

**Political will, military technology and aggregation technology in
Hirshleifer's social composition function.
Case-study of Reagan's Star War and NATO, 1970-1990.**

Working paper

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Abstract

The Strategic defense Initiative (SDI) of the first Reagan administration can be viewed as a political will to increase the pressure on the USSR by developing a national ballistic defense system. It takes place at a time when a summation technology prevails for the aggregation of contributions of NATO allies. We investigate whether SDI as an innovation in military technology induces a shift in Hirshleifer's social composition function for the western alliance. Panel data econometric tests over the period 1970-1990 do not confirm any break towards a best-shot aggregator of allied contributions to NATO. SDI as a private (national) good may bring positive spillovers for the allies. However, it also alters and probably weakens deterrence as a supranational public good in the alliance. Mutual preemption is then more likely to emerge as a Nash equilibrium whereas the standard deterrence game would prevent it. There are certainly lessons to be drawn from that episode for the current debates on ballistic defense.

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1. Introduction

For a government, the relations between military technologies and military strategies are never simple. It requires expertise and savoir-faire to understand and disentangle all their dimensions. Military technologies range from the English long bow to the Gribeauval cannon, from castles to nuclear warheads. Military strategies have to consider them as both constraints and opportunities. If budgets allow it, military innovations will be encouraged, possibly leading to arms races between competing nations. Things get even more intricate when decisions are taken by an alliance providing defense as a supranational public good, in a setting that amounts to the private provision of a public good (Bergstrom, Blume, Varian, 1986). A second set of technologies is then added to the decision-making framework, namely the aggregation technologies of national contributions to the alliance. In the Samuelsonian tradition, the only available aggregation technology is the summation of contributions (Samuelson, 1954, 1955). For a military alliance, it amounts to adding or gathering men-at-arms, soldiers, crossbowmen, tanks, etc... In this context, the relationship between military technology and military strategy in an alliance is thus probably limited to relatively simple settings. There is a linear cumulative effect of the contributions of the allies. For instance, an ally may add its troops or armored divisions to a task force of the alliance. In that case, the probability for the alliance to

win is proportionate to the number of deployed units, if they are homogenous. Free-riding is a pervasive threat to the alliance.

Alternatively, Hirshleifer's seminal work (Hirshleifer, 1983) fundamentally alters this landscape by introducing what is labeled a social composition function, thereby extending the set of available aggregation technologies to weakest-links and best-shots (Cornes, 1993; Cornes and Hartley, 2007). The weakest-link technology implies that the alliance has to rely on the minimal contribution to ensure collective protection. Typically, the risk of break-through of a fortified allied front at the site of the poorest fortification is an example of weakest-link technology. Free-riding becomes risky. Conversely, the best-shot technology is such that the largest of the individual contributions determines the collective defense output. For instance, hosting a best-shot with a first strike advantage induces a high probability of winning through pre-emptive attack. This may pave the way for free-riding by non best-shots, which may prove inconsistent in the long run. In this vein of research, Conybeare and Sandler (1990) and Conybeare et al. (1994) have provided pioneering econometric work on World War I alliances.

Collective action in the alliance and policy implications are significantly changed when the three technologies of aggregation of contributions are taken into consideration (Sandler, 2006). It is probably intuitive that the ally in possession of an innovative weapon will be a natural candidate for best-shot while the weakest-link usually evinces poor defensive structures or obsolete offensive capacities. Military strategy consequently has to be adapted to technological circumstances. Or is it the contrary? Can it be the case that one of the allies, through budgetary and research efforts, pushes forward a new military technology that will drive the alliance towards

a best-shot pattern? One can imagine that such has been the case with the nuclear policy and technology of the USA in the nineteen-fifties, prompting the best-shot social composition function to prevail in NATO until 1970 (Sandler and Forbes, 1980; Gadea et al., 2004; O’Neal and Elrod, 1989; Khanna and Sandler, 1996; Dutheil et al., 2011).

