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Economic Studies and Analyses

Editorial: Ohlédnutí za prvním ročníkem Ceny prof. F. Vencovského

Editorial: Looking Back on the 1st Year of Prof. F. Vencovsky Award

BOJKA HAMERNÍKOVÁ

Cena prof. F. Vencovského

Začátkem roku 2007 vyhlásila Dr. B. Šenkýřová, rektorka VŠFS soutěž o Cenu prof. F. Vencovského. Naplnil se tím záměr vrcholového vedení VŠFS posílit a dlouhodobě podporovat vědeckovýzkumnou činnost školy a hlavně podporovat mladé talentované výzkumníky. Soutěž v uvedeném roce byla ve znamení tématu: Nové výzvy pro ekonomii v globalizujícím se světě. Periodicita soutěže je dvouletá.

Do soutěže se mohli přihlásit ekonomové do 35 let. Podmínkou účasti bylo odevzdání původní teoretické stati v českém a anglickém jazyce. Z celkem 22 přihlášených vyhovělo podmínkám 14 prací. Prestižně obsazený nominační výbor, jehož členy byli Ing. M. Singer, Ph.D. - viceguvernér ČNB, prof. Dr. Ing. J. Frait, prof. Ing. M. Sojka,CSc., doc. Ing. P. Dvořák , CSc.- děkan FFÚ VŠE v Praze, vybral 5 laureátů a z toho vítěznou práci. O první místo se rozdělily dvě práce autorů (dotované odměnou 200 000,- Kč) A. Geršla a F. Novotného z ČNB.

Na třetím místě se umístil D. Prušvic z MF ČR (obdržel věcnou cenu - notebook). Čtvrté místo obsadil R. Horváth z ČNB (získal elektronickou databanku), pátý byl P. Jakubík, také z ČNB (jako cenu obdržel digitální fotoaparát).

Vyhlášení laureátů soutěže o Cenu prof. F. Vencovského proběhlo za velké pozornosti elektronických a tištěných médií na mezinárodní vědecké konferenci dne 16. 11. 2007 v Kongresovém centru České národní banky. Konference byla pořádána pod záštitou Guvernéra ČNB Z. Tůmy, který se osobně konference zúčastnil. Kromě domácích odborníků v čele s prof. J. Fraitem vystoupil významný americký ekonom S. Peltzman z Chicagské univerzity. Konference se zúčastnila také manželka zesnulého prof. F. Vencovského, paní Věra Vencovská s rodinou, jakožto i vnuk významného českého ekonoma K. Engliše.

Ohlédnutí za úspěšně proběhlým 1. ročníkem soutěže a mezinárodní vědeckou konferencí umožňuje konstatovat velký zájem ze strany mladých ekonomů, akademických institucí, ale též médií. Jméno p. prof. Vencovského - významného českého ekonoma a výjimečného vysokoškolského učitele samo o sobě předpokládalo vysokou úroveň připravenosti uchazečů o cenu i organizátorů konference. Konferencí vládl duch odborné zaujatosti, inspirativních myšlenek a nosných nápadů. Účast mladých odborníků a studentů byla tím nejlepším důkazem významu podobných počinů.

První ročník soutěže o Cenu prof. F. Vencovského je již úspěšně za námi. V brzké době zahájíme přípravu na ročník druhý.

Prof. F. Vencovsky Award

At the beginning of 2007 Prof. F. Vencovsky Award was announced by Dr. B. Šenkýřová, Rector of VSFS. It was the aim of VSFS top management to enhance and promote research and development activities of the school and encourage young talented researchers on a long-term basis. By organising the contest the aim was achieved. This year the contest was under the topic of "New challenges for economics in the globalising world". The contest takes place periodically every 2 years.

Economists up to 35 years of age were invited to take part on condition they had submitted an original theoretic essay in both Czech and English languages. Out of 22 submitted works 14 adhered to the conditions. The nomination committee consisting of renowned members – Ing. M. Singer, Ph.D.. Vice Governor of the CNB, Prof. Dr. Ing. J. Frait, Prof. Ing. M. Sojka, Doc. Ing. P. Dvořák, CSc., Dean of the Faculty of Finance and Accounting, University of Economics Prague, chose 5 laureates, and from among them the winning essay. The first place (allotted with CZK 200 000) was shared by two works by authors A. Geršl and F. Novotný of the CNB.

