

# Briefing Notes in Economics

*'Helping to de-mystify economics since 1992'*

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## A Note: Are (Positive) Real Options Values a Contradiction in Terms?

Norbert Hirschauer\* and Oliver Musshoff \*\*, †

\* Faculty of Natural Sciences III,  
Institute of Agricultural and Nutritional Sciences,  
Martin-Luther-Universität Halle-Wittenberg,  
Ludwig-Wucherer-Str. 2, D-06108 Halle (Saale), Germany.

\*\* Faculty of Agricultural Sciences,  
Department for Agricultural Economics and Rural Development,  
Georg-August-Universität Göttingen, Platz der Göttinger Sieben 5,  
D-37073 Göttingen, Germany.

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Claiming analogy with financial option pricing the real options approach assumes that the present value of investment cash flows (or: real asset value) can be replicated by a risk-free financial portfolio; that is, this present value is considered to be equivalent to an asset value in a complete capital market. It would be perfectly legitimate to ask whether the complete market assumption, which is the fundamental base of option pricing theory, also holds for real assets. This note, however, does not investigate the arbitrary question whether the assumptions of the real options approach are *adequate*. It asks the more fundamental question whether non-zero real option values are *consistent* with the very model assumptions. We demonstrate that this is not the case. Our systematic review of model assumptions refutes the widespread opinion that so called real options can be valued independent of subjective risk preferences. Consequently we have to conclude that, though computed real asset values may reflect flexibility, they never represent option values in line with option pricing theory. **JEL: C61, D80, G13.**

### 1. Introduction

Inspired by financial option pricing theory, the so called “new investment theory” or “real options approach to investment” investigates entrepreneurial flexibility (cf. McDonald and

Siegel, 1986; Dixit and Pindyck, 1994). Using the seeming analogy with American type financial options, the risk-free interest rate is used – independent of investors’ risk preferences – for determining early-exercise frontiers (optimal exercise strategies in terms

of critical present values  $V^*$  or trigger prices  $P^*$ ) and real option values  $F$  for time-interdependent business decisions under uncertainty.

In the classical application, a flexible and irreversible investment opportunity with uncertain outcome is interpreted as a real option where the possibility to delay the investment is equivalent to an American call: The investor has the right, but not the obligation, to buy a real asset (investment good) at a given strike price,  $I$  (investment costs). The present value,  $V$ , of future investment cash flows is interpreted as the value of the underlying asset which can presumably be replicated. This implies that an investment option is only exercised if its intrinsic value,  $i$  (the positive net present value of an immediate investment) exceeds the continuation value,  $f$  (the discounted net present value of the optimal future investment). The difference  $f - i$  (value of waiting) represents the opportunity costs over time. They are caused by the fact that “exercising an irreversible investment option now” competes with “exercising it later”. In other words: The only “innovative” part of the real options approach is its claim that – independent of investors’ risk preferences – the risk-free interest rate may be used for discounting. If just an arbitrary risk-adjusted discount rate is used, there is nothing conceptually new in the “new investment theory” compared to flexible investment planning which has been dealing with the problem of time-interdependent decision-making under uncertainty for decades.

American (financial) call options and investment opportunities have in fact two essential features in common: the stochastic development of the asset value and the flexibility of the exercise decision. A complete market for the underlying asset, however, is the additional precondition for a valuation of options independent of subjective preferences. Otherwise a risk-less replication portfolio or hedge portfolio cannot be constructed and an objective option value cannot be found. At first view it seems interesting to ask whether

the complete market assumption, which is generally acknowledged for financial markets, also holds for different types of real assets. Prior to that, however, this note shows that non-zero real option values are not consistent with the complete market assumption *per se*. Therefore, an investigation into the question whether the complete market assumption reproduces reality adequately is obsolete.

## 2. Comparison of Financial and Real Options

### *Financial Options*

Because the owner of a financial option has the right, but not the obligation to exercise his option at a given strike price, he can profit from unexpected positive stochastic shocks to the market value of the underlying asset. For instance, a positive value of a European option on a time continuous underlying asset (cf. Black and Scholes, 1973) requires a non-zero probability that the value of the underlying asset at expiration exceeds the strike price. It should be noted that the expected profit of “buying a financial option at its market price and exercising it according to the optimal strategy” is zero, because the option value is computed as a *fair price* resulting from homogenous expectations in a complete market. This is equivalent with the statement that all assets in a complete market yield the risk-free interest. More formally: In the absence of transaction costs the *computed value* of an option  $F$  must be equivalent to its *market price*  $M$  due to arbitrage:  $F - M = 0 \Rightarrow F = M$ .