To what extent can military innovations by an ally prompt inflexions to the existing patterns of collective action in an alliance? What is the relevance and significance of national political will in the evolution of the alliance’s social composition function? For instance, are there historical circumstances when political will is predominant in the ascent of a best-shot position? Such may have been the case with the Strategic Defense Initiative (SDI) initiated by US President Reagan in the early 1980s. The so-called Star War project contributes to a dramatic increase in military and specifically military space expenditures (Zervos, 2004). It is a prominent feature of Mr. Reagan’s first mandate. In short, the plan is to develop a National Missile Defense (NMD), a laser-based-system designed to protect the United States from long range nuclear missiles attacks. Political will is definitely at the origin of SDI. We shall go into more details in later developments but at this stage, Star War appears as a means to a renewed leadership of the USA. Being a national rather a theater missile defense system, it is and it has remained controversial: “inside the defense community, Star Wars never left us. Unfortunately, neither have the polemics surrounding it” (O’Hanlon, 1999: 68).

The controversy is an ongoing one. The new strategic concept of NATO published at the Lisbon Summit in November 2010 cites as a new threat the proliferation of ballistic missiles and nuclear weapons. In order to face it, NATO leaders have decided to develop missile defense capacities. The first step has been to

provide protection to NATO deployed forces, with theatre missile defense. The next step consists in protecting the civil populations of all NATO allies, with what can be labeled Territorial Missile Defense. In June 2011, NATO Defense Ministers approved the NATO Ballistic Missile Defense Action Plan. This strategic move will concern all the allies but the first contributor for the technologies involved remains the USA. Even if the time horizon for the plan is a decade, it can have an impact on the present behavior of the allies and it could soon drive the alliance towards a period of best-shot technology for the aggregation of individual contributions to NATO. Admittedly, Ronald Reagan did not properly reach the aim of an effective SDI, in budgetary and military terms. However, understanding what happened during the Star War period can illuminate the ongoing strategic shifts towards territorial missile defense. In particular, it can provide lessons about the likely evolution of aggregation technologies in the alliance.

To our knowledge, the few existing economic studies of Star War mainly focus either on the USA-USSR arms race (Zervos, 2004) or on the deterrence-defense tradeoff in a game-theoretic framework (Brams and Kilgour, 1988a, 1988b). Insightful though there are, such studies do not take into account two dimensions of the NMD system designed by the Reagan administration, which we would like to illuminate here. First, the relationship between the USA and NATO is largely absent from the debates. Admittedly, an NMD is evidently national, but the national policy of the former best-shot of the western alliance might be expected to extend its impact beyond strictly national interests. Now, SDI is conceived during a period when NATO works under a summation technology for contributions aggregation (Dutheil et al., 2011), which leads us to our second point. In budgetary and strategic terms, SDI is an endeavor of tremendous policy consequences: deterrence has been the key to the

initial strategy of NATO. Can it be replaced with defense provided by the Star War technology? Can we find empirical evidence that SDI provides a best-shot during the nineteen-eighties? Instead of adopting a long term perspective for the identification of social composition functions (Gadea et al., 2004; Dutheil et al., 2011), we focus our statistical analysis on the period 1970-1990 in order to try to capture and identify a possible breakpoint in aggregation technologies for the NATO alliance.

The article is organized as follows. Section 2 describes the way in which SDI is both a technological innovation and a political will that can be conceived as a means to alter the aggregation technology of contributions to a military alliance. Section 3 presents the econometric results testing the possibility for the USA to become a best-shot in NATO during the nineteen-eighties. Section 4 provides a discussion of those empirical results. Section 5 concludes.

2. “The Cold War is over”: an economic analysis of Star War

The quotation in the title of this section is from President Reagan leaving office in January 1989 after two mandates. In the early 1980s, the US-Soviet relations enter a phase of intense friction, possibly as potentially dangerous as the 1962 Cuban missile crisis. The magnitude of the threat is probably amplified by the US presidential campaign of 1980. Nevertheless, when the now elected President Reagan launches the Strategic Defense Initiative with his speech of March 23, 1983, it spurs or revives the space arms race between the two superpowers of the time. Econometric evidence (Zervos, 2004) reinforces the argument that SDI contributes to the bankruptcy of the Soviet Union. At the time of its launching however, heated arguments fuel a debate full of technical and strategic controversies sometimes evincing vested interests. Greenberg (2000) mentions how SDI can be conceived as a bargaining chip for arms

control negotiations; also, far from the popular missile-proof umbrella, SDI is possibly a system designed to preserve US missiles for wartime counterattacks; more ambitious is the interpretation of SDI as a means to undermine the 1972 Anti-Ballistic Missile Treaty, providing a way to modify it rather than withdrawing from it (O'Hanlon, 1999), thereby minimizing the diplomatic consequences of a rather bold initiative.