The third place was won by D. Prušvic of the MF CR (awarded a laptop), the fourth place by R. Horwath of the CNB (awarded an electronic databank) and the fifth was P. Jakubík, also of the CNB (awarded a digital camera).

The announcement of the winner of Prof. F. Vencovsky Award was paid much attention by electronic media and the press at the international scientific conference held on November 16, 2007 in the Congress Centre of the CNB. The conference was held under the auspices of the CNB Governor Mr. Z. Tůma who was present in person.Apart from local professionals headed by Prof. J. Frait a well-known American economist S. Peltzman of the University of Chicago delivered a speech. The conference was also attended by the late Prof F. Vencovský´s wife, and by the grandson of a great Czech economist K. Engliš.

Looking back on the successful 1st year of the contest and international scientific conference we can see deep interest of young economists, academic institutions and mass media. Prof. Vencovský was a great Czech economist and exceptional university teacher and his name itself supposed very well prepared candidates entering the contest and experienced organisers of the conference. At the conference there was an atmosphere of professional interest, inspiration and challenging ideas. The participation of young professionals and students was the best acknowledgement of the importance of such events.

The 1st year of Prof. F. Vencovsky Award is over. We are going to start preparations for the 2nd year in the near future.

Kontaktní adresa / Contact address

doc. Ing. Bojka Hamerníková, CSc.
Vysoká škola finanční a správní, o.p.s., prorektorka pro kvalitu výuky a výzkum
(e-mail: bojka.hamernikova@vsfs.cz)

Převis globální likvidity a rizika pro finanční stabilitu

Excess Global Liquidity and Risks for Financial Stability

JAN FRAIT*

1 Úvod

Tento příspěvek byl připraven při příležitosti konference „Nové výzvy v globalizujícím se světě", Praha, 16. listopadu 2007, spojené s vyhlášením prvního ročníku soutěže mladých ekonomů o Cenu prof. Františka Vencovského. S profesorem Vencovským jsem se v 90. letech nejprve potkával na Ekonomické fakultě v Ostravě, kam pravidelně zajížděl, a poté zde na půdě ČNB v Praze. S postupem času stále více oceňuji jasný jeho názor na potřebu zdravé měny, jeho kritiku snah o krátkodobou podporu ekonomické aktivity prostřednictvím měnové expanze a důraz na rovnováhu v reálné ekonomice. V paměti mám stále jeho varovné vystoupení na III. výroční konferenci ČSE v roce 2004 nazvané „Základem finanční rovnováhy je vyšší tvorba domácího kapitálu".

V této se době prof. Vencovský díval s nedůvěrou na měnový vývoj ve světové ekonomice a vyjadřoval obavy z tendence firem i domácností tak trochu bezstarostně se zadlužovat. Vývoj na mezinárodních finančních trzích v letošním roce mu dal alespoň částečně za pravdu a nezbývá než doufat, že jím zdůrazňovaná tvorba domácího kapitálu a z ní rezultující růst produktivity budou nadále podporovat finanční rovnováhu české ekonomiky. Ve svém příspěvku se dále zaměřím na několik vybraných aspektů vývoje světové ekonomiky v současné dekádě. Dříve než tak učiním, chtěl bych zdůraznit, že jde o mé vlastní názory, které nemusí nutně odrážet pozici ČNB.

2 Od boomu ke krizi?

Může se zdát paradoxní, že zatímco v roce 2006 analýzy makroekonomického vývoje a finanční stability skloňovaly termíny excess global liquidity a credit boom, od poloviny roku 2007 je vystřídaly opačné termíny liquidity crisis a credit crunch. Ve skutečnosti tento zvrat nepředstavuje nic nového pod sluncem – úvěrový boom vede často k bublině na trzích aktiv a po jejím splasknutí následuje silné omezení úvěrové dynamiky, které občas přeroste v zadření úvěrů a následně v deflaci v cenách aktiv. Tento cyklus není nikdy stejný, a proto se v jeho průběhu prakticky vždy vyslovuje tvrzení, že tentokráte to bude jiné. A toto tvrzení se jako obvykle ukázalo být naivním.

