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ABSTRACT

Risk Shifting, Technology Policy and Sales Contingent Claims: When is Launch Aid to the Aerospace Industry A Subsidy?*

This Paper studies the criteria with which the presence or absence of ‘subsidy’ in sales contingent Launch Aid R&D support may be determined when payoff-relevant market incompleteness limits the precision of market-based pricing to non-trivial intervals. The criteria currently employed in WTO and EU proceedings are consistent with correct accounting for the opportunity cost of capital when markets are complete and frictionless, but fail in the presence of payoff-relevant market incompleteness where the interval between bid and ask prices may not be finessed away. An economic definition of subsidy must necessarily capture opportunity cost, and we develop a definition that fully incorporates government’s opportunity cost in both complete and incomplete market settings. With this in hand we then revisit some commonly posed questions concerning the subsidy status of Launch Aid, giving indication of how they may be best resolved by those in possession of the relevant details.

JEL Classification: D52, F13, H25, L62 and O38
Keywords: civil aerospace, incomplete markets, R&D, sales contingent claims and subsidies

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1 Introduction

Since the end of World War II the UK government has provided new product development support to the UK civil aerospace industry under the general label of Launch Aid. Although the details of the scheme and the enthusiasm with which it has been applied have changed a number of times in the last fifty years, the underlying principles have not. Launch Aid is a form of discretionary government support for specific civil aerospace product development programs[1] in which government's up-front financial investment is repaid through a levy on sales. With the exception of the United States, similar schemes exist in other civil aerospace manufacturing nations, especially those heavily involved in the development of Airbus products.[2]

The principles underlying the operation of Launch Aid, both in terms of its provision and its workings, have largely been ignored in the literature. Gardner (1976) is still the definitive study of such issues, but is now very dated. The provision of Launch Aid by European governments to their civil aerospace industries has however become a particular bone of contention between the United States and the European Union. The United States government position is that Launch Aid is a prima facie case of unjustifiable subsidy to European manufacturers. According to the European position, Launch Aid is not a subsidy but a risk sharing 'Launch Investment'—a risk shifting instrument of finance—that the market fails to supply on its own. The main objective of this paper is to address the question of whether government-supplied Launch Aid constitutes a subsidy to the industry receiving such assistance.

Unanimous agreement on what precisely constitutes a subsidy is lacking on both theoretical and applied levels.[3] From the perspective of legal codification—intended to cover the breadth of possible occurrence of trade-distorting subsidies[4]—and arguably other wider issues, the ap-

[1] Airframe, aero-engine, major sub-assembly (wings, fuselage) and helicopter development programs have received Launch Aid support.

[2] Moreover, similar schemes for more widely-defined product development programs not restricted to the aerospace industry have been available in, for example, Canada, Sweden, Finland, The Netherlands and Israel. These have been administered, respectively, by Technology Partnerships Canada (TPC), Industrifonden [The Swedish Industrial Development Fund], TEKES [National Technology Agency of Finland], Senter [an agency of the Dutch Ministry of Economic Affairs] and The Office of the Chief Scientist (OCS; see Trajtenberg (2002))

[3] Alternative formalizations of 'subsidy' are reviewed in Supplement A, available upon request from the authors. Also see e.g. Lehner, Meiklejohn and Reichenbach (1991), Schwartz and Clements (1999), OECD (2001), Article 87 of The EC Treaty, and Article 1 of the Subsidies and Countervailing Measures (SCM) Agreement under the 1994 (Uruguay round) GATT.

[4] of which R&D subsidies make up only a limited part

proaches of the EU and the WTO to the definition of 'state aid' and 'subsidy' have some merit. But the point of departure for this paper is the formalization of 'subsidy' from the perspective of economic theory, taking full account of the complications introduced by market incompleteness that are of particular relevance with regard to government support for R&D.[5]

This paper aims to identify the criteria with which the presence or absence of 'subsidy' may be determined when payoff-relevant market incompleteness limits the precision of market-based pricing to non-trivial intervals within upper and lower bounds. This is the context of Cochrane and Saá-Requejo (2000) and Bernardo and Ledoit (2000).

Currently WTO (respectively EU) proceedings identify instances of 'subsidy' ('state aid') with criteria that are implicitly (explicitly) based on the Market Economy Investor Principle (MEIP), i.e. that a financial investment by the government incorporates a subsidy if a hypothetical private investor would not have invested on the same terms and conditions under the same circumstances. This principle of using a hypothetical private market investor operating under normal market conditions as a benchmark to determine both (a) whether subsidy/state aid is present and (b) to quantify its extent, has been accepted and employed in the EU by the Commission and the Court of Justice and in the WTO by the Dispute Settlement Body Panels.[6]

When markets for payoff-relevant state claims are complete and frictionless, MEIP-based rules are natural and correct—in the sense of properly accounting for the opportunity cost of capital—but redundant in that, by the very act of choosing to accept funding from government, the profit maximizing firm reveals this to be on cheaper or otherwise better terms than private-sector alternatives.

When markets for payoff-relevant state claims are *in*complete—whereby market-based pricing is limited in precision to non-trivial intervals between upper and lower bounds—MEIP-based rules single out and limit attention to the comparison between (a) the actual transacting price between government and manufacturer, and (b) a determination of the representative market financier's[7] <u>bid</u> price. Yet, under this form of market incompleteness, marginal rates of substi-

[5]Given that the details of Launch Aid contracts (e.g. repayment schedules) are project-specific and unavailable in the public domain, it will not be possible to indicate whether any particular Launch Aid contract represents a subsidy or not. Instead our purpose here is to present a general conceptualization of Launch Aid contracts and to indicate how such contracts may be valued so that those who are in possession of the relevant details may judge for themselves whether any particular contract embodies a subsidy or not.

[6]as well as the Appellate Bodies

[7]or, in the terminology employed by the EU, 'a hypothetical' investor's

tution are not equalized across agents: private benchmark valuations and pricing bounds are consequently free to differ between individual agents. Hence, under this form of market incompleteness, the difference between the transacting price and the market financier's bid price fails to have formal economic significance as a quantification of the (in)efficiency of capital allocation; here the market financier's bid price remains uninformative with regard to the government's true opportunity costs.

Insofar as the prohibition of subsidies rests formally on the suppression of product market distortions induced by inefficient capital allocation—i.e. improper accounting for the opportunity cost of capital—then the MEIP-criterion fails and misleads when markets for payoff-relevant state claims are incomplete. Considerations of opportunity cost are what motivate the preoccupation with the 'market rate of return' in corporate finance, and the Principle of Comparative Advantage in trade theory is obtained as an application of the Opportunity Cost Principle (Haberler, 1936). Any economic definition of subsidy must necessarily account for opportunity cost. Insofar as proper accounting for the cost of capital is necessary to the criterion for subsidy-neutrality, then according to this efficiency criterion the government should choose the trading counterpart with the lower ask price. The market financier's bid price—that which is elicited and used in applications of the MEIP-criterion—is in fact uninformative with regard to government opportunity cost in this context of payoff-relevant market incompleteness and heterogeneity of marginal rates of substitution, private valuations and pricing bounds.

Following this logic, in this paper we identify the repayment mechanism embodied in Launch Aid as an example of the class of generalized royalty-based instruments that we choose to call Sales Contingent Claims (SCC).[8] Individual Launch Aid contracts specify not only the levy repayment schedule, but also the agreed magnitude of government's up-front cash investment with which it obtains the rights to the future levy stream. Abstracting from the specifics of context, we refer to this net contract-package as a Sales Contingent Contract (SCCo).

In the narrow economic sense of 'subsidy', Launch Aid contracts then incorporate a subsidy if the government's up-front payment exceeds the market value of the Launch Aid SCC, or equivalently, if the net market value of the corresponding Launch Aid contract SCCo is less than zero. The wider, preferred sense of 'subsidy' in turn expands the set of alternatives across

[8]Kaivanto (2002) shows that there are many contracts in the economy that may be labelled as sales contingent and thus the methods we apply below may have wide applicability, however these wider issues are not the object of attention here.

which the Opportunity Cost Principle is applied, yielding additional conditions as bounds given by the manufacturer's and market financiers' ask prices. When markets are frictionless and complete—or more specifically, when payoff-relevant market incompleteness is absent—these conditions coincide with the Market Economy Investor Principle (MEIP). However when market incompleteness impinges upon the precise valuation of the SCC levy stream—i.e. squarely when government's role in completing the market with Launch Aid may be justified[9] from an economic standpoint—we argue that the prevailing WTO/EU interpretation of subsidy/state aid criteria diverges from strict consistency with the proper accounting for opportunity costs.

The paper proceeds as follows. In the next section we provide a brief history of UK Launch Aid with an emphasis upon disbursements and receipts. In section 3 we introduce the class of Sales Contingent Claims. Section 4 presents payoff-relevant market incompleteness. In section 5 we develop a definition of subsidy by building upon criteria that survive the relaxation from complete to incomplete markets. Section 6 revisits basic questions regarding Launch Aid's subsidy status. Section 7 concludes.

