, the lower the associated expected utility value will be. Therefore, the ambiguity averse decision maker will assign $\Pr\{y = y_{min}\} = 0.5$ and will evaluate the outcome as

$$0.5\, u(y_{min}) + 0.5\, u(y_{max}).$$

According to the Choquet expected utility approach, y_{max} is the first outcome in the decreasing sequence and y_{min} the second. Therefore, y_{max} will be assigned its lowest possible probability, which is 0.5. So now turn to y_{min}, which will be assigned the minimum with respect to the remaining probabilities. But because the assigned probabilities must add up to one, the only remaining probability is 0.5, which for that reason is also the *lowest* remaining probability. Therefore, the Choquet expected utility is obtained as

$$CE\{u(y)\} = 0.5\, u(y_{max}) + 0.5\, u(y_{min})$$

Regarding this example two remarks are in place. Firstly, in this specific case the maxmin approach and the Choquet expected utility approach lead to the same valuation of the ambiguous beliefs. This in not generally the case. [4] Secondly, it is easy to see that a decision maker who has to pay y, rather than receiving it, would evaluate the outcome as

$$CE\{u(-y)\} = 0.75\, u(-y_{max}) + 0.25\, u(-y_{min}).$$

This property, that a change in the ranking of the outcomes obtained in different states of nature may affect the weights assigned to them, is a general property of evaluating outcomes in the presence of ambiguity.

[3] Formally, consider beliefs over a finite state-space S that are described by a set-function $v: S \rightarrow [0,1]$, such that (i) $v(\emptyset) = 0$ and $v(S) = 1$ and (ii) for all A and B, subsets of S with A containing B, we have $v(A) \geq v(B)$. Such set function v is called a **capacity**. Consider a real-valued function h that assigns each state $s \in S$ the value $h(s)$. Consider a permutation $t_1,\dots,t_S$ of states of S such that $h(t_1) \geq \dots \geq h(t_S)$. Now the **Choquet expected value** of the function h with respect to the capacity v is obtained by taking the Choquet Integral of h over v and reads:

$$CE\{h\} := v(t_1)h(t_1) + [v(\{t_1,t_2\})-v(\{t_1\})]h(t_2) + [v(\{t_1,t_2,t_3\})-v(\{t_1,t_2\})]h(t_3) + \dots + [1-v(S)]h(t_S).$$

[4] In general, the multiple prior approach and the Choquet expected utility approach may lead to different outcomes, but for ambiguity averse decision makers and specific shapes of the set of priors P – as considered in this paper – the results of the approaches coincide. Because the Choquet expected utility approach is easier to generalize, it is the preferred approach for deriving theoretical results. But as the multiple prior is more intuitive, it is the preferred approach for the purpose of exposition. A discussion of both approaches is provided in Spanjers (1999/08, Chapter 7). For an exposition of the intuition of the Choquet integral see Spanjers (1999/08, Section 7.2). A mathematical treatment of the Choquet integral as a “horizontal” integral as compared to the “vertical” Riemann integral is provided in König (1997).

Now that we have seen how decision makers' beliefs are represented and outcomes are evaluated in the presence of ambiguity, we return to the evaluation of the different development strategies.

The Uncertainty Premium

The impact of ambiguity on the evaluation of the two development strategies by a risk neutral and ambiguity averse decision maker is illustrated in Diagram 2. This diagram contains the information of Diagram 1, but extends it by including the Choquet expected value of the available financial resources and of the attained output.

On the horizontal axis, the Choquet expected value of the available financial resources, $CE\{x\}$, is less than their expected value in the absence of ambiguity, $E\{x\}$. As outlined above, an ambiguity averse risk neutral decision maker puts the weight associated to x_{max} at the lower bound of its plausible probability value and, therefore, assigns the remaining probability mass to the only remaining outcome x_{min}. The Choquet expected evaluation of the output for the low technology strategy, $CE\{f(x)\}$, and for the high technology strategy, $CE\{g(x)\}$, are obtained in a similar way.

As in the case of risk, the decreasing returns to scale of the indirect production function f cause the Choquet expected value of the output to be less than the output for the Choquet expected financial resources. The additional presence of ambiguity, as compared to risk, leads to a difference between the output for the expected value of financial resources and the Choquet expected value of the output of

$$f(E\{x\}) – CE\{f(x)\}.$$

Thus, the difference due to the presence ambiguity is

$$E\{f(x)\} – CE\{f(x)\}.$$

The certainty equivalent for the Choquet expected value of the output is indicated in Diagram 2 as $\sigma_C(CE\{f(x)\})$.

