

## **Comments on the document:**

### **Disaggregating BT's beta by PwC (June 2005)**

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**Ofcom's approach to risk in the  
assessment of the cost of capital**  
Second consultation in relation to BT's equity beta

BT's response to the  
Ofcom consultation document  
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**Annexes to main response**

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This document includes the following annexes referred to in BT's main response, written on behalf of BT by Professor Ian Cooper, London Business School:

**Annex 1:**  
**Comments on the Brattle Group document "Beta analysis of British Telecommunications: Update"**

**Annex 2:**  
**Comments on the PwC document "Disaggregating BT's Beta"**

This document is available electronically at <http://www.btplc.com/responses>

## SUMMARY

This is a review of the econometric evidence in the document *Disaggregating BT's beta* by PwC. The evidence is in four parts:

1. Analysis of the betas of a selection of ICT companies.
2. Analysis of the evidence from historical changes in BT's beta.
3. Cross-sectional regression.
4. Time-series analysis.

The evidence is hard to interpret, for the following reasons:

1. The measure of beta used as the principle evidence for each test differs between the tests.
2. The measures of beta are inconsistent with those used in the analysis performed by Brattle for a closely related purpose.
3. The tests used by PwC are inconsistent with those used by Brattle.
4. PwC appears to weight evidence on *a priori* grounds.
5. It is not clear how the samples used for analysis have been chosen.
6. Different measures of the same thing are used in different parts of the analysis.

In addition to these problems, there are considerable econometric problems with all the tests except the first.

In my opinion, there is only one robust piece of evidence in the econometric analysis provided by PwC. It is that the sample of ICT businesses chosen by PwC has a higher average asset beta than the BT group. Even that analysis is subject to several significant weaknesses that reduce the robustness of the conclusions drawn. The quantitative interpretation placed on this by PwC is heavily affected by the fact that it uses betas that have not been adjusted to be optimal forecasts. This would significantly reduce the size of the adjustment to the access beta. In addition, uncertainty about whether these are the right comparators for the BT ICT business and whether the revenue weights are the right proxy for value adds to the uncertainty about the adjustment.

The only robust result found by the cross-sectional analysis essentially repeats the result from the ICT analysis.

PwC itself concludes that it is not possible to draw any firm conclusions from the historical changes analysis.

The time-series analysis is subject to so many problems that the results of it should, in my opinion, be ignored. It is not a standard procedure for beta disaggregation.

In my opinion, the econometric analysis of PwC stretches standard methods to the absolute limit. Even so, it still does not result in a beta estimate for the local access business alone. In the one case where PwC does estimate this beta, it discounts it.

Overall, my interpretation of the evidence is that PwC has made heroic efforts to extract the maximum amount of information out of data that are, essentially, uninformative about the problem to be addressed. I believe that this creates econometric and other problems that are so great that the conclusions must be extremely limited.

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## **1. Introduction**

This is a review of the document *Disaggregating BT's beta* by PwC (June 2005). The pages and paragraphs are referred to as follows:

PwC 1 means paragraph 1, PwC p6 means page 6.

The structure of the note is:

Section 2 discusses the general structure of the evidence given by PwC. Section 3 discusses the econometric evidence. Section 4 discusses the use of the evidence and section 5 gives my conclusions.

## **2. The general structure of the evidence**

### **2.1 Introduction**

The PwC document includes discussions of fundamental factors and regulatory practice, which I do not discuss in this note. The note concentrates on the econometric evidence in the PwC document. This is in four parts:

1. Analysis of the betas of a selection of 'ICT' companies (PwC 3.1.6).
2. Analysis of the evidence from historical changes in BT's beta (PwC 3.3).
3. Cross-sectional regression (PwC 5.2).
4. Time-series analysis (PwC 6).

### **2.2 Difficulties in interpreting the evidence**

The evidence is hard to interpret, for the following reasons:

1. The measure of beta used as the principle evidence for each test differs between the tests. In the ICT test an average of weekly, daily, and monthly betas is used for 'illustrative purposes' (PwC p15). In the cross-sectional test, the daily beta is used 'as an example of our output' (PwC p33). In the time-series test the 'preferred equation' uses weekly betas (PwC p43). It is not clear to me what criteria have been applied to make these selections. They may introduce biases into the conclusions drawn.