Interpreted in the social composition function framework of Hirshleifer, SDI is a military innovation supported by the political power in an attempt to strengthen the US position against the Soviet threat. A likely consequence is that the USA may become a best-shot within NATO again. Now, the inception of SDI approximately takes place in the middle of a period of summation technology for the NATO alliance. 1970-1990 is indeed characterized by the flexible escalation doctrine by which primary fronts involve non-nuclear engagements only, nuclear weapons being kept within second stage interdiction strikes. The technology of aggregation of technologies in the western alliance has thus moved from a best-shot aggregator, played by the USA from 1955 to 1970, to a summation technology that gives a renewed weight to conventional forces. Behind this change in aggregation technology lays a new strategic doctrine put forward by NATO directive MC14/3 of January 16, 1968 whereby "The conventional forces of the Alliance, land, sea and air, many of which are organically supported by tactical nuclear weapons, are a further essential component of the deterrent" (MC14/3, 25c). Conventional forces are defined as "those forces employable in a non-nuclear role, although they may have a nuclear capability" (MC14/3, A8). This new strategic concept is to be implemented through measures described in NATO directive MC48/3 of December 8, 1969. The USA does follow the strategic line proposing "The requirement for adequate conventional forces

and for improving capabilities for non-nuclear operations while maintaining NATO's nuclear capability. This should include achieving optimum dual capability, especially in air forces, and the flexibility to employ these forces in non-nuclear operations" (MC 48/3, 5b). Concurrently, the American political scene progressively develops rhetoric pushing forward the imminent Soviet domination, possibly culminating with Ronald Reagan's election. The Star War initiative can be seen as an attempt to go beyond the current state of strategic military doctrine of the time. Political will intends at shifting military doctrine which in turn would involve a change in aggregation technology in the western alliance.

Budgets indeed point at a "best-shot" effort by the USA. Since the announcement of SDI in 1983, the USA has spent \$3.5 billion a year on missile defense programs (O'Hanlon, 1999). The rise in space military expenditures matches that of the early 1960s during the space race between "Apollo and Sputnik". Furthermore, Zervos (2004) identifies 1986 as the date when the US space military expenditures surpass the Soviet ones for the first time in history, as a consequence of a trend rooted back in the mid-1970s. The ensuing candidacy for best-shot is exemplified by Sandler (2006): the star war best-shooter has the capability to destroy enough missiles from the first strike of the enemy to deter it from attacking. At the scale of the alliance, only one such system is required. The defense missile system can be viewed as a best-shot public good. There remains to check whether it is the case.

3. Econometric analysis

The panel goes over 1970–1990 for 14 NATO allies (Belgium, Canada, Denmark, France, Germany, Greece, Italy, Luxemburg, the Netherlands, Norway, Portugal, Turkey, the UK, and the USA). Data is obtained from NATO 2009 sources for

national defense expenditures (denoted by DEF_i for ally i) and IMF 2008 for GDP (denoted by GDP_i for ally i). Units are million USD and the logarithm of variables is used in the regressions on this balanced panel data set. Under a summation technology, considering a given ally i , the other allies' cumulated defense efforts are denoted by $SUM_i = \sum_{j \neq i} DEF_j$. Under a best-shot technology, $BS_i = \max_{j \neq i} DEF_j$ with $BS_{Best-shot} = 0$.