### *Real Options and Industry Wide Uncertainty*

Contrary to financial options, real options are not traded on markets. Hence, there is no certified right to buy a real asset at a given strike price,  $I$ , which may eventually be exceeded by the market value of the asset,  $V$ . An investor (owner of a real option) cannot profit from stochastic shocks to an underlying asset value if they are experienced by all market participants, that is, if it is a complete market. Today, and in all future periods, he just has the right to acquire the present value

of investment cash flows at exactly the price  $I = V$ . The investment decisions of competitors will always entail a zero-profit market environment because they already invest at a critical exercise value,  $V^* = I$ . Consequently we know *a priori* that risk-neutral valuation in combination with the absence of a traded title forces the value of waiting and the value of a real option to be zero.

Dixit and Pindyck, whose book “Investment under Uncertainty” (1994) triggered all recent publications on real options, take account of perfect competition using the term “industry wide shock”. They do not concentrate on the fact that this is, *per se*, equivalent with non-existing real option values and critical exercise values  $V^* = I$ . Instead they emphasise how critical exercise values can be computed in terms of critical prices  $P^*$ . Their line of thought runs as follows (cf. chapter 8): They assume a stochastic demand which may be described by geometric Brownian motion (GBM). Due to market entries and exits, the corresponding stochastic price process in a perfectly competitive market is a regulated GBM. Its parameters can be computed if functional relationships (e.g. the demand function) are known.<sup>1</sup> They essentially come to the conclusion that the investment strategy of a “myopic planner” who accounts for the correct parameters of the price process, but ignores the fact that it is a *regulated* process, is correct in terms of critical prices  $P^*$ . Consequently, an analytical calculation of optimal strategies is possible because it is not necessary to consider the unmanageable regulated process.

To avoid misunderstanding of this theoretically consistent (“option”) approach it

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<sup>1</sup> In their basic thought experiment Dixit and Pindyck implicitly assume that the elasticity of demand is one, and that variable costs and the rate of depreciation are zero. In this setting the demand process translates one to one into the price process, except for the fact that the latter is a *regulated* GBM.

should be noted, that it is not exploring a time-interdependent decision problem at all. There are no opportunity costs over time because the implicit assumptions (inputs to the model) are already:  $V^* = I$ ,  $i = 0$ ,  $f = 0$  and  $F = 0$ . The approach only answers the (technical) question of how an initial value  $P^*$  (which ensures that capitalized future prices equal the given investment cost  $I$ ) may be computed, if we act on the assumption that the price process is to be described by a regulated GBM.

The figure, further below, provides an overview of the results of the thought experiment of Dixit and Pindyck which are often subsumed as “optimality of myopic planning”:

- Myopic and non-myopic planners will derive the same critical exercise value in terms of a critical price  $P^*$  which exceeds the annualised investment costs  $k$  per unit of output.
- The myopic planner misinterprets this critical price  $P^* > k$  and believes that investing at  $P^*$  is equivalent to a present value of the investment  $V^*$  which exceeds the investment costs  $I$ . However, competitors invest as soon as investment costs are covered, and this produces a regulated price process which in fact reduces the effective  $V^*$  to the level of  $I$ .
- The myopic planner wrongly thinks that he enjoys a positive option value  $F$  and therefore “superprofits”. Due to competition, however, the option value is in fact zero.