2. The measures of beta are inconsistent with those used in the analysis performed by Brattle (2005) for a closely related purpose. Brattle concludes that a two-year beta using daily data is best for the estimation of BT's beta. PwC does not mention this measure. Brattle's criterion for its best estimate is stability, whereas the estimate chosen for PwC for its time-series analysis appears to be the least stable. Ofcom proposes to combine the conclusions of these two studies that are, in a large part, based on conflicting analysis of the same problem.
3. The tests used by PwC are inconsistent with those used by Brattle. For instance, Brattle also conducts tests similar to the 'historical changes' test of PwC. Brattle conducts the test in an entirely different way, discussed below. Brattle uses entirely different break points in the data.
4. PwC appears to weight evidence on *a priori* grounds. For instance, the result for the time-series analysis of the BT beta using access alone is given lower weight than the results based on access and core, even though it is the former that PwC is trying to estimate (PwC p45). It is not clear what criterion PwC is using to make this kind of choice. Similarly, the time-series analysis using daily data, which Brattle prefers, is given lower weight than that using weekly data because the results of the former are 'implausible' (PwC p45).
5. It is not clear how the samples used for analysis have been chosen. For instance, the sample of ICT companies chosen does not appear to be a sample that satisfies any simple criteria.
6. Different measures of the same thing are used in different parts of the analysis. For instance, the cross-sectional analysis uses revenue weights for different parts of the business, whereas the time-series analysis uses a mixture of book values and market values. It is hard to see how different measures of the same thing can both be the best measure. In general, the choice of the best measure of an economic entity does not depend on its use.

All the above make it difficult to determine how much weight to give different pieces of evidence.

### **3. PwC's econometric analysis**

#### **3.1 Introduction**

PwC presents two pieces of econometric evidence. The first is cross-sectional, based on the betas of ICT companies (PwC 3.1.6) and cross-

sectional regressions (PwC 5). The second is time-series analysis, based on betas in sub-periods (PwC 3.3) and time-series regressions (PwC 6).

## 3.2 Cross-sectional analysis

### 3.2.1 Test of the difference between ICT companies and BT

In my opinion, the only robust piece of evidence in the econometric analysis provided by PwC is that the sample of ICT businesses chosen by PwC has a higher average asset beta than the BT group (PwC 3.1.6). Even that analysis is subject to several significant weaknesses that reduce the robustness of the conclusions drawn. These are:

1. In its test of differences between a sample of ICT companies and BT, PwC (3.1.6) uses beta estimates that have not been adjusted to be optimal forecasts. Betas as high as the monthly betas in PwC Table 1 are known to be overestimates of future betas. This is why all widely used commercial beta services such as Bloomberg, Datastream and LBS that use monthly or weekly betas adjust such high estimates downwards. For instance, the asset beta based on the LBS estimate of Logica's beta is 1.29<sup>1</sup>, rather than the 2.14 reported by PwC as its estimate in Table 1. PwC includes the monthly estimates in its calculation of the adjustment to the BT beta. The use of unadjusted betas will overestimate the size of the adjustment that should be made to get the access beta.
2. Another indication that the PwC estimate may be implausible is that there is not a single industrial or commercial company in the UK market with an *equity* beta estimated by LBS based on monthly data higher than 1.82<sup>2</sup>, whereas PwC estimates the average *asset* beta based on monthly data for ICT businesses as 2.32 (PwC Table 1).
3. As discussed above, it is not clear how the comparison companies have been chosen. I do not know whether these are the most appropriate comparators. It is important, however, to ensure that the mix of activities in the firms used by PwC as ICT comparators is the same as that in the part of BT's business that it defines as ICT.
4. The estimate of the adjustment to get the beta of the access business is made using revenue weights. The correct weights to use are value weights. The use of revenue weights without any

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<sup>1</sup> London Business School Risk Measurement Service, April-June 2005 gives an equity beta of 1.45. I have combined this with leverage data from Datastream.