2 Launch Aid: The History

Kaivanto (2002) presents a detailed history of the legal, administrative and policy development of Launch Aid in the UK. In particular he reports revised estimates of the history of Launch Aid disbursements and receipts on both Airframe and Aero engines from 1973 to 1996 drawing on all publicly available data. Gardner (1976) provides similar data for the period from 1947 to 1973, though from the position of an informed government insider. However from 1996 onwards public domain information[10] is not available in disaggregated form. Hence in Table 1 we present net Launch Aid expenditures in cash and real terms aggregated over all projects for the period 1945 to March 31 2000. Although post-1996 maturing projects have tended to yield receipts to government greater than disbursements (e.g. the A320 program; see Figure 1), it is true that over the whole history of Launch Aid government disbursements have exceeded government receipts: excluding the Concorde program, total net real Launch Aid expenditure has been in excess of £6 billion.

insert Table 1 (on p. 32) about here

[9] prior to any consideration of whether a subsidy component is present or absent

[10] for instance, as found in the *Appropriations Accounts* or *Forward Look* publications

insert Figure 1 (on p. 34) about here

It would be misleading however to therefore immediately judge that Launch Aid as it operates today is a subsidy mechanism. The data available reveals ex post realizations. Given uncertainty over actual outcomes, the mere observation that, ex post, disbursements exceeded receipts does not constitute evidence that this was the ex ante intention. For Launch Aid to be viewed as a subsidy it is necessary that the terms of the Launch Aid contract be so ex ante.

Kaivanto (2002) details the contract form that has been applied to Launch Aid, to the extent that this is possible from information in the public domain. A standard Launch Aid contract will involve a payment K to the aerospace company[11] and a repayment schedule conditional upon sales whereby the aerospace company will pay a royalty to the government on each unit sold. The repayment royalty tends to be at a low rate for the first few units sold, increasing for later units and then, after some 'break even threshold', it returns again to a lower rate.

insert Figure 2 (on p. 35) about here

At this threshold—'the [sales] target at which HMG [Her Majesty's Government] expects to recoup its investment'—the levy schedule is heavily kinked (see Figure 2).[12] Assuming a correct discount rate ρ, the expected repayments are (as declared by government) ex ante expected to cover the payment K. Letting the repayments at time t be R_t, where R_t is dependent upon N_t, the number of units sold at time t, the contract is thus designed such that

$$K \leq \sum_t \frac{R_t(N_t)}{(1+\rho)^t} \tag{2.1}$$

where ρ is the appropriately specified discount rate. Over time, changes in the administration of Launch Aid have restricted the size of K such that it now can no longer exceed one third of total development costs. In addition, over time the assumed discount rate has varied as have the various royalty rates.

3 The Sales Contingent Claim abstraction

The defining characteristic of an SCC is that the payments to the holder of the claim are a function of realized sales. The claim may be written upon the units sold or on revenues realized.

[11] which may be spread over time or staged

[12] This wording, absent the square bracketed material, was provided to the authors in an explanatory communication by the UK Department of Trade and Industry in 1995.

Launch Aid clearly involves a sales contingent claim. When defined in this way sales contingent claims are quite commonly observed. Other examples of such claims include royalty-based patent licensing agreements, franchise agreements, piece work, sales commissions, revenue bonds, and share cropping.

It is useful to distinguish between the gross and net forms of the sales contingent contract. The gross (SCC) form we define as encompassing only the repayment schedule. The net (SCCo) form we define as also encompassing the principal paid. The net (SCCo) form is of particular relevance in the present context, because in encapsulating the Launch Aid contract, this is precisely the object of investigation with regard to the subsidy question. But if the Launch Aid contract were to be subsequently placed on the market, potential buyers would value the gross (SCC) form and compare this with the seller's asking price.

An SCC, as conceived here, heuristically consists of a contract whereby an issuer agrees to make a payment to the holder according to a function of the issuer's achieved sales over a specified time period. This function need not be linear, but in general the specification of the relevant sales can be intricate and non-trivial.

The notation and conventions needed to accommodate and represent the full range—in terms of complexity and horizontal differentiation—of SCCs observable in the economy can be found in Kaivanto (2002). As our primary concern and emphasis here is not on the definition of the general class of SCCs, we are free to employ a light variant of that notation, as befits our object of investigation.

In order to define an SCC it is necessary to specify (i) the relevant sales ψ, (ii) the (generalized royalty-based, sales contingent) payoff function $\varrho(\psi)$, and (iii) the stochastic sales process $\tilde{\psi}$.

The relevant sales are non-negative and real or integer valued ($\psi \in \mathbb{R}_+$ or $\psi \in \mathbb{I}_+$). The time period of 'relevant' sales must also be specified. It suffices to write ψ_t where $t = \{0, 1, ..., T\}$. Time $t = 0$ marks the origination or signing of the SCC contract (first possible payout at time $t = 1$), and time $t = T$ marks the end of the final period in which a payout may be required under the SCC.

SCC instruments have the payoff function

$$\varrho(\ell_F, \ell_V(\psi_t, \Sigma_{\tau=0}^{t}\psi_\tau, \boldsymbol{h}, t, \boldsymbol{o})) \qquad \begin{matrix} \varrho \geq 0 \; \forall \, \psi \geq 0 \\ \\ \partial\varrho/\partial\psi_t > 0 \end{matrix} \quad , \tag{3.1}$$

where ℓ_F denotes a possible fixed component of the SCC payoff and ℓ_V denotes its principal, variable component. In general the variable component ℓ_V may be an intricate, piece-wise linear, or even non-linear function of sales, including dependence on possibly e.g. cumulative sales $\Sigma_{\tau=0}^{t}\psi_\tau$, threshold terms $\boldsymbol{h}$, time t, and other terms $\boldsymbol{o}$. Consistency requires that the payoff function $\varrho\left(\ell_F, \ell_V(\psi_t)\right)$ be specified according to the units in which sales ψ_t are denominated. Only functions which yield non-negative payoffs for non-negative sales are admissible within the SCC class of instruments, where, furthermore, it is assumed that payoffs are monotonically increasing in sales.

Lastly, the stochastic sales process $\tilde{\psi}_t$ is to be specified. Pinning down the precise process that governs the evolution of sales is very demanding, and particularly with regard to valuation, it is the most critical step in defining an SCC. The probability distribution of sales at time t is a function of the evolution of demand D and the strategic game Ξ played between the set of $\mathcal{N}$ competing firms choosing from among the set of strategic actions $\mathcal{X}$ and giving rise to associated strategic uncertainty shocks ε_Ξ, given an initial value of sales in a preceding period. In general terms the distribution of sales at time t may be written as

$$\tilde{\psi}_t \sim f(D(\boldsymbol{d}, \varepsilon_D), \Xi(D, \mathcal{N}, \mathcal{X}, \varepsilon_\Xi), \psi_{t-1}, t) \quad . \tag{3.2}$$

Formally,

Definition 3.1 (Sales Contingent Claims). An SCC originated at time $t = 0$ defined on sales occurring in periods $t \in \{1, 2, ..., T\}$ may be written as the admissible $\psi_t \geq 0$, $\varrho_t \geq 0$, $\partial\varrho/\partial\psi_t \geq 0 \ \ \forall\, t \in \{1, 2, ..., T\}$ and consistent triple

$$\left(t, \tilde{\psi}_t, \varrho_t(\psi_t, \Sigma_{\tau=0}^{t}\psi_\tau, \boldsymbol{h}, t, \boldsymbol{o})\right) \quad , \tag{3.3}$$

where consistency ensures that sales ψ and the payoff function ϱ are denominated in the same units. Generically, the SCC originated at time $t = 0$ on the sales of firm $\mathsf{m}\in\mathsf{M}$ may be denoted as $\mathrm{SCC}_{\mathsf{m}0}(t, \tilde{\psi}_{\mathsf{m}t}, \varrho_t(\psi_{\mathsf{m}t}, \Sigma_{\tau=0}^{t}\psi_{\mathsf{m}\tau}, \boldsymbol{h}, t, \boldsymbol{o}))$, or where no confusion results, simply as $\mathrm{SCC}_{\mathsf{m}0}$. In turn, the associated class of SCC instruments comprises the set of all admissible and consistent triples

$$\left\{t, \tilde{\psi}_t, \varrho_t(\psi_t, \Sigma_{\tau=0}^{t}\psi_\tau, \boldsymbol{h}, t, \boldsymbol{o})\right\} \quad . \tag{3.4}$$

Henceforth the scope of this paper is limited to R&D programs financed with SCCs. Development and discussion takes place in terms of Launch Aid sales contingent claims denoted by $\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}$, where the 'LA' superscript represents the specification of an admissible and consistent

Launch Aid triple $\left(t, \tilde{\psi}_{\mathsf{m}t}, \varrho_t\right)$, the first subscript indicates the 'issuer' or 'writer' of the claim (here, manufacturer m), and the second subscript denotes the time period in which the claim is issued (here, t).

4 Incomplete markets

If Launch Aid SCCs were actively traded on the market, giving rise to a unique market price, then government provision of Launch Aid would become unnecessary. And in the event that government would supply Launch Aid SCCs when they were also actively traded on the market, the appropriate criterion for subsidy would be unambiguous. In the absence of active trading in Launch Aid SCCs, a unique market price might still be obtained as the present value of an appropriately specified replicating portfolio—if the SCC payoffs were spanned by the existing set of claims traded on the market. It is under the failure of (perfect) replication because of the failure of (perfect) spanning—that is, the condition of payoff-relevant market incompleteness—that the following analysis shall be conducted. But first, it is desirable to beyond the mere assertion that Launch Aid SCCs are indeed not observed to be traded on the markets.