For the analogue of an uncertainty premium – which reflects the losses due to both the risk and the ambiguity expressed as a reduction in available financial resources – one obtains

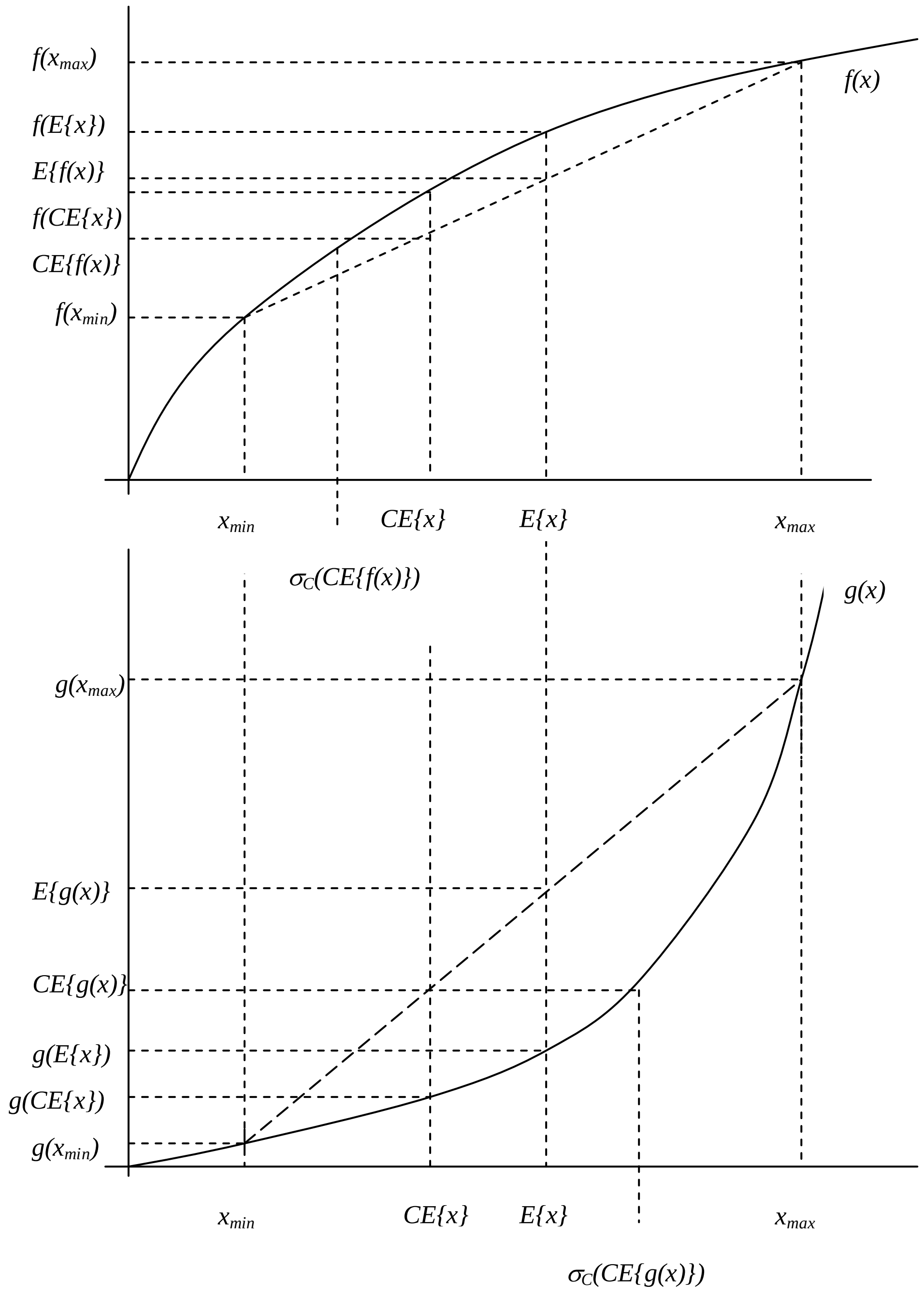
$$E\{x\} – \sigma_C(CE\{f(x)\}).$$

For the low technology strategy, the presence of ambiguity reinforces the effects of risk for a risk neutral and ambiguity averse decision maker.

As the lower panel of Diagram 2 indicates, this is not the case for the high technology strategy. For the indirect production function g for the high technology development strategy, which has increasing returns to scale, the difference between the output for the expected value of the available financial resources and the Choquet expected value of the output is

$$g(E\{x\}) – CE\{g(x)\}.$$

Diagram 2: Low technology strategy and high technology strategy under ambiguity



So the difference due to the presence of ambiguity is

$$E\{g(x)\} - CE\{g(x)\}.$$

The certainty equivalent for the Choquet expected output is denoted by $\sigma_C(CE\{g(x)\})$. For the analogue of an uncertainty premium – which reflects the loss due to both risk and ambiguity expressed as an equivalent (possibly negative) reduction in available financial resources – one obtains

$$E\{x\} - \sigma_C(CE\{g(x)\}).$$

As the diagram indicates, for the high technology strategy the presence of ambiguity counteracts the (positive) impact of risk.