<sup>2</sup> London Business School Risk Measurement Service, April-June 2005.

validation of whether they are a good proxy for value weights is not appropriate and can lead to large biases. According to PwC, the ICT business has a higher risk and required return than the other BT businesses. Therefore, all else being equal, the same amount of revenue will have less value in the ICT business than in the other businesses. This implies that, all else equal, the value weight of the ICT business should be lower than the revenue weight, and the adjustment to BT's beta smaller than the adjustment made by PwC.

### **3.2.2 Cross-sectional regression**

The cross-sectional regression (PwC 5) does not provide much more evidence for disaggregation than the examination of ICT betas discussed above. The only robust result it finds is that the ICT beta is significantly higher than the other parts of the business.

Therefore, it does not seem to merit lengthy discussion. However, there are some important issues that affect the interpretation of the results:

1. The disaggregation performed by PwC estimates a beta for the total fixed line business, rather than the local access business. According to PwC the fixed line business constitutes 75% of BT (PwC p34). Therefore, the cross-sectional analysis of PwC is a quite complicated way of adjusting the BT group beta for 25% of its business. However, it appears that some estimates give an aggregate beta for the BT group that is different from the actual beta (PwC p33). Since the fixed line business is such a large part of the total business, the BT group beta is fairly direct evidence about the beta of the fixed line business. In my opinion, a method that gives a beta that conflicts with the BT group beta has serious problems.
2. PwC says it tested a number of variables to control for other things that affect betas (PwC p31). However, it does not include a very important variable that Alexander et al (1996) find to be a primary variable explaining the cross-sectional difference in telco betas. This is the nature of regulation. It is likely that the proportion of fixed line assets is correlated with a variable measuring the presence of low-powered regulation. This will bias downwards the estimate of the beta for BT's fixed line business, which is subject to high-powered regulation.
3. PwC regresses the beta on the revenue mix of the companies rather than the proportions of value (PwC p 31). If the different parts of the business have different ratios of value to revenue (which they

should if they have different risks) the results will be biased. PwC (footnote 58) says that it tested for this, but it is not clear how this was done.

4. PwC does not say how the mix of activities for each company was estimated, and does not report these data. The results will be sensitive to these estimates, but it is not possible to comment further without the details of how the mix was estimated.
5. PwC includes a variable for emerging markets, which it finds generally to be insignificant. It says that the inclusion of this does not affect the results, but it does not report the results without it.

In my opinion, these issues, in addition to the concerns raised by PwC itself, make the estimates of the divisional beta of the fixed line business resulting from the cross-sectional analysis highly uncertain. In my opinion, the one robust result that the cross-sectional analysis finds is a repeat of the result of the ICT analysis. This is the principle conclusion reached by PwC (PwC p 35). In my opinion, the additional conclusion of PwC that ‘...the actual equations may give some indication of the magnitude of differences of divisional betas [of BT]...’ is not valid.

### **3.3 Time-series analysis**

#### **3.3.1 Evidence from historical changes**

PwC analyses the levels of BT beta estimates in different periods (PwC 3.3). Its conclusion is that ‘there are too many complicating factors to enable us to draw any firm conclusions from this analysis’ (PwC p22). I agree with this conclusion. However, in addition to the problems that PwC mentions, I believe there are others, including:

1. The betas for each period are measured using data from outside the period. For instance, the monthly beta for the period from Oct 2003 to April 2004 uses data that are, on average, from about June 2002.<sup>3</sup> This date falls in the earlier sub-period. In my opinion, therefore, it would be legitimate to conclude that the high asset beta, of 1.08, applies mainly to the earlier ‘Back to UK fixed telecommunications’ period, rather than the ‘Growing new wave and ICT period’ to which PwC attributes it. This would contradict one of PwC’s conclusions, that the BT beta fell during the ‘Back to UK fixed telecommunications’ period. PwC notes this problem (PwC page 22) but does not use the standard procedure to deal with

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<sup>3</sup> The middle of the period is about November 2004, and data are, on average, 2.5 years before this.

it. Brattle conducts similar tests, but estimates betas using data only from within the period, which is standard. In my opinion, the Brattle procedure is correct and the PwC procedure is non-standard and may introduce significant biases.