4.1 Why are Launch Aid SCCs not traded on free markets?

Mukerji and Tallon (2001) identify three conditions under which an asset will not be traded in any financial market equilibrium, that is, they identify three conditions under which markets for specific instruments close down endogenously. Firstly, for the asset in question, the range of variation of the *idiosyncratic* component of payoffs must exceed the range of variation of the *systematic* economic component of payoffs. Secondly, ambiguity (Knightian uncertainty) over the realization of the idiosyncratic component of payoffs must exceed a particular threshold $\bar{\mathcal{A}} \in (0,1)$.[13] This ambiguity threshold $\bar{\mathcal{A}}$—the amount of ambiguity sufficient to cause no trade, irrespective of the utility functions of the agents and the endowment vector—is expressed simply as the ratio of the range of the *systematic* to the *idiosyncratic* components of the asset's payoffs. Once endowments and utility functions are specified precisely, the operative ambiguity threshold will typically be lower than $\bar{\mathcal{A}}$. Thirdly, agents participating in the financial markets must be ambiguity averse.

[13] employing Fishburn's (1993) definition of ambiguity

Mukerji and Tallon (2001) make note of the following sources of idiosyncratic variation (p. 890, footnote 6):

> For instance, suppose a firm introduces a new product line, an innovation, into the market. In such a case, typically, it is not just the shocks commonly affecting firms in the same trade that will affect the sales of the new product but also more (brand) specific elements, *e.g.* whether (or not) the innovation has a "special" appeal for the customers. Another example of idiosyncratic shocks are shocks to firms' internal organizational capabilities.

Among the many sources of perturbations to a new civil aircraft's sales, three may be singled out for present purposes: I. The business (GDP) cycle; II. i) Technological uncertainty and ii) Project and/or production management uncertainty; and III. Is there a market for *this kind* of airliner—will a viable market for this type materialize? The first (I) is highly correlated with aggregate consumption—and by far the dominant determinant of aircraft sales in the short-to-medium term—while the latter two (II & III) are precisely those sources of idiosyncratic variation identified by Mukerji and Tallon (2001).

In particular, R&D programs for novel design configurations—representing a discrete step-change in technology (drastic or revolutionary innovation) as opposed to incremental innovation—clearly have high (II) technological and project/production management uncertainty as well as (III) market-materialization uncertainty. Here it is quite properly (Knightian) uncertainty rather than risk, since for a new design configuration there is no previous experience upon which to base a risk assessment. For subsequent (derivative) types and variants developed within a proven design configuration, the level of idiosyncratic uncertainty is lower, although arms-length investors may not be able to quantify precisely how much lower it is.

For SCCs written on new design configuration R&D programs, then, it is not unreasonable to conclude that the conditions for no trade are indeed met, and that hence manufacturers without substantial parallel military R&D and production may well not be able to finance such programs exclusively with market-traded instruments.

4.2 Pricing implications

The chosen framework for developing the implications of payoff-relevant market incompleteness and in particular for valuing SCCs is the consumption-based Stochastic Discount Factor (SDF) model.[14] Under the present set of conditions the SDF fails to be unique, and although Absence of Arbitrage does place 'no-arbitrage bounds' on the possible prices for $\mathrm{SCC}_{\mathrm{m}t}^{\mathrm{LA}}$, the range of no-arbitrage prices is typically too wide to be of practical economic significance. However, by imposing further—yet economically natural and appropriate—restrictions on the SDF, the range of price indeterminacy may be narrowed considerably from that demarcated by the no arbitrage bounds. Two recently developed approaches to implementing such restrictions have been proposed by Cochrane and Saá-Requejo (2000) and Bernardo and Ledoit (2000), known respectively as the No-Good-Deal approach and the Gain-Loss-Ratio approach. In conjunction with brief description, the relative merits of these two alternative approaches to the present problem-setting are discussed below.

4.2.1 No-Good-Deal restriction

The Cochrane and Saá-Requejo (2000) approach exploits the formal functional relationship between the *Sharpe ratio* and the *volatility of the SDF* $\sigma^2(m)$ as identified by Hansen and Jagannathan (1991). By supplementing Absence of Arbitrage with an upper bound of h on the Sharpe ratio, Cochrane and Saá-Requejo (2000) restrict the volatility of the SDF to $\sigma(m) \leq h/R^f$, thereby obtaining *No-Good-Deal* asset price bounds.[15] There is a long history of viewing high Sharpe ratios as 'good deals' that are attractive to investors. Restricting the maximum allowable Sharpe ratio to h is equivalent to assuming that investors do in fact buy high Sharpe ratio assets and portfolios—specifically, *all* investment opportunities above the exogenously fixed threshold h. Because of their connection to Sharpe ratios and therein to mean-variance efficiency, No-Good-Deal restrictions on the SDF have considerable theoretical and intuitive appeal.

The No-Good-Deal asset pricing bounds approach is inherently well-suited to short-dated, in-the-money pricing problems where returns may be reasonably and reliably assumed to be normally distributed. For long-dated, out-of-the-money pricing problems, the distribution of returns becomes more skewed, and No-Good-Deal asset pricing bounds become less accurate accordingly (Bernardo and Ledoit, 2000). As our primary objective here is to value long-dated out-of-the-money SCCs,[16] this must be regarded as a detraction—for present purposes, at least—

[14]See Campbell (2000) for a review and Duffie (1992) for a standard textbook treatment. For a systematic restatement of asset pricing theory within the consumption-based SDF model see Cochrane (2001).

[15]N.B. The Sharpe ratio bound truly 'supplements' or 'augments' Absence of Arbitrage in that the Sharpe ratio bound does *not* imply Absence of Arbitrage.

[16]N.B. Returns to R&D investment are typically highly skewed—see *e.g.* Scherer and Harhoff (2000).

from the suitability of the otherwise appealing No-Good-Deal asset pricing bounds approach.

4.2.2 Gain-Loss Ratio restriction

The Bernardo and Ledoit (1999, 2000) proposal for strengthening the no-arbitrage assumption involves imposing an upper threshold on the *Gain-Loss Ratio*, which in turn translates into pricing bounds around a benchmark. Like the No-Good-Deal approach, the Gain-Loss Ratio approach identifies the set of prices that precludes investment opportunities which exceed a given threshold level of attractiveness for a benchmark investor, where the measure of attractiveness employed is the Gain-Loss Ratio. However, unlike the No-Good-Deal approach, the Gain-Loss Ratio approach is not predicated on a non-skewed return distribution. Moreover, because arbitrage opportunities are uniquely characterized by an infinite Gain-Loss Ratio, any finite upper threshold $\overline{L}$ on the Gain-Loss Ratio also demarcates a formal *neighborhood* of the set of pure arbitrage opportunities. Hence, the Gain-Loss Ratio approach strengthens the no-arbitrage assumption to 'no *approximate* arbitrage'. The latter implies and is stronger than no-arbitrage by itself. As the Gain-Loss Ratio threshold is increased without limit $\overline{L} \to \infty$, the no approximate arbitrage condition converges to the conventional no-arbitrage condition. These two properties—the formal 'no approximate arbitrage' interpretation and equal applicability to skewed return distributions—make the Gain-Loss Ratio approach more suited to the present context than the otherwise more familiar Sharpe ratio based No-Good-Deal approach.

Computation of asset price bounds for non-traded portfolio payoffs (assets) $\tilde{z}' \notin Z$ ($Z \subset \mathbb{R}^S$ being the space of portfolio payoffs) requires the exogenous specification of (i) a Gain-Loss Ratio ceiling $\overline{L}$, (ii) a benchmark SDF $\tilde{m}^*$, and (iii) a set of basis assets $\tilde{b} \in \mathcal{B}$. Portfolio payoffs generated by linear combinations of the basis assets $\tilde{b} \in \mathcal{B}$ define the space of basis payoffs B, and, in turn, the attainable portfolio payoffs in B and the observed basis asset prices $p_B(\tilde{b})$ are used to learn about investors' marginal utilities and SDFs. Then, by applying these SDFs from B to the non-traded asset $\tilde{z}' \notin Z$ and simultaneously imposing the $\overline{L}$-restriction on the Gain-Loss Ratio, upper and lower bounds for the price of the non-traded asset $\tilde{z}'$ (here, $\mathrm{SCC}^{\mathrm{LA}}_{\mathrm{m}t}$) may be obtained.

4.2.3 The convention adopted

For the purposes of this paper, either approach to restricting the SDF could in principle be employed: each offers a method for parameterizing and computing price bounds considerably tighter than the no-arbitrage bounds, and none of what follows depends on or is altered by the choice between the No-Good-Deal bounds and Gain-Loss Ratio bounds. Yet because the current setting is one in which the distribution of returns is generally skewed, it is prudent to defer to the Gain-Loss Ratio formulation.

Because an incomplete market cannot, by definition, operate to equalize different agents' marginal rates of substitution, it is necessary to introduce some additional notation. The index g denotes the government, the index m denotes the manufacturer, and the index f denotes a particular market financier $\mathsf{f} \in \mathsf{F} \subset \mathcal{F}$. Henceforth the parameters—each specific to the manufacturer ($\overline{L}_{\mathsf{m}}$, $\tilde{m}^*_{\mathsf{m}}$ and $\tilde{b}_{\mathsf{m}}$), the government ($\overline{L}_{\mathsf{g}}$, $\tilde{m}^*_{\mathsf{g}}$ and $\tilde{b}_{\mathsf{g}}$) or the market financier ($\overline{L}_{\mathsf{f}}$, $\tilde{m}^*_{\mathsf{f}}$ and $\tilde{b}_{\mathsf{f}}$)—upon which Gain-Loss Ratio valuation is conditional, are omitted from the notation but taken as understood. Accordingly, price terms of the form $\underline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}|\overline{L}_{\mathsf{f}}, \tilde{m}^*_{\mathsf{f}}, \tilde{b}_{\mathsf{f}})$ are written simply as $\underline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$.