Using a long-run analysis (1955-2006), Dutheil et al. (2011) have previously identified break dates in 1970 and 1990 with a summation technology prevail over that sub-period. Focusing now the tests on that period, the hypothesis is tested again using Panel Corrected Standard Errors (PCSE) as recommended by Beck and Katz (1995). First, two models evidencing a constant aggregation technology are tested with fixed effects and lagged variables over 1970-1990:

$$(1) \quad DEF_{i,t} = \alpha_{1,i} + \beta_1 GDP_{i,t} + \gamma_1 SUM_{i,t-1}$$

$$(2) \quad DEF_{i,t} = \alpha_{2,i} + \beta_2 GDP_{i,t} + \gamma_2 BS_{i,t-1}$$

Coefficients for GDP are significant at the 1% level (respective values 0.677*** and 0.683***). However, none of the two aggregation technologies have significant coefficients (respective values -0.025 and -0.036). The strategy is then to introduce possible breakpoints d_k within the period. We define:

$$(3) \quad TECH1_{i,t-1} = d_k \times TECH_{i,t-1}$$

The aggregation technology is represented by variable $TECH$, which is such that $TECH = SUM$ or BS . The social composition function can be either summation or best-shot. Dummy variable d_k takes value 1 from 1970 until year k and value 0 afterwards. Until date k , $TECH1 = SUM1$ or $BS1$: during the first period, summation

or best-shot can prevail. Afterwards, $TECH2 = SUM2$ or $BS2$: there may or may not be a shift in the aggregation technology.

Using the PCSE method, we test all possible combinations of breakpoints d_k from 1970 to 1990 and of aggregation technologies (for instance $BS1$ then $SUM2$ or $SUM1$ then $SUM2$):

$$(4) \quad DEF_{i,t} = \alpha_i + \beta GDP_{i,t} + \delta_1 TECH1_{i,t-1} + \delta_2 TECH2_{i,t-1}$$

If the Star War hypothesis is verified, then we could expect a technology shift from summation to best-shot around 1983. However, in statistical terms, this is one possibility amongst many others. With a time horizon of 21 years and 4 possible combinations of aggregation technologies, 84 models are in competition and must be investigated as such. Detailed estimations are provided in appendix 1. Only five models emerge with significant coefficients. Table 1 sums up the results. Model A evidences best-shot until 1972 and then summation. Model B does the same with a break in 1975. Model E begins with best-shot with a break in 1981 followed by another best-shot. Models C and D show two summation periods with respective breaks in 1980 and 1981.

(Table 1 about here)

We then run J tests in order to cross-evaluate the five models remaining in competition (detailed results are provided in appendix 2). Models A, B and E can be rejected at the 1% threshold. Models C and D are quite similar, with close break dates and the same aggregation pattern. None of them is rejected at the 1% threshold. Model D cannot be rejected at the 5% threshold (except when compared to model C). At the 10% threshold, all models are rejected. All in all, model D and to a slightly lesser extent model C seem to provide the best specifications. Consequently, the econometric analysis does not confirm any technology shift towards best-shot.

4. Discussion

The likely shift of technology from summation to best-shot following SDI does not seem to take place. If ever there is a change in the behavior of the allies, it happens earlier in 1980 or 1981 and it remains within a summation framework. The election of Ronald Reagan and his falcon conception of nuclear strategy have a greater impact than a shift in military technology that will never be fully completed (Freedman 2003). International affairs analysts nevertheless talk at the time of a second cold war. However, a political initiative like SDI does not shift the social composition function towards a best-shot aggregator. To try to understand why, it may prove insightful to go back to the early years of NATO when the USA does play best-shot.

As Pedlow (1997) recalls it, the first NATO strategy document ever drafted emanates from the Standing Group on October 10, 1949. The Standing Group is a subdivision of the Military Committee (MC), composed of NATO's chiefs of staff. The draft is submitted to the MC which issues it after unsubstantial editorial changes as directive MC3 on October 19, 1949. The standing group is composed of generals Bradley, Morgan and Ely, respectively representing the USA, the UK and France. Reading MC3 is extremely rewarding for those interested in the making of collective action. The best-shot nature of the alliance at its inception is straightforwardly announced: "Insure the ability to deliver the atomic bomb promptly. This is primarily a US responsibility assisted as practicable by other nations" (MC3 7a). Under the item "cooperative measures", the directive claims that "The essence of our overall concept is to develop a maximum of strength through collective defense planning" (MC3 8). Though the expression "atomic bomb" is soon replaced in the later documents by "strategic bombing", it nevertheless remains that NATO basically aims at providing deterrence as a pure public good inside the alliance.