At first sight the myopic planning principle seems to be very useful. Nevertheless, we cannot use it for practical applications: Being able to neglect the fact of a *regulated* process is no remedy to the strategy problem in terms of trigger prices because we are not able to derive the correct parameters (drift and standard deviation) of the process in the first place: Neither the parameters of the original stochastic demand process nor the functional relationships between demand and price (elasticity of demand etc.) can easily be estimated empirically. Hence, we have to fall back on empirical price series which are

regularly available. However, using price series from a presumably competitive market leaves us with the problem of finding correct estimators for regulated time series. Furthermore, we cannot neglect variable costs in an adequate model. Instead of modelling stochastic prices, we have to make sure that capitalised stochastic investment cash flows equal the investment costs. Due to the fact that cash flows may be negative at times, we cannot assume that they follow a (regulated) GBM. Instead, we have to use open-ended statistical tests based on empirical time series in order to derive the most suitable cash flow process. Because we can no longer assume a regulated GBM with well-known parameters, the myopic planning principle cannot be used. Nevertheless, the theoretical model provides a valuable structural insight: The critical value of the stochastic cash flow will differ from annualized investment costs for all processes where expected future values do not equal the present one (e.g. regulated Brownian motion, Brownian motion with non-zero drift etc.). Such a finding must not be confounded with the existence of opportunity costs over time. On the contrary, it exactly brings forth a value of waiting and a real option value of zero consistent with the assumptions for risk-neutral valuation.

### ***Real Options and Firm-Specific Uncertainty***

Using the term “idiosyncratic shock” or “firm-specific shock” Dixit and Pindyck (1994, p. 249) describe a different set of assumptions. They now assume that individual firms may suffer or profit from individual shocks. Intuition is given by examples such as “a shift of fashion in an industry with differentiated products” or “a chance improvement in entrepreneurial skills”. In other words: They allow for individual cash flows and individual asset values  $V_{indiv}$  instead of a general market value  $V = I$ . The assumption that the individual asset value may exceed investment costs ( $V_{indiv} > I = V$ ) is equivalent with the assumption that a firm may enjoy a comparative advantage. Nevertheless assuming that the risk neutral valuation principle can be used, they calculate positive

real option values in the case of firm-specific uncertainty whenever there is a non-zero probability that the individual asset value exceeds the investment costs. However, due to arbitrage considerations, computing positive real option values conflicts with the fact that there is no market price for real options in the first place.

*Proposition:* It follows from a positive probability for  $V_{indiv} > I$  that the underlying real asset is not fully replicable and that the risk-neutral valuation principle cannot be used if no market price is paid for this comparative advantage.

*Proof:* If we accepted the risk-neutral valuation principle, we would compute a positive “option” value whenever there is a positive probability for  $V_{indiv} > I$ . However, a computed positive option value needs to be matched by a positive option price. Otherwise it is not an arbitrage-free market we would have to conclude that the individual real asset earns an interest rate above the risk-free interest (“superprofits”). This, in turn, would be a violation of the essential option pricing assumption of complete markets and fully replicable assets. In brief: if no *price* is paid for a real “option”, there can be no “option” value either.

*Conclusion:* Contrary to a complete market where the underlying asset and the option are traded allowing for a consistent use of contingent claim analysis, the risk-free interest rate cannot be justified any more with the risk-neutral valuation principle, but only with the simplifying model assumption of risk-neutral decision-making. Therefore, the term “real option value” is rather misleading in the context of firm-specific shocks. In order to be more precise, one should term  $F$  the “value of a flexible investment opportunity for a presumably risk-neutral decision-maker”.

With financial option contracts we can indeed determine the fair price for the option and anticipate its future value. When the option is

traded, its market price coincides with the computed value (apart from transaction costs). With individual entrepreneurial opportunities we would have to make the following loophole reasoning if we wanted to “save” the risk-neutral valuation principle: “The real option does not yet exist, but will be brought to existence if we pay the computed option price.” Paying that price would then be equivalent with procuring the comparative advantage of a positive probability that the individual asset value exceeds the investment costs.” Obviously, this is neither a sensible way out nor the perspective taken by those who value real “options”.

### 3. Contribution of the Real Options Approach to Investment Theory?

We have to state that contingent claim analysis and therefore the risk-neutral valuation principle is not consistent with the existence of positive real options values. Instead of a problem solving *new* approach which justifies the utilisation of the risk-free interest rate independent of individual risk attitudes, we are again facing the *old* problem of how to determine the individual risk attitude. We need to know the individual risk attitude and therefore the risk adjusted discount rate in order to determine the optimal investment strategy and the value of flexibility. If we use – for the sake of simplicity – the risk-free discount rate, we are only able to determine the optimal strategy and the value of flexibility for a presumably risk-neutral decision-maker. That is, we are not able to differentiate which part of an initially computed value of waiting is in fact due to opportunity costs over time, and which part would be eliminated if we correctly accounted for individually required risk premiums.