5 What is a subsidy?

Many definitions exist for what constitutes a subsidy. As many of the existing definitions, criteria and interpretations of 'subsidy' derive from complete markets reasoning, let us begin here with the (strong) assumptions of complete and frictionless markets. Indeed in this setting it is straightforward to show that correct accounting for the opportunity cost of capital—or in more general terms, faithful application of the Opportunity Cost Principle—results in precisely those operational criteria employed by WTO and EU bodies.

To facilitate the formation of meaningful comparisons it is useful to control for the various dimensions along which the terms of government-supplied and market-supplied finance differ. To ensure the all-up consistency of terms in the comparison, consider that the manufacturer m offers to issue (i) the government, and in turn (ii) the market financier, with a structurally and parametrically identical Launch Aid sales contingent claim, $\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}$. With the receivable component in the respective transactions thus controlled, the difference in the favourability of terms is then reflected entirely in the relative magnitude of the up-front contributions $K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t}$ and $\overset{\text{stated}}{K}{}^{\mathrm{LA}\mathsf{m}}_{\mathsf{f}t}$. Yet here it must be kept in mind that the government's up-front payment is a real transacting price $\breve{\wp}_t^{\mathrm{LA}} = K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}}$, and as such, will generally fall below its own bid price and above the manufacturer's ask price,[17] realizing the potential gains from trade: $\overline{p}_t^{\mathsf{m}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) \leq \breve{\wp}_t^{\mathrm{LA}} = K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} \leq \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$. The market financier, on the other hand, does not make an actual up-front contribution, but makes a statement of what it is willing to offer—i.e., possibly including some considerations of bargaining power and bargaining tactics, a bid price such that $\overset{\text{stated}}{K_{\mathsf{f}t}^{\mathrm{LA}}} \leq \underline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$.

In the complete and frictionless markets setting, each of the following two criteria produces the same subsidy status answer for any given test case. They are written in terms of a hypothetical UK Launch Aid contract, but equally they could concern e.g. Canadian TPC contracts.

S.1 *A Launch Aid contract incorporates a subsidy component if the terms of the government's financial contribution are more favorable than would be available to the manufacturer in the market (as per the EU MEIP or the WTO 'market financier test'), that is*

$$\text{if} \quad K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} > \max_{\mathsf{f}\in\mathsf{F}}\{\overset{\text{stated}}{K_{\mathsf{f}t}^{\mathrm{LA}\mathsf{m}}}\} \ . \tag{S.1}$$

In this criterion the set $\mathsf{F} \subseteq \mathcal{F}$ refers to the collection of investors that are deemed to comprise 'the market'.

S.2 *A Launch Aid contract* $\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LA}\mathsf{g}} = (K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}}, \mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ *incorporates a subsidy component if the government's financial contribution* $K_{\mathsf{g}t}^{\mathrm{LA}}$ *exceeds the market-based value to the government of the gross* $\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}$ *issued by manufacturer* m*, that is*

$$\text{if} \ \ K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} > \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) \tag{S.2a}$$

$$\Leftrightarrow \ \text{if} \ \ \underline{p}_t^{\mathsf{g}}(\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LA}\mathsf{g}}) < 0 \ . \tag{S.2b}$$

Note that in the order of logical priority—i.e., which criterion follows from or is implied by which—correct opportunity cost accounting is primary and fundamental. It is from opportunity cost reasoning that **S.2** follows. In the restricted context of complete and frictionless markets, criterion **S.1** also follows from the Opportunity Cost Principle. This is because (i) the bid-ask spread collapses to zero and when markets are complete and frictionless. Specifically, the distinction between the market financier's bid $\underline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ and ask $\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})$ prices vanishes, $\underline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) = \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}) = p_t^{\mathsf{f}}(\mathrm{SCC}_{\cdot t}^{\mathrm{LA}})$, and that in turn $p_t^{\mathsf{f}}(\mathrm{SCC}_{\cdot t}^{\mathrm{LA}}) = \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\cdot t}^{\mathrm{LA}}) =$

[17] if, as is reasonable to assume, all of the bargaining power does not lie on one side or the other

$\overline{p}^{\mathsf{g}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}) = p^{\mathsf{g}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}) = \underline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = p^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t})$. Assuming that the market financier's offered terms $\overset{\text{stated}}{K}{}^{\mathrm{LA}\mathsf{m}}_{\mathsf{f}t}$ reflect only its private bid price $\underline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = p^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t})$, being devoid of bargaining premia,[18] then in turn this <u>bid</u> price[19] serves as a proxy for the market financier's <u>ask</u> price[20] $\overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t}) = p^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t})$, and thereby conveys the information necessary to compute government's opportunity cost of purchasing the uncertain payoff stream $\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}$ from the manufacturing firm rather than from a market financier. Finally, the WTO 'market financier test' and the EU 'MEIP'—essentially, criterion **S.1**—follow as complete and frictionless markets implications of the Opportunity Cost Principle or **S.2**. Moreover, although **S.1** and **S.2** are implicationally equivalent in the complete and frictionless markets setting, the latter **S.2** criterion is technically more robust to the relaxation of the complete markets assumption. As is detailed below, criterion **S.1** fails to survive this relaxation.

Nevertheless note that in this complete and frictionless markets context it is evident that when a firm accepts funding from the government it does so because the terms are better than those available on the market. Frictionless and complete markets equalize all market participants' private marginal valuations thereby allowing a precise, unique pricing of project repayment uncertainty, and this defines the opportunity cost for private investors and government alike. Given that the firm may be uncontroversially assumed to choose the best deal from among the government and private sector offers of finance, it chooses to opt for government-supplied finance only if the government requires a risk premium that is insufficient to cover the opportunity cost of capital. It might be suggested that the deal with the government could be motivated by lower transaction costs, but non-zero transaction costs violate the presently maintained assumption, that markets are frictionless, which is necessary to prevent the emergence of bid-ask spreads. Hence, in the complete and frictionless markets setting, not only is it true that the MEIP criterion **S.1** is redundant, but so also is **S.2**, insofar as mere observation of government-supplied finance per se is sufficient to establish the presence of 'subsidy'.

In what follows the assumption of complete markets is relaxed, returning us back from the purely theoretical, ideal and abstract domain to the empirical world, where markets are acknowledged to be incomplete in general.

[18] i.e., devoid of premia resulting from true bargaining power or from bargaining tactics

[19] that price at which it is willing to purchase the Launch Aid sales contingent claim $\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}$ being written or issued by the manufacturer m

[20] that price at which it is willing to 'write' or 'issue' a sales contingent claim having payout obligations defined by $\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t}$, identical to $\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}$ save for the identity of the issuer

5.1 Relaxation to incomplete markets

Whereas the acknowledgement that 'markets are incomplete in general' is suggestive of the absence of markets in some generic background sense, it is payoff-relevant market incompleteness specific to the payoff stream defined in the Launch Aid sales contingent claim contract $\mathrm{SCCo}^{\mathrm{LAg}}_{\mathsf{m}t} = (K^{\mathrm{LAm}}_{\mathsf{g}t}, \mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$ that holds implications for the specification of sensible subsidy-criteria. In a strict sense, frictions of any sort such as non-zero transaction costs $c^{\mathrm{ta}} > 0$ are sufficient to induce bid-ask spreads and the breakdown of the correspondence between criterion **S.1** (MEIP and the WTO 'market financier test') and the Opportunity Cost Principle. However, in order to avoid the suggestion that empirically observed transaction costs $\check{c}^{\mathrm{ta}}$ are small overall and that the induced bid-ask spread may be ignored, i.e., with the assertion that $\underline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}|\check{c}^{\mathrm{ta}}) \approx \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t}|\check{c}^{\mathrm{ta}})$, we concentrate here on payoff-relevant market incompleteness and the attendant non-trivial valuation bounds and bid-ask spreads that clearly cannot be finessed away.

5.1.1 Implications for S.1-type criteria

Both the EU MEIP and the WTO 'market financier test' are **S.1**-type criteria, that is, they ask whether the government intervention provides finance to the manufacturer on terms more favorable than would be available to the manufacturer 'in the market'. Given that non-trivial pricing bounds must be taken seriously as being characteristic of the valuation of Launch Aid SCCs and that these bounds become bid and ask prices in rational trading policies, it then becomes crucial to ask the question, 'What is the precise economic meaning of using a representative market financier's stated bid price as the benchmark for evaluating the transacting price between government and the manufacturer?'

In the standard case the realized transacting price $\check{\wp}^{\mathrm{LA}}_t = K^{\mathrm{LAm}}_{\mathsf{g}t}$ lies within the interval between the manufacturer's ask price and the government's bid price $\overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) \leq \check{\wp}^{\mathrm{LA}}_t = K^{\mathrm{LAm}}_{\mathsf{g}t} \leq \underline{p}^{\mathsf{g}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$, so the finding that the market financier's bid price falls below the transacting price—the condition that criterion **S.1** and the WTO 'market financier test' classify as 'subsidy' and the EU MEIP classifies as 'state aid'—does tell us that the government's bid price exceeds the bid price of the market financier. However, without additional assumptions or information it is not possible to infer whether this market financier's bid price falls above or below the manufacturer's ask price. Hence, with this information, we cannot conclude one way or another whether an independent financing arrangement between the market financier and the manufacturer is feasible, or contrarily, not feasible.