The intuition for this is that the increasing returns to scale of the indirect production function *g* has a similar effect as a risk loving von Neumann-Morgenstern utility index would have. The valuation of the output of the risky financial resources exceeds that of the output for their expected value. The ambiguity aversion, however, reduces the valuation of the ambiguous output below the valuation of the output its absence. Therefore, the impact of ambiguity is qualitatively different from that of risk.

The above discussion of the impact of ambiguity on the indirect production functions of the low technology and the high technology strategy focused on a static analysis of output levels. The main interest of policy makers and investors, however, is in the middle and long term effects of these strategies, which requires an analysis in a dynamic setting. In order to address these effects, the next section focuses on growth rates.

4. Growth

In this section we focus of our attention on growth rates. We start by extending the above discussion of the impact of ambiguity to the growth of output. Then we present per capita growth rates of selected developing and emerging countries from different parts of the world. In this data we look for indications that the data is in line with our theoretical findings, both regarding the two proto-typical development strategies and regarding the potential impact of ambiguity on the choice of development strategy.

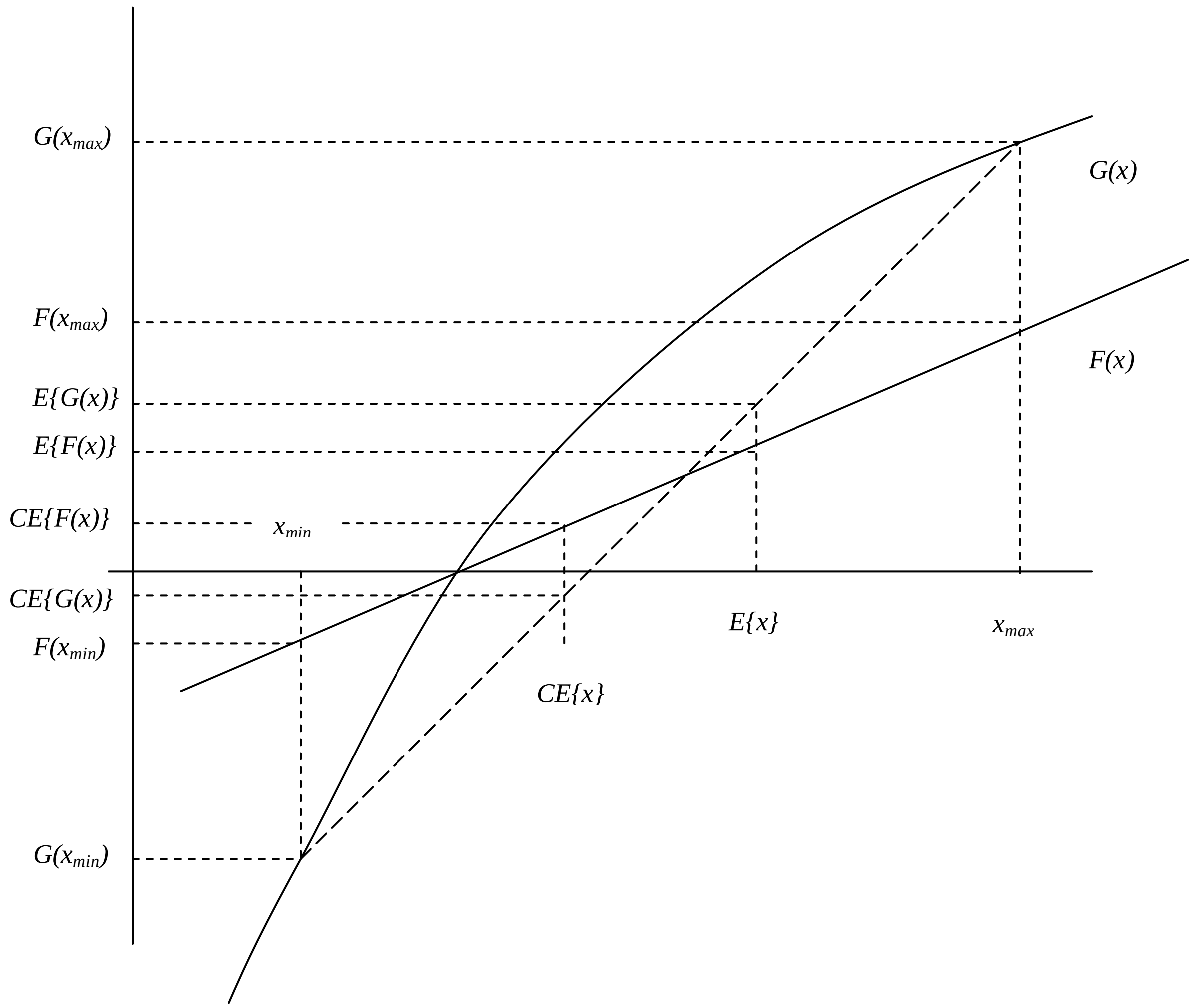
Ambiguity and Growth

The growth rates associated with the two development strategies are depicted in Diagram 3. In line with the previous section, the diagram displays the growth rate as an indirect function of the available financial resources. The functions *F* and *G* are indirect growth functions. Thus, $F(x)$ is the growth rate that results from the interactions of the relevant decision makers when financial resources of size *x* are available and a low technology development strategy is followed. Similarly, *G* is the indirect growth function associated with the high technology strategy.