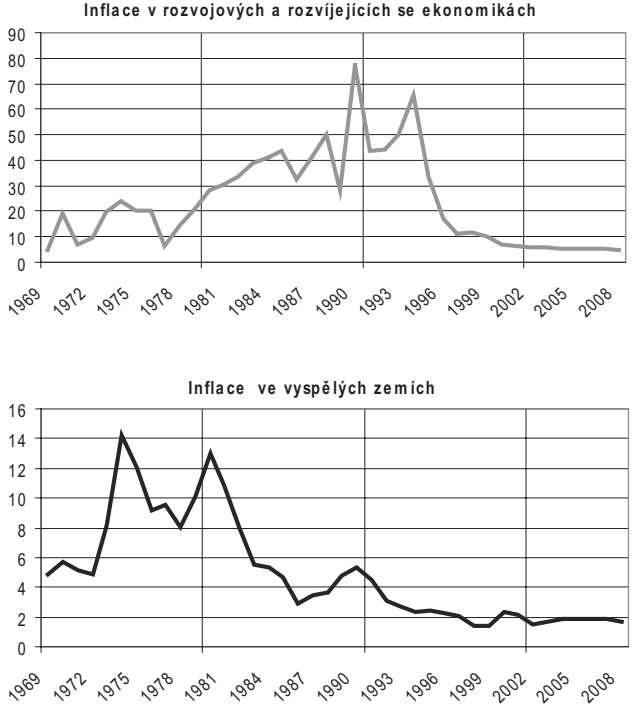
V řadě aspektů je však příběh této dekády jiný – odehrál se na pozadí a zároveň v souvislosti s makroekonomickou stabilizací a výrazným poklesem inflace. Vývoj, který nastal od druhé

* *Jan Frait je náměstkem ředitele Samostatného odboru ekonomického výzkumu a finanční stability České národní banky a profesorem Ekonomické fakulty VŠB-TU v Ostravě.* *Příspěvek odráží některé z výsledků vzniklých v rámci grantového projektu GAČR 402/05/2758.*

poloviny 90. let, získal oprávněně označení „great moderation" (Graf 2.1). Inflace celosvětově klesla do nezvykle nízkých úrovní, ale stala se celosvětově nebývale stabilní (podrobněji viz Frait a Komárek, 2006). Interpretace této pozoruhodné skutečnosti nebyla zejména zpočátku zcela přesná a přispěla k nadměrnému sebeuspokojení a přehlížení rizik.

Ukázalo se, že celosvětový pokles inflace má řadu pozitivních aspektů, ale spoustu problematických jevů v ekonomice neřeší. Nejprve jsme si uvědomili, že s poklesem inflace se příliš nesnížila volatilita nominálních měnových kurzů, jak předpokládaly teorie vzniklé v 70. a 80. letech. Nyní jsme si znovu potvrdili zkušenost, že bubliny na trzích aktiv mohou vzniknout i v prostředí nízké a stabilní inflace.