To summarize our argumentation briefly: (i) It seems not to be realistic, but it would be consistent with the risk-neutral valuation principle of option pricing theory to assume industry wide uncertainty and complete markets for real assets. However, in spite of the widely used term “real option approach” for such settings, we know a priori that

positive values of waiting and real option values cannot exist. (ii) It seems to be realistic, but it is not consistent with option pricing theory to assume firm-specific shocks and therefore incomplete markets for real assets. In spite of the widely used term “real option approach” for such settings, the risk-free interest rate cannot be justified with the risk-neutral valuation principle, but only with the simplifying assumption of risk-neutral decision-making. Hence, we are back to flexible investment planning and the problem of how to estimate individual risk attitudes.

### 4. Conclusion

The objective of our review was to investigate the potential of the real options approach in order to avoid misinterpretations. Realising the limitations of the so called real options approach gives us the chance to assess its effective contribution to time-interdependent decision-making in general and flexible investment planning in particular:

First of all, powerful technical procedures have been developed recently for pricing American type options and other complex financial options. Some of them integrate stochastic simulation of the state variable into a general backward-recursive framework of option pricing. Others use e.g. stochastic simulation connected with genetic algorithms. Sparked off by the real option discussion, many economists dealing with dynamic decision problems now make use of these procedures in other fields than option pricing. This generates a great advantage compared to traditional decision tree approaches and enables them, for instance, to solve the time-interdependent problem of flexible investment planning more easily. It also allows for practical problem solutions even if real world complexities such as non GBM-processes and/or multiple stochastic variables and correlations have to be considered.

Secondly, the real option discussion enhanced the conceptual understanding of the interactions between uncertainty, flexibility

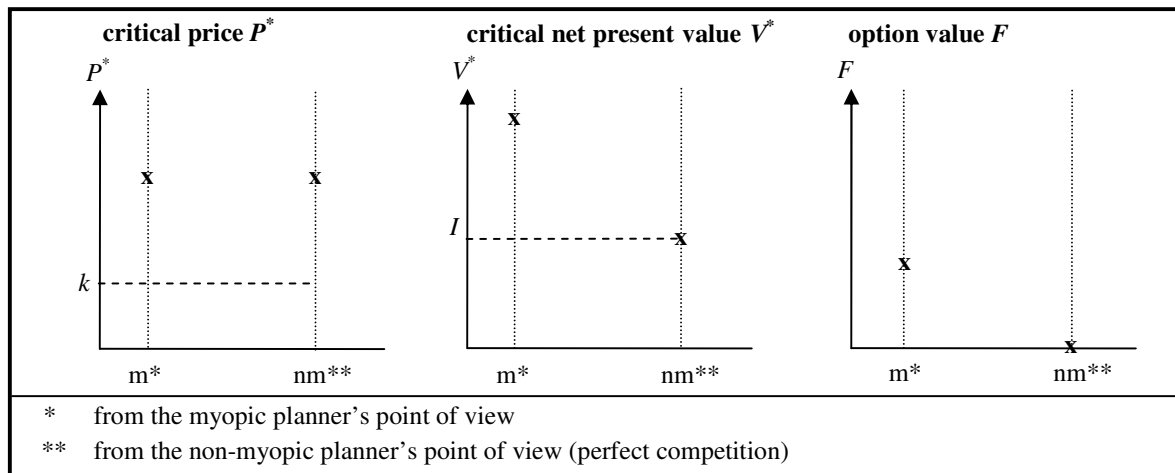
and irreversibility. It generated valuable insights into the structure of time-interdependent decision problems, regardless of what the actual discount rate is. The effects of various determinants (such as the standard deviation of the underlying asset, the interest rate etc.) upon the value of entrepreneurial flexibility can be easily demonstrated. Thus, the real options approach to investment has increased the awareness that there is an economic value to flexibility, and that investment decisions are time-interdependent problems. Equally helpful are the easy-to-understand terms “continuation value”, “value of waiting” and “real option value”, always

taking into account that their naming cannot be justified by the risk-neutral valuation principle.