Deterrence is plainly and forcefully described in directive MC48 of November 22, 1954. “In face of the threat of such a war, the primary aim of NATO, must more than ever before, be to prevent war. This aim can only be achieved if the Allied nations are so powerful in the vital elements of modern warfare that the enemy will conclude that he has little hope of winning a war involving NATO. This means that NATO must be able to withstand the initial Soviet onslaught, to deliver decisive atomic counter-attacks against the war-making capacity of the enemy, and to prevent the rapid overrunning of Europe” (MC48 33). In economic terms, deterrence is a pure public good. It is non rival: unlike conventional forces, retaliation can take place whatever the magnitude or geographical aim of the threat. It is also non- excludable: all allies are protected and none can be excluded. Finally, the use of the public good is mandatory for the allies once they have signed the Treaty. Furthermore, deterrence is a credible commitment through the automatic pledge of retaliation sustained by the fact that NATO would have a first-strike advantage and a second-strike capability thanks to its sufficient stockpile of nuclear weapons.

First-strike deterrence thus works as a collective good provided by the members of the alliance. The aggregation technology is not summation, but best-shot. This does not mean that contributions to the alliance other than the best-shot are redundant or useless. The latter statement is too often read and it is contradicted by the very writing of such a fundamental document as directive MC48. Complementarity remains crucial in the alliance but that does not contradict the existence of an overwhelming contribution. In this respect, the standard formulation of best-shot may not fully convey its full meaning.

President Reagan's political endeavor may have altered the previous system of deterrence as a public good for the members of the alliance. In a context of summation for the social composition function, since 1970, SDI can appear as an attempt at reinstalling the best-shot status of the USA. However, to become a successful best-shot implies that you have the capacity to provide the core of the public good that unites the allies. Now, the Star War initiative is a National Missile Defense (NMD) with strategic aims radically different from standard Theater Missile Defense (TMD), e.g. Patriot missiles. Our point is that this national defense initiative amounts to fueling the alliance with a private good. SDI is indeed a public good at the US level but at the NATO level, it is a private good that becomes one of the joint products of the alliance as they have been analyzed by Sandler and Hartley (2001): strategic, tactical and conventional weapons are complementary in the overall strategy.

SDI as a private good released to the alliance does have positive spillovers. The problem is that by providing this type of defense, deterrence as a public good in the alliance is altered and probably weakened. This argument can be formalized by using the game-theoretic analysis of Brams and Kilgour (1988a, 1988b). The standard deterrence game is based on the game of chicken. The main difference however lies in the fact that a chicken game involves qualitative choices of cooperation or non-cooperation: the "lose-win" or "win-lose" outcomes are Nash equilibria while the "mutual compromise" and "mutual disaster" are unstable when the equilibrium concept is Nash. On the contrary, a deterrence game implies quantitative choices of levels of cooperation in two stages, namely the initial choice of levels of preemption and non-preemption, then the subsequent determination of the level of retaliation after facing initial preemption by the other player. Both players make a pre-play choice of

probabilities of preemption and retaliation. Then, they simultaneously play and let the game unroll until one out of three Nash equilibria is reached.

Two of the Nash equilibria in a deterrence game involve preemption by one of the players. They straightforwardly correspond to the two pure-strategy equilibria in the chicken game but the important point here is that in such instances retaliatory threats, though possible, are never used (such threats are not allowed with chicken). The third Nash equilibrium is the mutual deterrence equilibrium where both probabilities of preemption and of retaliation are taken into account by the players. Retaliation probabilities can be conceived as pre-committed threats to respond (in probability) to the other player's non cooperative attitude. With an apparent paradox, mutual threats work to the advantage of both players since it helps to reach the mutually satisfactory cooperative outcome. The inherent instability of this Pareto-superior outcome in a chicken setting is thus overcome through preemption and retaliation commitments.