Since in this context of payoff-relevant market incompleteness the market financier's bid and ask prices diverge $\underline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) < \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})$, the level of the market financier's bid price is not directly informative of the ask price, and yet it is the ask price which is the relevant reference point for computing the government's opportunity cost of making the up-front contribution $K_{\mathsf{g}t}^{\mathrm{LAm}}$ in the Launch Aid sales contingent contract $\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LAg}} = (K_{\mathsf{g}t}^{\mathrm{LAm}}, \mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$. Given the limited information elicited under **S.1**-type criteria and the attendant indeterminacy over whether the market financier's bid price falls above or below the manufacturer's ask price, it transpires that the market financier's ask price may fall within one of four intervals.

In the uppermost interval, $\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}) > \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$, trade between government and the market financier is infeasible.

In the third interval, $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) \geq \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}) > \breve{\wp}_t^{\mathrm{LA}}$, trade between government and the market financier is feasible in principle, but strictly dominated by the transaction with the manufacturer no matter what the bargaining division of gains to trade. The maximum excess gain that government can earn from the trade with the market financier is simply the total available gains to trade: $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) - \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})$. This excess gain is the government's opportunity cost of investing in the manufacturer-issued Launch Aid sales contingent claim $\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}$ at the price $\breve{\wp}_t^{\mathrm{LA}} = K_{\mathsf{g}t}^{\mathrm{LAm}}$, which gives an excess gain of $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) - \breve{\wp}_t^{\mathrm{LA}}$. Since $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) - \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}) < \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) - \breve{\wp}_t^{\mathrm{LA}} \Leftrightarrow \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}) > \breve{\wp}_t^{\mathrm{LA}}$ by the definition of the interval, the government minimizes its opportunity costs—i.e., acts in accordance with the Opportunity Cost Principle—by investing in the manufacturer-issued Launch Aid sales contingent claim on the terms $\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LAg}} = (K_{\mathsf{g}t}^{\mathrm{LAm}}, \mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$.

In the second interval, $\breve{\wp}_t^{\mathrm{LA}} \geq \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}) > \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$, trade between the government and the market financier is feasible in principle, but is dominated by the existing transaction with the manufacturer for most bargaining solutions. For instance, division of the gains to trade between government and the market financier by implementation of the symmetric Nash Bargaining Solution uniformly implies the dominance of the existing government-manufacturer transaction. However, given the existing, fixed transacting price between government and manufacturer $\breve{\wp}_t^{\mathrm{LA}}$, if the division $d_{\mathsf{f}}^{\mathsf{g}} : d_{\mathsf{f}}^{\mathsf{g}} \in [0,1]$ of the gains to trade between government (share $d_{\mathsf{f}}^{\mathsf{g}}$) and the market financier (share $1 - d_{\mathsf{f}}^{\mathsf{g}}$) is sufficiently asymmetrical in the government's favor $d_{\mathsf{f}}^{\mathsf{g}} > \frac{\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) - \breve{\wp}_t^{\mathrm{LA}}}{\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) - \overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})} \quad \Leftrightarrow \quad K_{\mathsf{g}t}^{\mathrm{LAm}} > K_{\mathsf{g}t}^{\mathrm{LAf}}$, then it becomes rational—in the Opportunity Cost (minimization) Principle sense—for the government to purchase the Launch Aid sales contingent claim from the market financier rather than from the manufacturer. Without additional assumptions concerning the division of gains to trade, a unique answer is not possible in this second interval. Restrictions on the value of the division parameter $d^{\mathsf{g}}_{\mathsf{f}}$ must ultimately make recourse to bargaining solution concepts, and, in order to introduce asymmetry, some specific assumptions regarding relative bargaining power. Following this approach it may prove difficult to avoid tenuous assumptions in specific contexts of interest. Nevertheless, it is clear that if both manufacturer and market financier are allowed to bid against each other and each stops at its respective private valuation, i.e., $\overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$ and $\overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})$, then it will be the manufacturer that enters the winning bid. This follows from the open rather than closed specification of the interval's lower bound.

In the first interval, $\overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) \geq \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})$, trade between the government and the market financier is feasible. For $\overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})$ it is the division of gains to trade which is crucial, whereas thereafter $\{\overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t}) : \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) > \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})\}$, the government-financier transaction dominates the government-manufacturer transaction for most bargaining divisions of the gains to trade. If the identity of the issuer is to be selected through a (private values) bidding, tendering or auction process, the market financier will submit the opportunity cost minimizing bid in all but the $\overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})$ case of this interval.

insert Table 2 (on p. 33) about here

Overall, then, in the present context of payoff-relevant market incompleteness there are clear cases where unambiguous conclusions regarding the fidelity of the Launch Aid contract $\mathrm{SCCo}^{\mathrm{LA}\mathsf{g}}_{\mathsf{m}t} = (K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t}, \mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$ to the Opportunity Cost Principle *are* possible. Yet, as the final column in Table 2 makes plain, **S.1**-type subsidy criteria such as the EU MEIP and the WTO 'market financier test' fail to elicit the very information required to draw such conclusions. A representative or 'hypothetical' market financier's bid price is simply uninformative of the opportunity costs that government faces in its decision to conclude a Launch Aid contract $\mathrm{SCCo}^{\mathrm{LA}\mathsf{g}}_{\mathsf{m}t}$. Hence its status as a benchmark is problematic, at least in the context of payoff-relevant market incompleteness where valuation bounds are non-trivial.

S.1-type criteria are problematic in three different ways. The first is simply the above-discussed elicitation of a bid price rather than an ask price. This is fairly easy to redress. However, the second and third problem areas are more general and less easily dispatched. The second concerns information structure: particularly in the above analysis of **S.1**-type criteria, both the government and the market financier are assumed to be perfectly informed not only of the structural parameters defining the Launch Aid sales contingent claim payout function $\varrho_t(\psi_t, \Sigma_{\tau=0}^{t}\psi_\tau, \boldsymbol{h}, t, \boldsymbol{o})$, but also of the stochastic sales generating process $\tilde{\psi}_t$. This latter assumption that the manufacturer is able and willing to inform government and market financiers precisely and without bias about the stochastic sales process $\tilde{\psi}_t$ is a strong one. Finally, the third problem area concerns the choice of benchmark bargaining structure, auction or tendering process that pins down the values of the up-front contributions $K_{\mathsf{g}t}^{\mathrm{LAm}}$ and $\overset{\text{stated}}{K_{\mathsf{f}t}^{\mathrm{LAm}}}$ in relation to $\overline{p}_t^{\mathsf{m}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ and $\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})$ as well as each other. Every choice of bargaining structure, auction or tendering process also involves making particular assumptions regarding information structure. It will become apparent later on that these latter two problem areas are not unique to **S.1**.

5.1.2 Implications for S.2 criteria

Unlike **S.1**-type criteria, the **S.2** criteria make no reference to the bid or ask prices of market financiers.[21] The primary consequence of relaxing the complete markets assumption to admit payoff-relevant market incompleteness is that unique market values become infeasible both theoretically and pragmatically, whereupon it becomes necessary to entertain 'market-based' valuations that restrict possible asset values to non-trivial intervals. The simplification embodied in **S.2** entails that, instead of having to contend with a collection of different agents' bid and ask prices, a straightforward comparison between the government's ask price $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ and its up-front contribution $K_{\mathsf{g}t}^{\mathrm{LAm}}$ is all that is called for to ascertain whether a subsidy is present or not. When $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) < K_{\mathsf{g}t}^{\mathrm{LAm}}$ government is subsidizing the manufacturer to the amount of $K_{\mathsf{g}t}^{\mathrm{LAm}} - \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) = -\underline{p}_t^{\mathsf{g}}(\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LA}})$. Conversely, when $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) > K_{\mathsf{g}t}^{\mathrm{LAm}}$ government appropriates for itself positive gains to trade. Finally, when $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) = K_{\mathsf{g}t}^{\mathrm{LAm}}$, the Launch Aid sales contingent contract involves neither a subsidy nor positive gains to trade.

S.2 criteria perform well throughout the relaxation to incomplete markets as long as the transitions of interpretation appropriate to the more general context are adhered to: from market value to market-based value; from precise prices to price intervals; and from the irrelevance of specifying a price as a bid or an ask price, to its relevance and necessity. However, omission of the set of market financiers $\mathcal{F}$ is not innocuous: it limits the application of opportunity cost

[21]By this omission, the problem of deciding on an information structure is averted, as is the problem of deciding on a bargaining structure or tendering process.

calculus to the comparison between the actual manufacturer transaction at price $\breve{\wp}_t^{\mathrm{LA}} = K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}}$ and the government's 'internal' option of going to the (incomplete) market at price $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$. Clearly, this limitation of the application of the Opportunity Cost Principle cannot stand without separate justification. Because this limitation is a manifestation of bargaining structure in place of a wider bidding structure—which in turn is a reflection of information structure—it becomes necessary to examine these structural features explicitly.

5.2 Information and bidding structure

The determination of a threshold price for distinguishing between subsidy and subsidy-neutrality involves making particular assumptions regarding the structure of information and the structure of the bidding or bargaining process. Control over who gains access to the specific details of the sales contingent contract $\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LA}\mathsf{g}}$ resides with the manufacturer insofar as it has recourse to commercial confidentiality stipulations and clauses. Through this control, the manufacturer effectively defines the information structure, that is, the subset $\mathsf{F} \subset \mathcal{F}$ of market financiers that have access to the details and parameters of the sales contingent claim $\mathrm{SCC}_{\cdot t}^{\mathrm{LA}}$. When the cardinality of this set is zero $|\mathsf{F}| = 0$, the manufacturer and government are left to bargain bilaterally over the gains to trade. When the cardinality of this set is 1 or more $|\mathsf{F}| \geq 1$, market financiers are also in a position to bid for, or offer to issue, the sales contingent claim $\mathrm{SCC}_{\cdot t}^{\mathrm{LA}}$. Hence it is the information structure that determines whether a bilateral bargaining or open bidding structure emerges.