The impact of individual developing and emerging economies on worldwide technological progress is limited. Although technological progress is largely exogenous for these countries, they can benefit from worldwide technological progress. This is reflected in the shape of the indirect growth functions.

The growth rate generated by a low technology strategy is assumed to be positive but not very high. This seems reasonable, as technological progress in low technology sectors is likely to be slow and to be characterized by marginal reductions in production costs. If the country does not have the financial recourses to upgrade to the newest technology, one would expect that the profit margins and wages would fall. But variable production costs would remain below the international price level and production would continue. A temporarily limited access to financial resources would reduce growth, perhaps even making it negative, but it would be unlikely to trigger an economic crisis. Similarly, an abundance of financial resources would create the opportunity of increased growth rates, but only to a limited extend. Even considerable additional investments would be unlikely to result in a significant increase in competitiveness and would be unlikely to cause competitors to significantly reduce their output or leave the market.

Diagram 3: Growth for the low technology strategy and the high technology strategy under ambiguity



The properties of a high technology strategy are in sharp contrast to this. The growth obtained through a high technology strategy is likely to be high when the strategy is successful, but failure may well result in an economic crisis. The technological progress in high technology sectors is likely to be both rapid and revolutionary, meaning that new production technologies make existing technologies obsolete.

As long as a country following a high technology strategy has access to sufficient financial resources, it will be able to keep up with technological progress. It will be able to maintain its position in the international market and to benefit from generous profit margins. But if the access to financial resources is temporarily limited, this may have serious consequences. The crucial ongoing research and development will be interrupted, causing a rapid loss of market share. As a result of the increasing internal and/or external returns to scale average production costs increase, reducing competitiveness even further.

An abundance of financial resources, on the other hand, may increase the growth rate above its already high level. This increase, however, will be at a decreasing rate. When the production frontier is approached, further increases in growth rates require large financial commitments. Furthermore, the processes and infrastructural projects that lead to external increasing returns to scale take time to plan and implement. The time-span of the temporary abundance of financial resources may be shorter than the implementation lags associated with these projects and processes.

The shape of the indirect growth functions F and G in Diagram 3 reflects these considerations.

Diagram 3 depicts a situation in which a policy maker with the objective of maximizing expected growth rates chooses a high technology development strategy. The expected growth rate of such strategy, $E\{G(x)\}$, exceeds that of a development strategy that focuses on low technology sectors, $E\{F(x)\}$. As discussed above, a drawback of the high technology strategy is its vulnerability to unfavourable international developments. The growth rate is more volatile and every once in a while an economic crisis is will occur. The policy maker may be tempted to follow a low technology strategy, "prudently" avoiding economic crises. In a situation as depicted in Diagram 3, the cost of avoiding economics crises, however, is high. In the long run, the associated reduction in the growth rate leads to a standard of living that is less than it could have been.

When risk neutral but ambiguity averse policy makers and investors face ambiguity in the form of incalculable political risk, the situation becomes even worse. In their decision making, these decision makers put an increased weight on bad outcomes. In the situation depicted in Diagram 3, the weight on x_{min} is increased at the expense of the weight assigned to x_{max}. Therefore, the resulting Choquet expected growth rate is reduced for both development strategies. But this is not the only consequence of the presence of ambiguity. The reduced availability of financial resources associated with x_{min} "merely" leads to a reduced growth rate, $F(x_{min})$, for a low technology strategy, whereas it leads to a full-blown economic crises if a high technology strategy is pursued, indicated by $G(x_{min})$. As a consequence, the presence of ambiguity can reverse the order of the valuation of the two development strategies. It may cause a low technology development strategy to be pursued where a high technology strategy would have been better, the distortion being caused by the pessimism and excessive cautiousness of the risk neutral but ambiguity averse policy makers and investors.

This possibility that the presence of ambiguity, as caused by incalculable political risk, may lead policy makers and investors to pursue inappropriate development strategies, is sufficiently worrying to warrant a brief examination of selected annual per capita GDP growth rates, looking for indications that this actually happens in real life decision making.