Unfortunately, when Star War constraints are introduced in the previous setting, preemption equilibria become more likely, to the detriment of the deterrence equilibrium. To sum up the argument, assume that for instance player 1 possesses an SDI defense system and player 2 does not (or does to a much lesser extent). Player can use SDI to blunt a second strike by player 2. Player 1's advantage of attacking augments: strike first; attenuate the retaliatory second strike of player 2 by using SDI. Brams and Kilgour (1988a, 1988b) show that the Star War shield of a player structurally increases the probability of preemptive behavior. Deterrence as a public good inside the alliance is thus to a certain extent threatened by a "private" defense initiative. Admittedly, the NATO alliance in the 1970s, 1980s and 1990s works under

a joint product framework. However, SDI substantially differs from the conventional or even theater ballistic national defenses, in that it profoundly changes the structure of the underlying deterrence game.

5. Conclusion

The NATO alliance in the 1970s and 1980s works under a summation technology where complementarity prevails between strategic, tactical and conventional weapons. In this context, the Strategic Defense Initiative of President Reagan's first mandate reflects the political will of the new administration to bend down the USSR, pushing forward a national defense system in an alliance characterized from its inception by nuclear deterrence. It thus induces a trade-off between deterrence and defense, possibly threatening the stability of nuclear deterrence, even if it takes place in a joint product summation context.

However, the USA fails to become a best-shot again as we have demonstrated with our econometric tests. A likely explanation is that if an ally is to become again a best-shot in an alliance primarily based on deterrence, it must provide tools reinforcing deterrence rather than possibly weakening it. The national defense of a given ally, however ambitious and powerful, if it mostly amounts to a private good contribution to the alliance, cannot claim the status of a public good contribution to the social composition function.

There are certainly lessons to be drawn from that Star War episode. It may illuminate the current debates on missile defense. NATO is facing multiple threats rather than the ballistic one alone. It seems very unlikely that the USA would become a best-shot in a near future. As we have demonstrated it, even in circumstances when the threat was clearly identified, namely the USSR-USA space of the early 1980s, the

latter would not become a best-shot. During the first seven decades of its existence, NATO has been working under either best-shot or summation technologies. Now, the current variety and dispersion of threats is such that the strategic fog of war, to paraphrase Clausewitz, has rarely been so thick. While free-riding probably is an increasingly risky game to play, the yet neglected weakest-link technology may want renewed consideration. The achievement of the Territorial Missile Defense strategy might be a way to prevent it.

Finally, a new avenue for research could contemplate the deterrence game in a multiple players setting, which seems to be realistic now that threats are more diffused amongst a significant number of potential rogue states. A guess is that missile defense strategy, even within the framework of a summation social composition function, “would be able to knock down enough of an enemy’s missiles so that if he ever pushed a button to attack, he would be doing so in the knowledge that his attack was unable to prevent a devastating retaliatory strike (Reagan’s memoirs, quoted by Greenberg, 2000: 140). And that would prove useful to NATO, if not best-shot.

Table 1: Estimation results for the significant technology combinations

Variables	Model A $k = 1972$	Model B $k = 1975$	Model C $k = 1980$	Model D $k = 1981$	Model E $k = 1981$
<i>GDP</i>	0.720*** (8.913)	0.714*** (8.786)	0.704*** (9.859)	0.713*** (9.958)	0.675*** (9.900)
<i>SUM1</i>			-0.217** (-2.027)	-0.243** (-2.132)	
<i>SUM2</i>	-0.010** (-2.225)	-0.009* (-1.927)	-0.212** (-1.996)	-0.238** (-2.106)	
<i>BS1</i>	-0.009* (-1.882)	-0.008* (-1.763)			-0.155* (-1.802)
<i>BS2</i>					-0.151* (-1.771)
R^2	0.994	0.994	0.995	0.995	0.995