2. The dating of the break points between periods chosen by PwC is arbitrary. For instance, they might have chosen to date a break point at the sale of O<sub>2</sub>. This would satisfy standard econometric criteria for the dating of a break point. When break points cannot be dated precisely, it introduces severe problems in this type of analysis (see Brattle (2005)).
3. Some of the beta estimates used are inherently implausible. For instance, the weekly asset beta looks like it changes from about 2.3 to about 0.1 between late 2000 and late 2001 (PwC Chart 4). This clearly indicates an econometric problem, yet PwC's analysis treats it as though it measures a change in the fundamental risk of BT.

PwC itself concludes that it is not possible 'to draw any firm conclusions from [the historical changes] analysis' (PwC p22). In my opinion, when the above problems are included, this conclusion is even truer.<sup>4</sup>

### **3.3.2 Time-series regression**

Because it does not reach any firm conclusions from its historical changes analysis, PwC concludes that it needs 'to investigate time-series movements in a more robust manner' (PwC p22). To do this, it conducts a series of time-series regressions (PwC 6). This raises the issue of whether this time-series analysis is the robust evidence that PwC is seeking. In my opinion, it is not.

The time-series analysis of BT's beta suffers from a large number of well-known econometric problems, including the following:<sup>5</sup>

1. The time-series result that PwC uses is based on weekly betas. The use of weekly betas conflicts with the use of daily betas advocated by Brattle and the use of daily betas by PwC as its main evidence elsewhere. PwC acknowledges that daily betas do not give plausible disaggregated beta estimates (PwC p45). This is taken by PwC as a reason to give more weight to results based on weekly

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<sup>4</sup> There is a version of this type of analysis that is sometimes used when companies merge. It involves observing the beta of the acquired company and adjusting the merged company for it. In this case, however, the date of the change is known, and the beta of the separate target company can be observed before the merger, so the problem is entirely different.

<sup>5</sup> Discussion of most of these can be found in any standard econometrics textbook, such as Judge et al (1988).

betas. An alternative interpretation is that the whole procedure is unreliable. Apart from the fact that daily betas give implausible results, PwC does not explain why it prefers weekly betas. It does not say how it dealt with the well-known problem of the dependence of the estimates on the day of the week, which it acknowledges as a problem elsewhere (PwC p33). As discussed in the previous section, the weekly betas look the most implausible. As is acknowledged by PwC, they are highly erratic (PwC p33).

2. (Measurement error) PwC attributes almost all variation in the market value of BT to the non-access business by using book values for the access business. If, as is likely, the true market value of the access business has varied over the period in a way that is correlated with the level of the stock market, this may bias down the estimate of the access beta. It will attribute all the increase in beta estimates when the stock market was high to the non-access business. This is a potentially large bias. PwC says that it tested for this (PwC p45) and that it does not make a difference, but it is not clear that its test is the right one, and it does not report the results.
3. (Serial correlation, overlapping data) In its regressions PwC uses overlapping periods as if they are non-overlapping, or with a limited correction for the serial correlation that is induced. This can result in very large biases when the data overlap as much as the data used by PwC. It can lead to apparent statistical significance where none exists. The correct adjustment for overlapping data is complex (Hansen and Hodrick (1980)). PwC appears to accept that one statistically correct approach would make it difficult to reach conclusions (PwC p40 fn 67).
4. (Omitted variables) PwC does not include some other variables that might explain the changes in beta over the period. For instance, the *estimates* of BT's beta over this period are related to changes in the volatility of the stock market (Cooper (2005)). PwC does not include this variable, except indirectly through dummies. Omitting this and any other variables that are related to the change in beta estimates may bias down the estimate of the access beta. The analysis performed by PwC may attribute changes in beta estimates to changes in the mix of operations when they are actually caused by other factors.
5. (Heteroscedasticity) PwC estimates without making any correction a regression that includes data that, in Brattle's opinion, exhibit heteroscedasticity (Brattle (2004) p 5). PwC Chart 8 also appears to indicate heteroscedasticity, in that the spread of the points is clearly related to the proportion of non-core activities. Omission of any

adjustment for heteroscedasticity will tend to bias estimates and exaggerate the significance of any results.