To conclude this review: Given the state of the academic discussion it may be sensible to settle on using the terms “real option” and “real option value” in the context of flexible investment planning, although, strictly speaking, they are a contradiction in terms. However, *if* we do so, we should always be aware of the fact that - contrary to financial option pricing - these terms are *not* to be justified by the risk-neutral valuation principle.

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**Figure 1:** The myopic planning principle: Critical price  $P^*$ , critical present value  $V^*$ , and option value  $F$  for myopic and non-myopic planners.



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\* **Dr. Norbert Hirschauer** is acting Professor of Farm Management at the Institute of Agricultural and Nutritional Sciences of the Martin-Luther-Universität Halle-Wittenberg. He has written extensively on decision support in investment/finance and risk management. His current research and his recent publications are focused on behavioral risks in the agro-food business and on innovative hedging instruments including weather derivatives.

\*\* **Oliver Musshoff** is Professor of Agricultural Economics at the Universität Göttingen. His main areas of research are business management and operations research. He has published numerous articles on investment, finance and risk management. His current research interests are focused on the optimization of production decisions and the use of hedging instruments. Oliver Musshoff thanks the German Research Foundation for its financial support.

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**Book Review:**

*William Easterly*. (2006) *The White Man’s Burden: Why the West’s efforts to aid the rest have done so much ill and so little good*. Published by the Penguin Press. New York. PP 436. ISBN 1-59420-037-8.

In the past six decades, richer countries have directed over \$2 trillion of foreign aid to poorer countries. In the last decade of the twentieth century alone, the latter have received \$50-60 billion of aid every year. Still today nearly half of the world’s population lives on less than two dollars a day and has no access to sanitation. According to a recent influential book by Jeffrey Sachs entitled *The End of Poverty: Economic Possibilities for Our Time*, a fundamental problem is that much of the world’s poor are caught in a poverty trap. In order to help remedy this situation, Sachs suggests a “big push” through substantial increases in aid – as well as better coordination of this aid. Since its publication in 2005, Sachs’ book has received much attention in both academic and government circles.

Against this backdrop, Easterly’s new book enters the stage with a remarkably simple, yet sagacious question: If it is so easy to end poverty, why has it not been done? Thus, Easterly spends over 400 pages persuading us why the solution is more profound than simply having to spend even more money on aid. Easterly can hardly be accused of being anti-development aid since he is one of the world’s most respected development economists. Even without his impressive qualifications (former senior economist at World Bank, now a professor at NYU), his central message is quite logical: When one has repeatedly done something that has not worked in the past, one cannot just keep on doing more of the same.

Easterly criticizes past aid strategies on several fronts. First, donors often boast

about how much aid they have given instead of paying adequate attention to how well it has worked. Second, just as the demise of the former Eastern Bloc showed us that central planning does not work, analogously aid should not be centrally planned – without enough attention to the agents, markets, and circumstances on the front lines. Solutions to end poverty, rather than being centrally planned, have to be innovative, include trials and errors, and involve supporting individuals and markets that work well. A good example of this type of support is the creation of economic and social initiatives from below such as those provided by the Grameen Bank – whose founder won the Nobel Peace Prize in 2006.

Related to this is the issue of monitoring. Inadequate monitoring can lead to disastrous outcomes. Consider a case where an administrative fiat by a bureaucratic central planner is issued to build a school, with good intention to improve literacy in a region. However, little else is done, such as procuring enough teachers to staff it or ensuring that those who are available *continue* to show up for work. The members of the local community know that the project has failed. Nonetheless, the donor extols its generosity to its constituents on how well the project *must* be doing. The bottom line is that the locals and aid workers at the grass roots are in a better position to monitor aid projects and judge their failures and successes than the bureaucrats in suits. On this basis, Easterly suggests that donor agencies create and finance an independent international evaluation body with trained staff from both rich *and* poor countries to evaluate random samples of an agency's efforts.

Easterly then turns to several studies which conclude that “aid works if there is good governance in poorer countries” – a notion which has become widely accepted in many circles. Based on his own recent work published in journals and those of some other economists, Easterly argues that this

conclusion is deeply flawed and does not stand up to additional empirical scrutiny.