(*), (**), (***) : respectively significant at 10%, 5% and 1% level

Appendix 1: Estimations of breakpoints under the various aggregation combinations

	pcse1970	pcse1971	pcse1972	pcse1973	pcse1974	pcse1975	pcse1976
<i>GDP</i>	0.701***	0.704***	0.748***	0.644***	0.652***	0.743***	0.693***
<i>SUM1</i>	-0.070	-0.073	-0.090	-0.044	-0.091	-0.089	-0.079
<i>SUM2</i>	-0.070	-0.072	-0.092	-0.040	-0.086	-0.091	-0.078
	pcse1977	pcse1978	pcse1979	pcse1980	pcse1981	pcse1982	pcse1983
<i>GDP</i>	0.706***	0.721***	0.706***	0.704***	0.713***	0.727***	0.711***
<i>SUM1</i>	-0.099	-0.093	-0.146	-0.217**	-0.243**	-0.139	-0.092
<i>SUM2</i>	-0.098	-0.093	-0.143	-0.212**	-0.238**	-0.137	-0.092
	pcse1984	pcse1985	pcse1986	pcse1987	pcse1988	pcse1989	pcse1990
<i>GDP</i>	0.730***	0.744***	0.744***	0.766***	0.773***	0.741***	0.714***
<i>SUM1</i>	-0.074	-0.075	-0.108	-0.074	-0.086	-0.087	-0.085
<i>SUM2</i>	-0.075	-0.075	-0.108	-0.076	-0.089	-0.088	0.000

	pcse1970	pcse1971	pcse1972	pcse1973	pcse1974	pcse1975	pcse1976
<i>GDP</i>	0.662***	0.664***	0.715***	0.623***	0.619***	0.710***	0.660***
<i>SUM1</i>	0.012***	0.006	0.009**	0.003	0.004	0.008*	0.001
<i>BS2</i>	0.015***	0.008	0.008*	0.008*	0.010**	0.007	0.002
	pcse1977	pcse1978	pcse1979	pcse1980	pcse1981	pcse1982	pcse1983
<i>GDP</i>	0.674***	0.688***	0.656***	0.639***	0.644***	0.689***	0.700***
<i>SUM1</i>	0.002	-0.000	-0.005	-0.005	-0.008*	-0.003	-0.001
<i>BS2</i>	0.003	-0.000	-0.003	-0.002	-0.005	-0.003	-0.002
	pcse1984	pcse1985	pcse1986	pcse1987	pcse1988	pcse1989	pcse1990
<i>GDP</i>	0.726***	0.738***	0.729***	0.749***	0.747***	0.711***	0.714***
<i>SUM1</i>	-0.004	-0.003	0.000	0.003	0.002	0.003	-0.085
<i>BS2</i>	-0.006	-0.005	-0.000	0.000	-0.001	0.003	0.000

	pcse1970	pcse1971	pcse1972	pcse1973	pcse1974	pcse1975	pcse1976
<i>GDP</i>	0.674***	0.672***	0.720***	0.627***	0.624***	0.714***	0.662***
<i>BS1</i>	-0.015***	-0.008*	-0.009*	-0.008*	-0.011**	-0.008*	-0.003
<i>SUM2</i>	-0.013***	-0.007	-0.010**	-0.003	-0.005	-0.009*	-0.001
	pcse1977	pcse1978	pcse1979	pcse1980	pcse1981	pcse1982	pcse1983
<i>GDP</i>	0.674***	0.687***	0.654***	0.637***	0.642***	0.688***	0.700***
<i>BS1</i>	-0.004	-0.001	0.002	0.001	0.004	0.002	0.001
<i>SUM2</i>	-0.003	-0.001	0.004	0.004	0.006	0.002	0.001
	pcse1984	pcse1985	pcse1986	pcse1987	pcse1988	pcse1989	pcse1990
<i>GDP</i>	0.726***	0.739***	0.731***	0.750***	0.747***	0.712***	0.704***
<i>BS1</i>	0.005	0.004	-0.001	-0.001	-0.000	-0.004	-0.064
<i>SUM2</i>	0.003	0.003	-0.001	-0.003	-0.003	-0.004	0.000