6. (Misspecification) PwC uses the combined proportion of access and core, whereas it is trying to estimate the beta of access alone. It reports that there is a result using access alone, which it does not use (PwC p45). Therefore, the results it reports are from a regression that is misspecified.
7. (Non-normality) All the significant tests assume normal distributions, but the rapid changes in beta estimates in Chart 7 suggest that this may well not be true. PwC does not test for non-normality, which will lead to spurious significance tests. There is evidence of non-normality in the data on which these estimates are based (Cooper (2005)). This may lead to non-normality in the residuals of the regressions used by PwC. Inspection of PwC Chart 8 suggests that it does.
8. (Ex-post selection of dummy variable) PwC chooses its TMT boom dummy variable by looking at the *ex post* behaviour of beta (PwC p39 fn 65). This can induce significant biases. The dummy periods chosen differ from the periods in the historical change analysis discussed in the previous section. It is not clear why they are different, since they are attempting to measure the same thing, structural changes in BT's beta. Their difference illustrates the potentially arbitrary nature of such analysis.
9. (Misspecification) The level of beta in a period is generated by the average mix of operations during that period. PwC appears to assume that the level of beta during a period is related to the mix of operations at the end of the period. This will bias the estimates.

These problems are not merely of academic interest. Any one **alone** can generate spurious results and introduce large biases in a time-series regression of the type estimated by PwC. PwC itself acknowledges many of them. In my opinion, taken together they mean that the time-series analysis conducted by PwC does not give any quantitative or directional evidence about the relative beta of the access business of BT. In my opinion, it is not the 'robust' analysis that PwC is looking for.

This conclusion is reinforced if one looks more closely at the variation in beta estimates from which PwC derives its conclusions. PwC does not attempt to explain the precipitous changes in beta shown in Chart 7 (PwC p38). It is completely implausible that these are caused by changes in the mix of BT's operations, yet the subsequent analysis treats them as such. They are almost certainly statistical artefacts, but no attempt is made to investigate them.

Furthermore, time-series analysis of the type proposed by PwC is not mentioned by any standard authority on divisional cost of capital estimation. For instance, the approach is not mentioned in the book on estimation of the cost of capital written by three senior PwC practitioners in the area (Ogier et al (2004)). It is not mentioned in any standard corporate finance textbook of which I am aware. All these books discuss the estimation of divisional cost of capital, of which the estimation of the beta of BT's local access business is an example. The standard methods are the ones that have survived tests of their reliability. It is, in my opinion, dangerous to use non-standard methods whose properties are not known.

### **3.4 PwC's econometric analysis: Conclusion**

In my opinion, there is only one robust piece of evidence in the econometric analysis provided by PwC. It is that the sample of ICT businesses chosen by PwC has a higher average asset beta than the BT group. Even that analysis is subject to several significant weaknesses that reduce the robustness of the conclusions drawn. The quantitative interpretation placed on this by PwC is heavily affected by the fact that it uses betas that have not been adjusted to be optimal forecasts. This would significantly reduce the size of the adjustment to the access beta. In addition, uncertainty about whether these are the right comparators for the BT ICT business and whether the revenue weights are the right proxy for value adds to the uncertainty about the adjustment.

The only robust result found by the cross-sectional analysis essentially repeats the result from the ICT analysis.

PwC itself concludes that it is not possible 'to draw any firm conclusions from [the historical changes] analysis' (PwC p22).

The time-series analysis is subject to so many problems that the results of it should, in my opinion, be ignored. It is not a standard procedure for beta disaggregation.

## **4. The use of the evidence**

Apart from the detailed evaluation of the econometric evidence, I disagree with PwC on two fundamental points regarding the interpretation of this evidence. These are the analogy it makes with

standard beta estimation and the weight it gives to different parts of the evidence.