Letting $\underline{\mathsf{f}} \in \mathsf{F}$ denote the index of the market financier having the lowest ask price for the sales contingent claim $\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}}$ among the set of informed market financiers F

$$\underline{\mathsf{f}} := \begin{cases} |\mathsf{F}| = 0 & \emptyset \\ |\mathsf{F}| \geq 1 & \underset{\mathsf{f} \in \mathsf{F} \neq \emptyset}{\arg\min} \{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})\} \end{cases} \tag{5.1}$$

then, given the set of actively participating market financiers $\mathsf{F} \subset \mathcal{F}$ defined by the information structure, the government's lowest feasible contracting prices with the manufacturer are

$$K^{\mathrm{LAm}}_{\mathsf{g}t}(|\mathsf{F}|) \quad := \quad \begin{cases} K^{\mathrm{LAm}}_{\mathsf{g}t}(0) = K^{\mathrm{LAm}}_{\mathsf{g}t} \\ K^{\mathrm{LAm}}_{\mathsf{g}t}(|\mathsf{F}| \geq 1) = \begin{cases} \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) > \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) & \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) \\ \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) & \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) \\ \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) < \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) & \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) - \epsilon \end{cases} \end{cases} \tag{5.2}$$

while the government's lowest feasible contracting prices with the market financier are

$$K^{\mathrm{LAf}}_{\mathsf{g}t}(|\mathsf{F}|) := \begin{cases} K^{\mathrm{LA}\emptyset}_{\mathsf{g}t}(0) = \emptyset \\ K^{\mathrm{LAf}}_{\mathsf{g}t}(|\mathsf{F}| \geq 1) = \end{cases}$$

$$\begin{cases} \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) > \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) & \min\left\{\min_{\mathsf{f}\in\mathsf{F}\setminus\{\underline{\mathsf{f}}\}}\{\overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})\}, \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})\right\} - \epsilon \\ \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) & \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) \\ \overline{p}^{\mathsf{m}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) < \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) & \overline{p}^{\mathsf{f}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\mathsf{f}}t}) \end{cases} . \tag{5.3}$$

In the present setting, where the payout $\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}$ and its value to the government is fixed across the possible transactions being considered, choosing the alternative with the lowest *opportunity* cost is equivalent to choosing the alternative with the lowest *direct* cost. So when $|\mathsf{F}| = 0$ the government acts in accordance with the Opportunity Cost Principle if $K^{\mathrm{LAm}}_{\mathsf{g}t} \leq \underline{p}^{\mathsf{g}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$. Notice that this is implicationally equivalent to the **S.2**-type criteria discussed above.[22] More generally, the government is acting in accordance with the opportunity cost principle if the realized transacting price $\wp^{\mathrm{LA}}_t$ is the minimum over the lowest feasible contracting prices (5.3) and (5.2) and at least as good as the government's 'internal option' of going directly to the (incomplete) asset market:

$$\hat{\wp}^{\mathrm{LA}}_t(\mathsf{F}) = \min\left\{K^{\mathrm{LAf}}_{\mathsf{g}t}(|\mathsf{F}|), K^{\mathrm{LAm}}_{\mathsf{g}t}(|\mathsf{F}|)\right\} \leq \underline{p}^{\mathsf{g}}_t(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) \ . \tag{5.4}$$

Here the realized transacting price $\wp^{\mathrm{LA}}_t$ is clearly conditional on the exogenously given information structure $\mathsf{F} \subset \mathcal{F}$. Therefore the move from (5.4) toward a determination of a benchmark price having global optimality properties—properties making it suitable and justifiable as the standard for distinguishing subsidy from subsidy-neutrality—cannot proceed without settling on a particular standard for the information structure. Natural candidates include $|\mathsf{F}| = 0$ and

[22]see p. 14

$|\mathsf{F}| = |\mathcal{F}|$, corresponding to the extremes of complete commercial confidentiality and full public disclosure, respectively, neither of which is subject to particular selections of f from $\mathcal{F}$ for inclusion in F becoming reflected in $\wp_t^{\mathrm{LA}}$. Against this background it becomes clear that the 'gain to trade' that the manufacturer secures for itself by insisting on strict commercial confidentiality may include a rent component that derives from control over access to information that is required for valuation as a prelude to bidding for, or offering to issue, the sales contingent claim $\mathrm{SCC}_{\cdot t}^{\mathrm{LA}}$. Only if $\min_{\mathsf{f}\in\mathcal{F}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})\} \geq K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}}$ does this constitute a pure gain to trade. If $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) \geq K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} > \min_{\mathsf{f}\in\mathcal{F}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})\} \geq \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ then $K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} - \min_{\mathsf{f}\in\mathcal{F}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})\}$ is the manufacturer's rent component and $\min_{\mathsf{f}\in\mathcal{F}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})\} - \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ is the manufacturer's gain to trade. Finally, if $\overline{p}_t^{\mathsf{m}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}}) > \min_{\mathsf{f}\in\mathcal{F}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}_{\mathsf{f}t}^{\mathrm{LA}})\}$ then it is one of the market financiers, not the manufacturer, that is the economically efficient issuer of the sales contingent claim $\mathrm{SCC}_{\cdot t}^{\mathrm{LA}}$.

The possibility for rents can be eliminated through government-mandated compulsory public disclosure, but this in turn may disadvantage the manufacturer relative to its competitors. Actual public disclosure in this context may not be desirable. Nevertheless it does not follow that the definition of subsidy must be restricted as well. On the contrary, the definition of subsidy needs to be broadened to allow the full application of the Opportunity Cost Principle. This has the side-effect denying the manufacturer rents based solely on the control over information structure. Thus, we strengthen **S.2** to

S.3 *A Launch Aid contract incorporates a subsidy component if the government's financial contribution exceeds that which would obtain upon application of the Opportunity Cost Principle under full public disclosure, that is*

$$if \;\; K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} - \min\left\{\hat{\wp}_t^{\mathrm{LA}}(\mathcal{F}), \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})\right\} > 0 \;\; . \tag{S.3}$$

Indeed this is the conceptualization of 'subsidy' that has the sought-after properties absent in **S.1** and **S.2**. Technically, the $\hat{\wp}_t^{\mathrm{LA}}(\mathcal{F})$ term implements the private-values sealed-bid single-round second-price reverse auction outcome, and $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$ is the government's reservation (bid) price. More formally and explicitly, **S.3** may be re-expressed as follows.

Definition 5.1 (Subsidy). The value of the subsidy contained in $\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LA}\mathsf{g}}$ is the minimum positive amount $\varsigma_t^+ \in \mathbb{R}_+$ by which the observed up-front contribution $K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}}$ must be decreased $\hat{K}_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} = K_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}} - \varsigma_t^+(\mathrm{SCCo}_{\mathsf{m}t}^{\mathrm{LA}})$ such that the modified contract $\mathrm{S\hat{C}Co}_{\mathsf{m}t}^{\mathrm{LA}\mathsf{g}} = (\hat{K}_{\mathsf{g}t}^{\mathrm{LA}\mathsf{m}}, \mathrm{SCC}_{\mathsf{m}t}^{\mathrm{LA}})$

complies with the Opportunity Cost Principle under full public disclosure $\mathsf{F} = \mathcal{F}$. Writing $\underline{\underline{\mathsf{f}}} := \arg\min_{\mathsf{f}\in\mathcal{F}} \{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})\}$, then $\varsigma_t(\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}) =$

$$\begin{cases} \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) > \overline{p}_t^{\underline{\underline{\mathsf{f}}}}(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\underline{\mathsf{f}}}t}) & K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t} - \min\left\{\min\limits_{\mathsf{f}\in\mathcal{F}\setminus\{\underline{\underline{\mathsf{f}}}\}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})\}, \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}), \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})\right\} \\ \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) = \overline{p}_t^{\underline{\underline{\mathsf{f}}}}(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\underline{\mathsf{f}}}t}) & K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t} - \min\left\{\overline{p}_t^{\underline{\underline{\mathsf{f}}}}(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\underline{\mathsf{f}}}t}), \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})\right\} \\ \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) < \overline{p}_t^{\underline{\underline{\mathsf{f}}}}(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\underline{\mathsf{f}}}t}) & K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t} - \min\left\{\overline{p}_t^{\underline{\underline{\mathsf{f}}}}(\mathrm{SCC}^{\mathrm{LA}}_{\underline{\underline{\mathsf{f}}}t}), \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})\right\} \end{cases},$$

of which the positive part $\varsigma_t^{+}(\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}) := \max(0, \varsigma_t(\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}))$ is the *value of the subsidy* contained in $\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}$. The *subsidy*-label is reserved for the strictly positive instance $\varsigma_t^{++}(\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}) := \{\varsigma_t(\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}) : \varsigma_t(\mathrm{SCCo}^{\mathrm{LA}}_{\mathsf{m}t}) \in \mathbb{R}_{++}\}$.