	pcse1970	pcse1971	pcse1972	pcse1973	pcse1974	pcse1975	pcse1976
<i>GDP</i>	0.678***	0.685***	0.729***	0.630***	0.631***	0.725***	0.681***
<i>BS1</i>	-0.036	-0.041	-0.073	-0.013	-0.043	-0.070	-0.056
<i>BS2</i>	-0.034	-0.040	-0.074	-0.009	-0.037	-0.071	-0.054
	pcse1977	pcse1978	pcse1979	pcse1980	pcse1981	pcse1982	pcse1983
<i>GDP</i>	0.689***	0.707***	0.684***	0.671***	0.675***	0.703***	0.702***
<i>BS1</i>	-0.074	-0.067	-0.092	-0.133*	-0.155*	-0.085	-0.068
<i>BS2</i>	-0.073	-0.067	-0.090	-0.129	-0.151*	-0.084	-0.068
	pcse1984	pcse1985	pcse1986	pcse1987	pcse1988	pcse1989	pcse1990
<i>GDP</i>	0.735***	0.746***	0.733***	0.755***	0.759***	0.727***	0.704***
<i>BS1</i>	-0.049	-0.046	-0.083	-0.055	-0.061	-0.066	-0.064
<i>BS2</i>	-0.050	-0.048	-0.082	-0.057	-0.064	-0.066	0.000

Appendix 2: J tests

	Test A_A	Test A_B	Test A_C	Test A_D	Test A_E
<i>GDP</i>	0.0000	0.1408	0.0555	0.0596	0.0231
<i>BS1</i>	0.0000	-0.0072	-0.0078*	-0.0077*	-0.0087*
<i>BS2</i>					
<i>SUM1</i>					
<i>SUM2</i>	0.0000	-0.0085*	-0.0091**	-0.0089**	-0.0102**
Model A	1.0000***				
Model B		0.8396			
Model C			0.9699***		
Model D				0.9643***	
Model E					1.0250**

	Test B_A	Test B_B	Test B_C	Test B_D	Test B_E
<i>GDP</i>	0.0986	0.0000	0.0386	0.0467	0.0142
<i>BS1</i>	-0.0062	0.0000	-0.0060	-0.0058	-0.0067
<i>BS2</i>					
<i>SUM1</i>					
<i>SUM2</i>	-0.0068	0.0000	-0.0069*	-0.0066	-0.0079*
Model A	0.8939*				
Model B		1.0000***			
Model C			0.9836***		
Model D				0.9683***	
Model E					1.0215**

	Test C_A	Test C_B	Test C_C	Test C_D	Test C_E
<i>GDP</i>	0.0535	0.0897	-0.0000	0.0495	0.1172
<i>BS1</i>					
<i>BS2</i>					
<i>SUM1</i>	-0.1984*	-0.1949*	-0.0000	-0.1141	-0.1377
<i>SUM2</i>	-0.1937*	-0.1901*	-0.0000	-0.1098	-0.1335
Model A	0.9396**				
Model B		0.8769*			
Model C			1.0000***		
Model D				0.8691**	
Model E					0.8027*

	Test D_A	Test D_B	Test D_C	Test D_D	Test D_E
<i>GDP</i>	0.0821	0.1411	0.0443	0.0000	1.5766*
<i>BS1</i>					
<i>BS2</i>					
<i>SUM1</i>	-0.2216*	-0.2197*	-0.1321	-0.0000	-0.4869**
<i>SUM2</i>	-0.2169*	-0.2149*	-0.1278	-0.0000	-0.4771**
Model A	0.9112*				
Model B		0.8174			
Model C			0.8876**		
Model D				1.0000***	
Model E					-1.2180

	Test E_A	Test E_B	Test E_C	Test E_D	Test E_E
<i>GDP</i>	-0.0477	-0.0020	0.0143	-0.6706	0.0000
<i>BS1</i>	-0.1639*	-0.1544*	-0.0695	0.1817	0.0000
<i>BS2</i>	-0.1597*	-0.1502*	-0.0659	0.1763	0.0000
<i>SUM1</i>					
<i>SUM2</i>					
Model A	1.0585**				
Model B		0.9761*			
Model C			0.9171***		
Model D				2.0025**	
Model E					1.0000**

(*), (**), (***) : respectively significant at 10%, 5% and 1% level

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