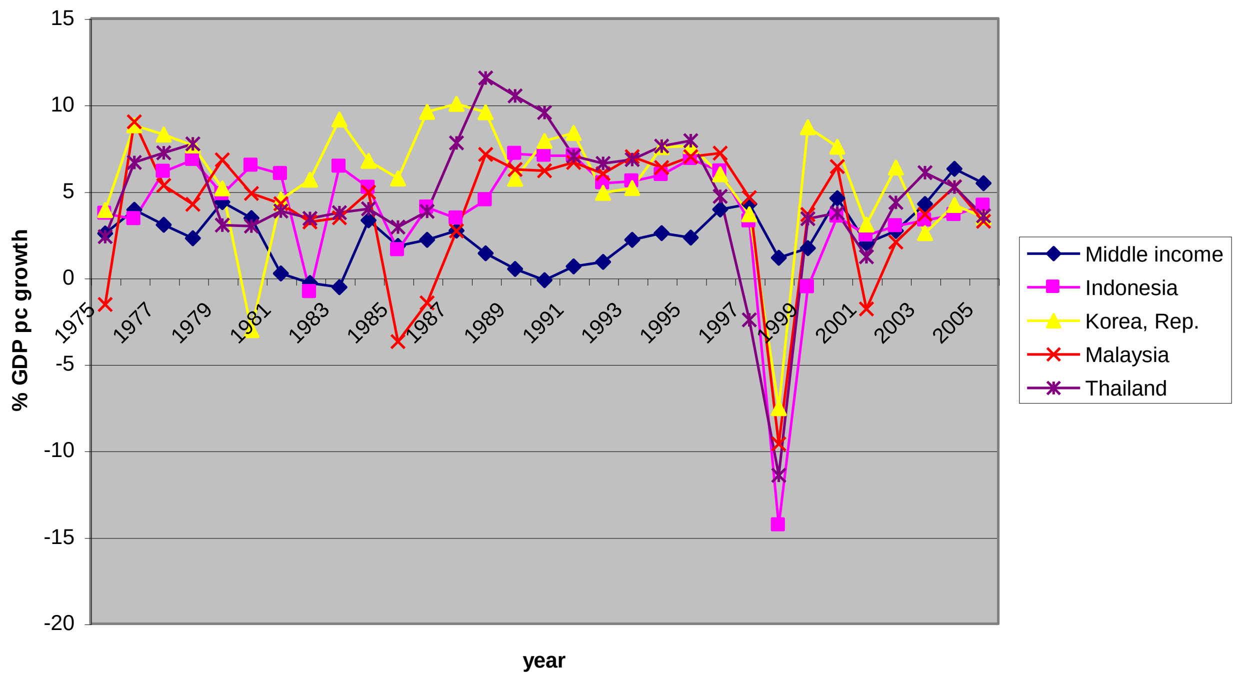
Growth Rates of Selected Countries and Regions

We examine annual per capita GDP growth rates in our search for indications that the presence of incalculable (political) risk has a distorting effect on the development strategies of emerging countries. We focus on emerging countries rather than low income developing countries, as they are more likely to satisfy the basic pre-requisites for a high technology strategy. Emerging countries are more likely to have a real choice between a low technology and a high technology development strategy.

Four groups of countries are considered. The first group of countries is from East Asia. For the purpose of comparison we also look at two groups countries of from other parts of the world, viz. South America and North Africa. The fourth group consists of the BRIC-countries excluding Brazil (which is included in the group of South American countries), viz. China, India and Russia. For each of these groups we examine World Bank's World Development Indicator data on the annual growth rate of per capita GDP for the period from 1975 to 2005.

For the geographical area of East Asia we focus on Indonesia, Korea, Malaysia and Thailand. The per capita growth rates for these countries are depicted in Figure 1. Interestingly, in the