#### **4.1 Analogy with standard beta estimation**

PwC several times says that the difficulty of estimating betas in general justifies the use of its disaggregation techniques. For instance, in justifying its general approach:

‘We note that in many business applications it is difficult to find a significant number of good comparators for beta estimation, but conducting such analysis on less than perfect comparators is generally preferred to not conducting the analysis at all. We also note that any calculation of beta involves a degree of judgement.’  
(PwC p28)

As a justification for giving little weight to the fact that time-series analysis using daily data gives ‘implausible results’:

‘..uncertainty surrounding how to calculate beta is an inherent issue in financial economics, and such analysis can still be of value.’  
(PwC p45)

As a justification for its conclusions:

‘There is, for example, no precise, accepted estimate of BT’s group beta available to Ofcom, but nevertheless Ofcom needs to adopt a figure....’ (PwC p48)

In my opinion, the analogy between PwC’s evidence on the disaggregation of BT’s beta and normal beta estimation is invalid. For instance, when the BT group beta is being estimated, the evidence is direct. It involves only share prices, which can be measured accurately. The historical level the beta of BT’s share price relative to a market index can be measured directly. What is at issue is how to convert this to an optimal forecast. In the evidence for disaggregation produced by PwC the evidence is extremely indirect. It involves a mixture of share price data and other information, such as revenue shares, which are imperfect proxies for the variables of interest. The share price data is for variables (such as ICT companies) that are only extremely indirectly related to the variable of interest, the beta of the local access business of BT. It also involves complex problems of statistical inference. The idea that these two problems, estimating the group beta of BT and estimating the beta of

the local access business, are in any sense equivalent is, in my opinion, wrong.

Even when PwC's methods are compared with normal divisional cost of capital analysis, this conclusion is still true. In normal divisional cost of capital estimation, the companies used may be imperfect proxies, but they are imperfect proxies for the division whose cost of capital is being estimated. This introduces one extra layer of difficulty over estimating a cost of capital for a company directly. In the procedures applied by PwC, there is not just the problem of choosing proxies and estimating their betas, but these proxy betas do not estimate the beta for the local access business. So complex issues of statistical inference arise, over and above any normal problems with beta estimation and proxy choice. As I have discussed above, my opinion is that these make the quality of information so poor as to be unreliable.

In my opinion, the issue is one of the quality of the evidence. Normal beta estimation carries some uncertainty, but the evidence is quite direct. The type of disaggregation analysis performed by PwC carries an entirely different order of uncertainty and the evidence is entirely indirect.

#### **4.2 The weight given to the evidence**

At several important points in the analysis, there is a choice between different interpretations of the evidence. Examples are:

The result for the time-series analysis using access alone implies that 'the beta for core is less than the beta for access' and 'access & core gives a markedly higher beta for the rest of the business than is the case if access only is applied' (PwC p46). This seems to imply that the estimate for access alone is markedly higher than the beta for access & core combined. PwC appears to draw the implication from this that the results using access alone are unreliable. In my opinion, there are no clear grounds for this interpretation. In my opinion, equally valid interpretations are that the whole procedure is unreliable, or that the result for access & core combined is unreliable.

PwC calculates the implied group beta for its disaggregated betas based on its cross-sectional analysis. It finds, for the daily local market betas, that this is similar to the actual beta of BT. It reports this result as supportive of its analysis, whereas it also reports that 'for some of the other regressions there is difference between BT's

predicted and actual beta.’ (PwC p33) An alternative interpretation is that the procedure is unreliable because it generally appears to lead to divisional beta estimates that are inconsistent with the BT group beta.

The time-series analysis using daily data, which Brattle prefers, generates results that are ‘implausible’ (PwC p45). As a result, PwC bases its time-series results on weekly data. In my opinion, an equally valid interpretation is that the procedure is unreliable.

PwC says that ‘not too much reliance can be placed on the absolute numbers emerging from our time series analysis’. Yet it interprets the evidence as though it suggests that ‘deviations from the group beta could be relatively large’ (PwC p47). In my opinion, an equally valid interpretation would be that these deviations could be relatively small.

In my opinion, the correct interpretation in all these cases is that almost all of the econometric evidence tells one little about the beta of the BT local access business. It is extremely indirect. It is ambiguous. In my opinion, it is fraught with the econometric difficulties discussed above.

## **5. Conclusions**

In my opinion, the econometric analysis of PwC stretches standard methods to the absolute limit, because of the problems given above. Even so, it still does not result in a beta estimate for the local access business alone. In the one case where PwC does estimate this beta, it discounts it.

Therefore, my interpretation of the evidence is that PwC has made heroic efforts to extract the maximum amount of information out of data that are, essentially, uninformative about the problem to be addressed. I believe that this creates econometric and other problems that are so great that the conclusions must be extremely limited.

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