Implicit in much of the development thus far, including the development of the formalization of **S.3** in Definition 5.1, has been the assumption that $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}) \geq \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$. This assumption was made purely for convenience and simplicity of presentation. Yet, even if $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}) < \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$, Definition 5.1 yields sensible results. The manufacturer's ask price $\overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$ that we have been referring to is one without padding; it is not a tactically-inflated, flexible figure to be used in bargaining negotiations, but the manufacturer's internal or true ask price, given the parameters $\overline{L}_{\mathsf{m}}$, $\tilde{m}^{*}_{\mathsf{m}}$ and $\tilde{b}_{\mathsf{m}}$. As a consequence of this formulation, if

$$K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t} - \min\left\{\min_{\mathsf{f}\in\mathcal{F}\setminus\{\underline{\underline{\mathsf{f}}}\}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})\}, \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}), \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})\right\} > K^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t} - \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$$

$$\Leftrightarrow \qquad \min_{\mathsf{f}\in\mathcal{F}\setminus\{\underline{\underline{\mathsf{f}}}\}}\{\overline{p}_t^{\mathsf{f}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{f}t})\} < \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) \qquad \text{or} \qquad \underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) < \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$$

the subsidy-neutral price $\hat{K}^{\mathrm{LA}\mathsf{m}}_{\mathsf{g}t}$ falls below the manufacturer's ask price, and the manufacturer will find it infeasible to conclude a subsidy-neutral contract with the government. Thus Definition 5.1 does indeed generate sensible results even for the $\underline{p}_t^{\mathsf{g}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t}) < \overline{p}_t^{\mathsf{m}}(\mathrm{SCC}^{\mathrm{LA}}_{\mathsf{m}t})$ case.

S.3 and Definition 5.1 have been developed entirely within the incomplete markets setting, so there is little to be gained from asking what the implications of incomplete markets are for **S.3** criteria. By examining **S.3** under complete markets, however, we may revisit and further redeem on our earlier claims. Specifically, it was claimed that **S.1**-criteria correctly account for opportunity cost when markets are complete and frictionless. It is straightforward to show that under Complete and Frictionless Markets (CFM), **S.3** $\overset{\mathrm{CFM}}{\Rightarrow}$ **S.1**. This is because under these conditions the bid and ask prices of each agent—m, g and $\forall\,\mathsf{f} \in \mathcal{F}$—collapse around their central values, and furthermore each agent's precise valuation is equalized with those of all the remaining agents: a unique market price, common to all agents, emerges. Let us denote this market price with $p_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t})$. Then (S.3) reduces to $K^{\mathsf{LAm}}_{\mathsf{g}t} - p_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t}) > 0$, which is equivalent to (S.1) under $\mathsf{F}=\mathcal{F}$ and the assumption that $\overset{\text{stated}}{K^{\mathsf{LAm}}_{\mathsf{f}t}}$ is devoid of premia resulting from bargaining power or premia that are manifestations of bargaining tactics, i.e. that $\overset{\text{stated}}{K^{\mathsf{LAm}}_{\mathsf{f}t}} = p_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t})$.[23] Following the same reasoning it is evident that **S.2** $\overset{\mathrm{CFM}}{\Rightarrow}$ **S.1**, but that either market incompleteness or market frictions yield **S.3** $\overset{\neg\mathrm{CFM}}{\not\Rightarrow}$ **S.1** and **S.2** $\overset{\neg\mathrm{CFM}}{\not\Rightarrow}$ **S.1**.

6 Launch Aid revisited

Launch Aid is unlike many governmentally administered support schemes in that it imposes a repayment obligation upon the recipient manufacturer. The schedule of this repayment obligation is tailored to the specific product R&D program in question. These features have the effect of imposing constraints on answers to a number of questions that may be asked about Launch Aid. Hence, not all questions turn out to be equally informative, and neither are they all equally pertinent.

6.1 Is Launch Aid a subsidy?

At face value, this question invites an all-or-nothing, discrete yes or no answer. However, different product development programs have different risk characteristics and different risk exposure profiles; likewise, different product development programs have different SCC repayment schedules. Hence a general, all-or-nothing, yes or no answer is not strictly correct. The answer must be contract-specific, as a reflection of the parameters of a particular contract, not one that holds in general for all Launch Aid contracts. In order to be pertinent, the question itself requires reformulation to elicit particularistic rather than abstract knowledge, albeit without sacrificing the theoretical properties and generality of the criterion used to make the determination.

6.2 When is Launch Aid a subsidy?

This question invites the application of a subsidy criterion that again yields discrete yes or no answers. The question is pertinent and may be answered by application of criterion **S.3**. Even

[23]Indeed if this assumption does not hold, then the **S.1**-type criteria are revealed to contain an element of arbitrariness that raises a separate series of questions. Nevertheless it is not our intention to prosecute a critique of **S.1**-type criteria on the basis of the hypothesis that $\overset{\text{stated}}{K^{\mathsf{LAm}}_{\mathsf{f}t}} < p_t(\mathrm{SCC}^{\mathrm{LA}}_{\cdot t})$.

if a Launch Aid contract incorporates only a very small, minuscule subsidy component, this question draws the answer, 'Yes, this Launch Aid contract is a subsidy.' Hence a more qualified form of the question is: 'When does a Launch Aid contract incorporate a subsidy component?' Though properly qualified, the information provided by the answer to this question remains coarse-grained. A more fine-grained, $\mathbb{R}_+$-valued answer is elicited by the question, 'What is the value of the subsidy component in this Launch Aid contract?' If the answer to this question falls within the subset $\mathbb{R}_{++}$, then the Launch Aid contract is said to contain a subsidy component. More than the other alternatives discussed above, it is this latter question formulation—one which invites application of Definition 5.1—that in our view provides the means for identifying the most pertinent and fine-grained information for the purposes of policy making, decision making and dispute resolution.

7 Conclusion

This paper is concerned with the junction between several different domains, some of which are theoretical, some of which have to do with the institutions and practices of particular international organizations, and some of which have to do with government schemes for the support of R&D, in particular Launch Aid support for civil aerospace product development programs. The core of the paper is theoretical, both in its motivation and its subsequent development, yet it carries distinct real-world implications.

What otherwise might remain a purely comparative exercise becomes an independent locus of substantive theoretical interest because the WTO (EU) criteria for 'subsidy' ('state aid') are found to be inconsistent with full accounting for government opportunity costs—that is, inconsistent with full application of the Opportunity Cost Principle—in the particular case where payoff-relevant market incompleteness limits the precision of market-based pricing to non-trivial intervals between upper and lower bounds. The class of Sales Contingent Claims, or in other words, the class of generalized royalty-based instruments—of which the Launch Aid repayment schedule is a particular example—is inherently subject to payoff-relevant market incompleteness when written on novel and previously untried products and technologies. By introducing and formalizing this general class of claims that includes Launch Aid as a particular example, we are able not only to make the case for the applicability of the Mukerji and Tallon (2001) market incompleteness result to Launch Aid, but also to provide for its natural extension to the wider class of SCC-based contracts written on products and technologies belonging to the category of 'radical innovation'. Given that recent and practical yet theoretically-grounded asset pricing frameworks such as those developed by Cochrane and Saá-Requejo (2000) and Bernardo and Ledoit (2000) have shown that payoff-relevant market incompleteness entails non-trivial price intervals rather than unique, precise market valuations, it follows that market financiers' bid prices are not identical to their ask prices, but that it is their ask prices that are relevant to the government's opportunity cost calculus, not the bid prices as elicited and used in WTO (EU) subsidy (state aid) proceedings. This inconsistency gives cause for pause because full accounting for opportunity costs is unquestionably a necessary property of an economic definition of subsidy. Moreover, consistency with the Opportunity Cost Principle is highly desirable from the perspectives of trade policy, trade institutions and the economic theory of trade because, as has been well-known since the early work of Haberler (1936), the theory of comparative advantage may be understood as an implementation of the Opportunity Cost Principle. Thus the development of an approach to the definition of 'subsidy' that fully incorporates the government's opportunity costs in both complete and incomplete markets settings responds not only to the imperatives of economic theory, but also to the imperatives of securing coherent foundations for the advancement of international trade and to the imperatives of securing coherence in the analytical framework within which technology policy may implement Arrovian innovation-facilitating risk-shifting. Such risk-shifting need not be implemented exclusively through SCC-based schemes, but the case as developed here speaks especially to the class of SCC-based schemes and to Launch Aid for civil aerospace product development programs in particular.

Where markets are complete and usefully approximated as frictionless, existing WTO (EU) criteria—which are implicitly (explicitly) given an operational interpretation in terms of the Market Economy Investor Principle—continue to carry the full force of theoretical validity. In no way do the present results suggest that the MEIP is anything but correct, appropriate and instrumental to furthering the expansion of world trade when applied for example to clear-cut production subsidies or export subsidies.

Nevertheless, within the specific context dealt with in this paper, the shortcomings of MEIP-type criteria and the problems and discrepancies that issue from the use of MEIP-type criteria call for amelioration. The root cause of these various problems lies in the MEIP-criterion's failure to survive—in the sense of failing to account for the true opportunity costs facing government—

through the relaxation to incomplete markets. A major contribution of this paper is the development of just such a criterion. Herein referred to as the S.3 criterion, it may be expressed as follows: A Launch Aid contract incorporates a subsidy component if the government's financial contribution exceeds that which would obtain upon application of the Opportunity Cost Principle under full public disclosure of information regarding the form and defining parameters of the Launch Aid contract.