Figure 1: Per capita GDP growth rates for East Asia

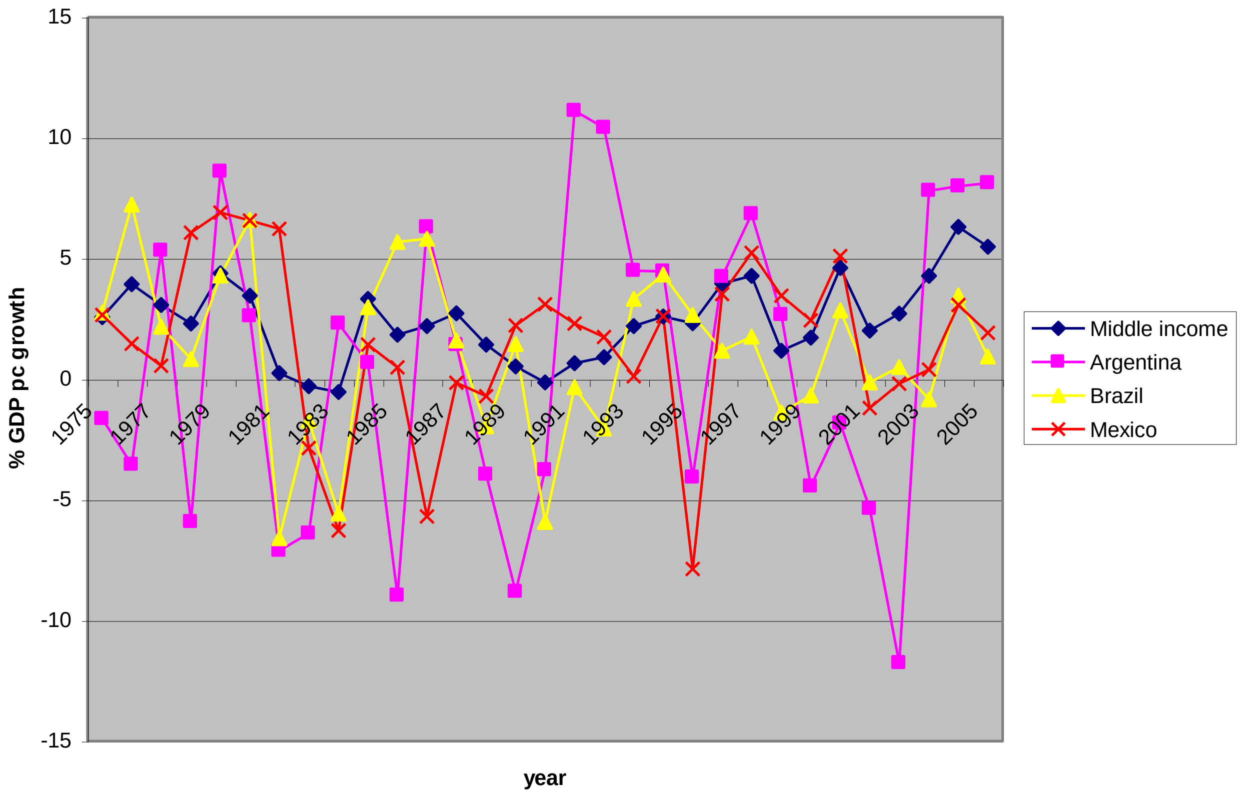


period before the East Asian crisis of 1997, the growth rates of these countries are well above the average of the middle income countries. Before the 1990s the growth rates also show a fair amount of volatility, as would be expected for a high technology strategy. From the early 1990s until the crisis in 1997, the growth rates where stable and well above the average of the middle income countries. Once again, this is in line with what we would expect for a high technology oriented development strategy.

After the crisis, however, we find that growth rates have stabilized and no longer exceed the average of the middle income countries. Our theoretical analysis makes it tempting to interpret this as the consequence of an increase in the perceived incalculable risks of global financial flows. It would be capable of reversing the valuation of the two development strategies, causing a shift from a high technology to a low technology development strategy.

The second geographical area we look is South America, where Argentina, Brazil and Mexico are selected. During the last three decades South America has seen many economic crises, which could potentially be a consequence of a high technology strategy. Our theoretical analysis suggests that if such a strategy is followed, these countries would be vulnerable to crises, but would also display periods of high economic growth. The annual per capita growth rates for these countries are depicted in Figure 2.

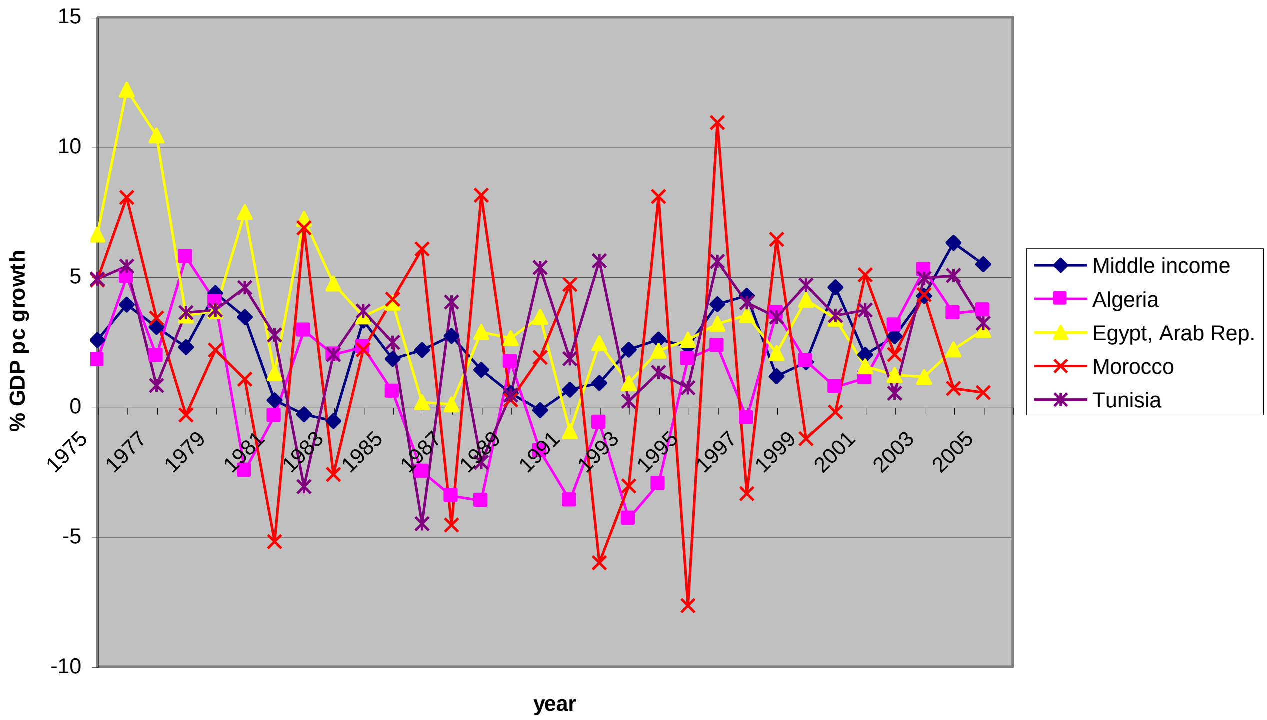
Figure 2: Per capita GDP growth rates for South America