Throughout the monograph Easterly is careful not to claim that he has all the answers to the woes of aid. Above all, he denounces the complacent and patronising attitude of donors who think they know how to solve poorer peoples' problems better than the stakeholders themselves. One of his blunt messages is that donors should not try to transform governments and societies or waste time with more summits and declarations. Rather, he suggests that aid should aim to make *individuals* better off. Easterly invites us to get back to the basics and asks that aid agents: 1) be held accountable for their actions; 2) not be afraid to search; 3) experiment by trial and error and learn from past experiences; 4) receive adequate feedback from the poor; and 5) reward successes and penalize failures.

It is hard to think what more Easterly could have said to stir up further debate on foreign aid. I wish he could have spent more time condemning the practice of the tying of aid – which many economists see as a major impediment to the effectiveness of aid. Easterly sees tying as merely a rich-country hypocrisy. I also wish that he could have taken a more forceful approach in linking the outcome of aid to trade issues. High levels of subsidies, especially by donors like the United States and the European Union, depress prices and effectively shut out producers from developing nations. If aid is to generate economic growth or alleviate poverty, it ought to be taken in tandem with the removal of farm subsidies and opening of markets to facilitate export growth by developing countries.

Overall, time will prove this to be one of the most influential books ever written on the subject of foreign aid, its past failures, and possible paths to its future.

**B. Mak Arvin**



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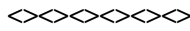
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**Abhijit V. banerjee and Esther Duflo:** ‘What is Middle Class about the Middle Classes around the World?’, *Journal of Economic Perspective*, Volume 22, 2.

**J. Steven Landefeld, Eugene P. Seskin and Barbara M. Fraumeni:** ‘Taking the Pulse of the Economy: Measuring GDP’, *Journal of Economic Perspective*, Volume 22, 2.

**Orley Ashenfelter:** ‘Predicting the Quality and Prices of Bordeaux Wine’, *The Economic Journal*, Volume 118, 529.



### **Online resources of interest (courtesy of [intute.ac.uk](http://intute.ac.uk))**

The Key Indicators of the International Labour Market is “a critical step toward the development of a set of tools for evaluating and designing labour market policies in relation to labour force participation, employment, unemployment, educational attainment, wages and compensation cost, productivity and labour cost, as well as poverty and income distribution.” The site outlines the 18 key indicators by introducing them, giving definitions and sources and highlights of the data. There is a link to working papers and publications and information about the background of the key indicators. The data is gathered by the ILO (International Labour Organization).

<http://www.ilo.org/public/english/employment/strat/kilm/index.htm>

The Manchester Institute of Innovation Research combines the two former research centres PREST (Policy Research in Engineering, Science and Technology) and CRIC (Centre for Research on Innovation and Competition), to form a new centre for innovation research in 2007, based at the University of Manchester. The Institute has a focus on innovation across both the public and private sectors. Their website includes brief details of their work including news and event information, with links to papers and presentations from their seminar series, a list of working papers, information about the postgraduate courses taught at the Institute and a list of staff.

<http://www.mbs.ac.uk/research/innovation/>

The Consultative Group to Assist the Poor (CGAP), with offices in Paris and

Washington, DC, is a “... a consortium of 33 public and private development agencies working together to expand access to financial services for the poor in developing countries.” Agencies involved with this project include; the World Bank, European Commission, African Development Bank, Japan Bank for International Cooperation and the Bill & Melinda Gates Foundation. The website contains useful information on a wide range of related matters, including their poverty assessment tools, microfinance regulation and documents on how to train people in understanding microfinance lending, CGAP publications and a helpdesk for further guidance.

<http://www.cgap.org/>

Economics of Education is part of the World Bank website and draws together the various activities, publications and research they undertake in this area. They work in five key topic areas: economic analysis of education interventions, finance and expenditures in education, public-private partnerships in the education sector, school-based management and impact evaluation. Each topic area includes an overview, key issues, publications, projects and learning/event information. Reports are made available as PDF downloads. As this is a World Bank resource, the emphasis is on international, comparative and developmental education in developing countries.

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