This is not an undemanding criterion. It does not attempt to proceed from a 'consensus' or 'representative' market price where, owing to market incompleteness, none such exists. Hence from the outset it distinguishes between market financiers' bid and ask prices, and does not err, as MEIP-type criteria do, in confusing the former for the latter. It is the latter, ask prices, that confront the government as alternatives to the manufacturer's ask price for the SCC written on the sales of the yet-to-be-developed product. The S.3 criterion stipulation regarding the full public disclosure of information is also crucial. Firstly, the S.3 criterion does not require *actual* full public disclosure. It simply sets the critical price as that which *would* obtain under full public disclosure. This makes the criterion amenable to third-party (such as government) implementation—if this party can specify the market financiers' benchmark SDFs ($\tilde{m}^*_{\mathsf{f}}\ \forall\, \mathsf{f} \in \mathcal{F}$), basis assets ($\tilde{b}_{\mathsf{f}}\ \forall\, \mathsf{f} \in \mathcal{F}$) and Gain-Loss Ratio thresholds ($\overline{L}_{\mathsf{f}}\ \forall\, \mathsf{f} \in \mathcal{F}$). Secondly, the critical price set by the full public disclosure stipulation is the maximal price that denies the manufacturer any informational rent which otherwise accompanies the ability to impose and to enforce commercial confidentiality. On the product market side, those directly concerned have argued that preservation of the commercial confidentiality of the Launch Aid contract details is necessary in order to avoid disadvantaging the manufacturer in the bidding battles for new orders. However, on the (financial) capital market side, the commercial confidentiality of the Launch Aid SCCo-details perforce prevents the emergence of a wider bidding structure, instead ensuring that a limited bilateral bargaining structure emerges between the government and the manufacturer. Whereas relationship lenders are known to extract rents through the 'informational capture' of their clients, here it is the manufacturer, on the other side of the financing transaction, that is in the position to extract rents through what may be described as the 'informational exclusion' of other market financiers. The difference, in terms of consequences, between the narrow (S.2) and the wide (S.3) applications of the Opportunity Cost Principle, is that the latter deprives the manufacturer of the possibility to extract informational rents through the ‘informational exclusion’ which is implemented by strict preservation of commercial confidentiality.

In sum, the S.3 criterion developed here (i) captures the opportunity costs facing government even under payoff-relevant market incompleteness, (ii) considers a wide enough (complete) sample of alternatives so as to eliminate informational rents, and (iii) reduces to the MEIP-criterion when markets are complete and frictionless, yet in achieving these things (a) it does not rule out gains from trade, on either side, between government and the manufacturer, and (b) neither does it harm the manufacturer’s ability to compete in the product market. Properly implemented, the present S.3 criterion cannot be thought of as being inherently permissive or ‘soft’ on government subsidies, but neither can it be thought of as being intrinsically biased against government support per se as long as such support falls within the recognized boundaries of legitimate government intervention to complete the market.

In implementation, it is more helpful to make recourse to a more involved formalization (Definition 5.1) of subsidy developed directly from the S.3 criterion. Instead of being confined to the binary yes/no answer that criterion S.3 was framed to answer, application of Definition 5.1 returns the value of the subsidy component embedded in the contract, strictly positive instances of which are affixed with the subsidy-label. It is this definition that supplies the most pertinent and fine-grained information for the purposes of governmental policy making and decision making, and it offers similar prospects as a standard for dispute resolution on inter-governmental and international levels as well, though these latter levels are constrained by hard-won established formulations rooted in law, international conventions and institutional practice. Indeed the formulations encountered on inter-governmental and international levels are evidently modelled on the legal notion of *fair market value*. Fair market value, it may be noted, is interpreted as being a consensus price obtained from a broad market, not a specific transaction in which the parties are identified. As we have been at pains to press home, such a unique consensus market price only exists when the market is complete—and in this paper we are specifically concerned with the domain of government-manufacturer contracts, typically Sales Contingent Claim contracts on R&D programs bent upon ‘radical innovation’, that are subject to payoff-relevant market incompleteness.

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Table 1: Net Launch Aid expenditures in cash and real terms (1945–31/3/2000).

Year[a]	Net LA I[b] (cash £m)	Net LA II[c] (cash £m)	Net LA[d] (cash £m)	Net LA[e] 1945–31/3/74 (1974 £m)	GDP deflator	Net real LA 1945–31/3/00 (2000 £m)
1969-70	-3.1		-3.1		10.126	
1970-71	-2.6		-2.6		10.972	
1971-72	54.7		54.7		11.973	
1972-73	47.5		47.5		12.939	
1973-74	15.6		15.6	665.9	13.861	4804.1
1974-75	36.2		36.2		16.594	218.2
1975-76	2.0		2.0		20.774	9.6
1976-77	9.6		9.6		23.594	40.7
1977-78	-14.4		-14.4		26.820	-53.7
1978-79	8.8		8.8		29.769	29.6
1979-80	100.7		100.7		34.772	289.6
1980-81	53.0		53.0		41.115	128.9
1981-82	83.9		83.9		45.023	186.3
1982-83	50.6		50.6		48.154	105.1
1983-84	76.7		76.7		50.315	152.4
1984-85	73.5		73.5		52.966	138.8
1985-86	88.6		88.6		55.855	158.6
1986-87	96.3	95.9	95.9		57.673	166.3
1987-88	23.9	26.7	26.7		60.800	43.9
1988-89	75.9	75.8	75.8		64.942	116.7
1989-90	91.2	91.1	91.1		69.586	130.9
1990-91	89.3	89.2	89.2		75.016	118.9
1991-92	-4.3	-4.5	-4.5		79.591	-5.7
1992-93	-43.3	-40.5	-40.5		82.166	-49.3
1993-94	-52.7	-54.0	-54.0		84.197	-64.1
1994-95		-43.2	-43.2		85.314	-50.6
1995-96		-34.7	-34.7		87.745	-39.5
1996-97		-61.3	-61.3		90.514	-67.7
1997-98		-119.2	-119.2		93.304	-127.8
1998-99		-125.9	-125.9		95.913	-131.3
1999-00		-134.5	-134.5		98.194	-137.0
		Total net real LA expenditures 1945–31/3/2000 (2000 £m):				6,112

[a]The financial year runs from April 1 to March 31.

[b]Derived from the Written Answer of Mr. Sainsbury, *Hansard*, 4 May 1994, c509-10w.

[c]From *Forward Look 2001*, Table 1: Net Government expenditure on SET by departments in cash terms 1986-87 to 2003-04, p. 132–133.

[d]Composed of the Net LA I series from 1969-70 to 1985-86, and the Net LA II series from 1986-87 to 1999-00.

[e]Derived from Table 1, Gardner (1976) p. 153; figure excludes £697.5m for the Concorde and its Olympus 593 engines. According to Gardner, the Concorde has never been considered to be a normal part of the Launch Aid scheme.

Table 2: Summary of interval-specific conclusions.

	Interval	Opportunity Cost Principle violated?	OCP violated by symmetric Nash BS?	Winner of private values tender?	Inference[a] from **S.1** (MEIP) "$\underline{p}_t^{\mathsf{f}} < \breve{\wp}_t^{\mathrm{LA}}$" ?
4.	$\overline{p}_t^{\mathsf{f}} > \underline{p}_t^{\mathsf{g}}$	no	no	manufacturer	ambiguous
3.	$\underline{p}_t^{\mathsf{g}} \geq \overline{p}_t^{\mathsf{f}} > \breve{\wp}_t^{\mathrm{LA}}$	no	no	manufacturer	ambiguous
2.	$\breve{\wp}_t^{\mathrm{LA}} \geq \overline{p}_t^{\mathsf{f}} > \overline{p}_t^{\mathsf{m}}$	$d_{\mathsf{f}}^{\mathsf{g}} > \frac{\underline{p}_t^{\mathsf{g}} - \breve{\wp}_t^{\mathrm{LA}}}{\underline{p}_t^{\mathsf{g}} - \overline{p}_t^{\mathsf{f}}}$	no	manufacturer	ambiguous
1.	$\overline{p}_t^{\mathsf{m}} \geq \overline{p}_t^{\mathsf{f}}$	$d_{\mathsf{f}}^{\mathsf{g}} > \frac{\underline{p}_t^{\mathsf{g}} - \breve{\wp}_t^{\mathrm{LA}}}{\underline{p}_t^{\mathsf{g}} - \overline{p}_t^{\mathsf{f}}}$	$\overline{p}_t^{\mathsf{m}} > \overline{p}_t^{\mathsf{f}}$	mkt financier[b]	ambiguous

[a]Given the **S.1** (MEIP) observation $\underline{p}_t^{\mathsf{f}} < \breve{\wp}_t^{\mathrm{LA}}$, what interval membership or non-membership may be inferred?

[b]for all but $\overline{p}_t^{\mathsf{m}} = \overline{p}_t^{\mathsf{f}}$ case

Figure 1: Net non-cumulative annual cash value (£m) of Launch Aid 1970–2000 (data from Table 1 sources).

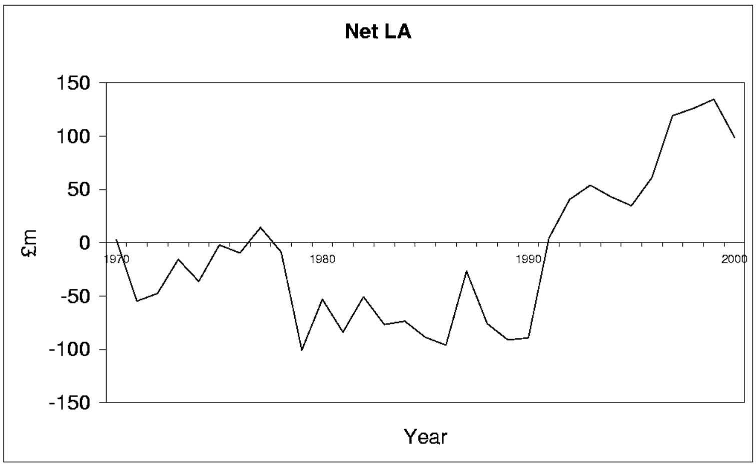

Figure 2: Hypothetical Launch Aid cumulative receipts schedule