The data in Figure 2 provide no indication that a high technology strategy has been followed. In particular the growth rates of Brazil and Mexico are below, rather than above the average per capita growth rates for middle income countries. Besides, from the beginning of the 1990s these growth rates are relatively stable, suggesting that the two countries follow low technology development strategies. Only Argentina exhibits high and volatile growth rates in the period from the early 1990s onward. But the high growth in the early 1990s may well be a rebounce from the economic crisis in the preceding years, whereas the crises at the beginning of the 21st century lasted longer than one would be led to expect.

For North Africa, the per capita growth rates of Algeria, Egypt, Morocco and Tunisia are depicted in Figure 3. With the exception of Tunisia, where the growth rate was volatile, the growth rates of the selected counties are more or less in line with the average of the middle income counties and relatively stable. This suggests that these countries are following a low technology strategy. The decision in favour of a low technology strategy may well be driven by the incalculable political risk related to the Middle East. Ambiguity averse policy makers would be expected to follow such strategy, even if the proximity to and treaties with the European Union would seem to make a high technology oriented development strategy a more than promising alternative.

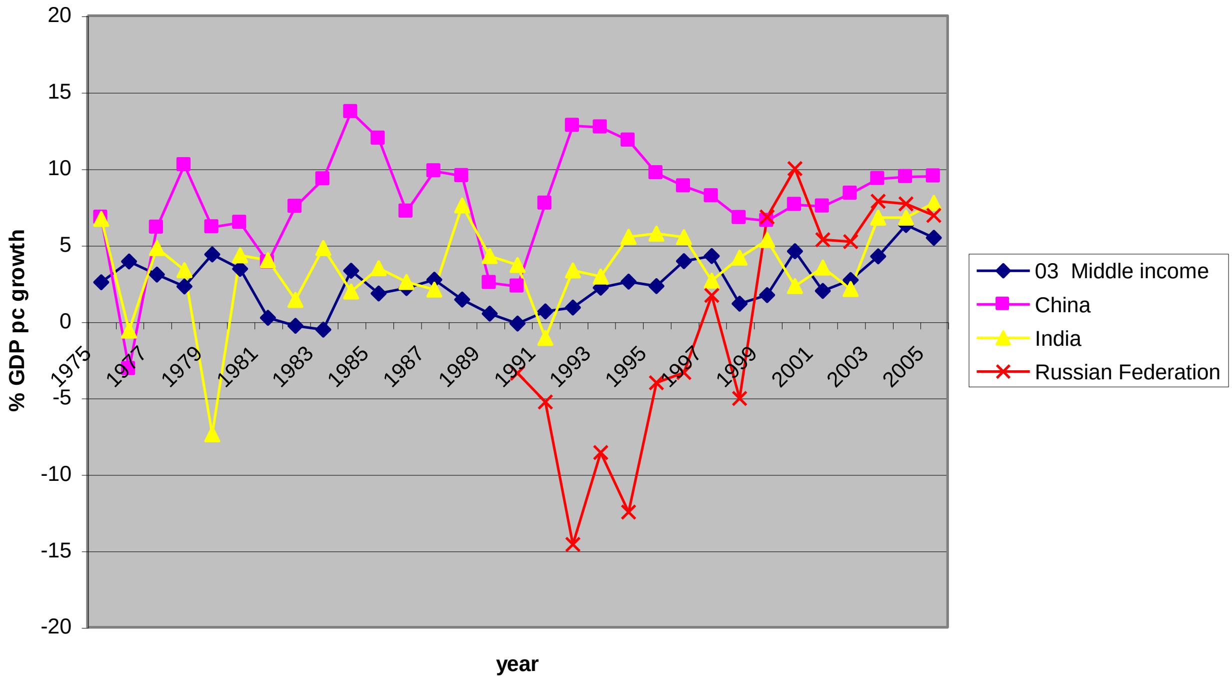
Figure 3: Per capita GDP growth rates for North-Africa



Finally, we have a brief look at the per capita growth rates of the BRIC counties excluding Brazil, viz. Russia, India and China. From Figure 2, it seems that from the early 1990's onward the growth rate of Brazil is relatively stable and more or less in line with the average growth rate of the middle income countries. Figure 4 suggests that the same holds for India from the beginning of the 1980s onwards. Both countries seem to follow a low technology development strategy. The growth rates for China, by contrast, seem to indicate that since the early 1980s it has been following a high technology oriented development strategy.

From the data in Figure 4 it is difficult to judge if Russia is following a low technology or a high technology strategy. The growth rates of the early 1990s may well be dominated by the effects of the collapse of the Soviet Union. The growth rates in the 21st century are slightly above the average for the middle income countries but seem rather stable. In the light of our theoretical arguments, this would be compatible with a low technology development strategy with enhanced growth rates due to increases in the price oil. As in the case of North Africa, this may be the consequence of incalculable political risks. Given the geographical proximity to the European Union, it would seem that in the absence of this ambiguity, a high technology development strategy would be warranted.

Figure 4: Per capita GDP growth rates for China, India and Russia



The above discussion of growth rates seems to illustrate our theoretical arguments. This is particularly true for the impact of ambiguity, be it caused by incalculable political risk or by the possibility of unpredictable reversals of international financial flows.

5. Policy Recommendations

The brief and superficial inspection of growth rates illustrates the general theoretical analysis of this paper. It suggests that the presence of ambiguity distorts the decisions of policy makers and investors in a number of countries and regions. For these countries and regions the presence of ambiguity may have led to low technology oriented development strategies where high technology strategies would have been more appropriate. Is this inevitable, or are there ways of correcting this unfortunate situation?

The first sort of policy measures one would be looking for are measures that either remove the sources of ambiguity or insulate the development strategies from their effects. Therefore, the answers may depend on the source of the ambiguity.

In the case of the incalculable political risks in the Middle East, which seem to affect the development strategies of the countries in North Africa, a comprehensive peace agreement would tackle the problem at its root. This, however, is an issue of international politics, the solution of which lies outside the realm of economics. Given the cause of this ambiguity, there seems to be little in the way of devising (international) economic institutions that can remove its impact. Indeed, some may argue that low technology oriented development strategies in this region respond to the calculable risk of the conflict escalating, rather than mere ambiguity.

Something similar may apply to the incalculable political risks in Russia. Although some form of the rule of law has been re-introduced under the Putin presidencies, it is generally believed that the independence of legislative and judicial spheres from the executive has not yet been established. This is were the root of the incalculable political risks in Russia lies, and which makes it vulnerable to the political risks that are associated with individual persons and their supporters. The re-introduction of the rule of law has significantly reduced the incalculable political risk associated with the Yeltsin presidencies. Still, the removal of the remaining political risk is likely to be a long term project for Russian politicians and governments. Integrating Russia in regional and (strengthened) international governance structures would be likely to help, but it is difficult to see how (international) economic institutions can be devised that reduce the impact of the current incalculable political risks.

This leaves us with the ambiguity that is caused by unpredictable reversals of international financial flows, which seems to affect the East Asian countries. This incalculable risk is inherent in the process of globalisation, but it can more easily be dealt with than the political risks discussed above. Our theoretical analysis suggests that it is a temporary shortage of financial resources that leads to crises like the East Asian crisis of 1997. It may be difficult to prevent a panic amongst investors – be it enhanced by speculators or not – but it is possible to develop national policies and international institutions that are capable of cushioning the impact of a sudden and temporary reversal of financial flows.

A tried and tested national policy to reduce the impact of a reversal of financial flows is the accumulation of large currency reserves, a policy that is currently being implemented by most East Asian countries. On the international level, there already exists an institution whose task it is to cushion the impact of sudden and temporary reversals of financial flows, viz. the International Monetary Fund. Unfortunately, the instruments it currently has at its disposal seem to be inadequate for the task. An appropriate reform of the IMF would do much to reduce the impact of the ambiguity caused by unpredictable reversals of international financial flows. It would potentially encourage some countries in East Asia and beyond to abandon their current low technology oriented development strategies for more promising high technology strategies.

Surely, this kind of "insurance" against the sudden reversal of financial flows would lead to higher volatility and to an increase in the number of economic (almost) crises involving emerging economies. But this would not be the despicable consequence of a moral hazard problem. Rather, it would bring the amount of economic crises closer to its optimal level by removing a source of ambiguity that leads to excessively cautious behaviour by international investors and policy makers.

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