Graf 2.1: Great Moderation

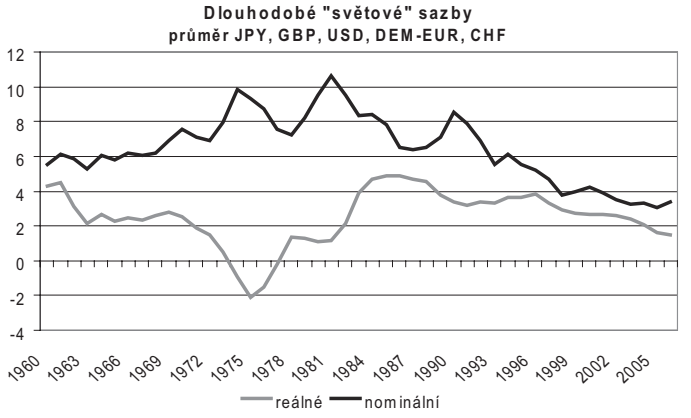


Pramen: IMF International Financial Statistics CD-ROM

V souvislosti se současnými turbulencemi na finančních trzích jsem zaznamenal názor, že to je paradoxně právě nízká inflace vedoucí k nízkým úrokovým sazbám, která se podepsala pod nadměrnou úvěrovou kreací v některých ekonomikách a následnými bublinami na trzích aktiv. Důvodem by měla být peněžní iluze vyvolaná poklesem nominálních úrokových sazeb na nezvykle nízkou úroveň. Jinými slovy, lidé si nebyli schopni uvědomit, že nominální sazby jsou tak nízké jen díky velmi nízké inflaci. Tento názor nesdílím, neboť po dlouhou dobu jsou nízké nejen nominální, ale i reálné sazby.

Příčinami nerovnovážného vývoje bylo spíše udržování neadekvátně uvolněných měnových podmínek po příliš dlouhou dobu ze strany centrálních bank některých velkých ekonomik, makroekonomické politiky a strukturální vývoj v některých asijských rozvíjejících se ekonomikách a pomalé strukturální reformy v některých vyspělých zemích. Neoddiskutovatelným faktorem stojícím za úvěrovým boomem byl výrazný pokles světových reálných úrokových sazeb. Jedním z možných měřítek jsou průměrné ex post reálné úrokové sazby dlouhodobých sazeb klíčových měn. Existuje řada alternativních měřítek, ale většina z nich by pravděpodobně ukázala na to, že světové reálné úrokové sazby až do roku 2006 klesaly (viz Graf 2.2). K jejich růstu docházelo až v roce 2007, což bylo zřejmě příliš pozdě.

Graf 2.2: Dlouhodobé světové úrokové sazby



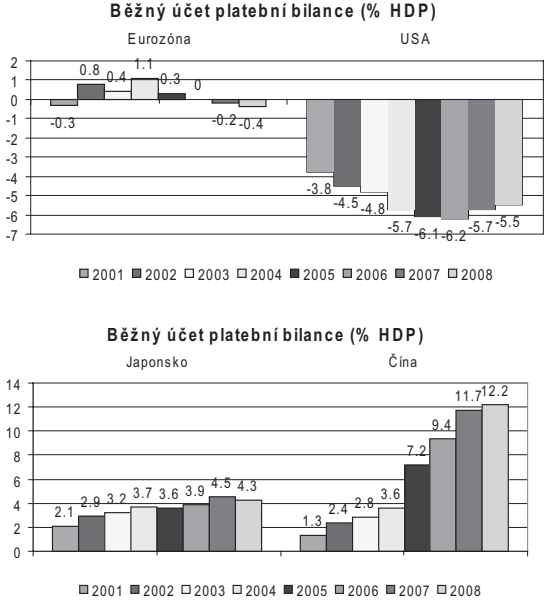
Pramen: IMF International Financial Statistics CD-ROM

Výše uvedený vývoj reálných úrokových sazeb byl jedním z faktorů za rychlým růstem úvěrové kreace, který pak vyvolal to, co bylo tak trochu nepřesně označováno za globální převis likvidity. Jedním z dobrých měřítek je rozdíl mezi skutečným podílem úvěru do privátního sektoru na HDP a jeho dlouhodobým trendem. Analýzy OECD ukázaly, že tento rozdíl v roce 2006 vzrostl k 15 %.

Dalším nezanedbatelným faktorem byl a stále do jisté míry je globální přebytek úspor, přesněji řečeno globální nerovnováha v distribuci úspor kombinovaná s utlumenými investicemi do reálné ekonomiky. Za přebytkem úspor zejména v asijských ekonomikách a jeho investováním v zahraničí je nutno hledat nejen strukturální faktory, jakými jsou absence stabilního finančního sektoru, praktická neexistence sociální politiky a demografický vývoj, ale i cyklické faktory související s nízkými výnosy na domácích trzích (např. v Japonsku). Ve vyspělých zemích vzrostly úspory také, a to ve firemním sektoru, který měl v posledních letech sice relativně velké zisky, ale málo z nich investoval. To může být důsledek předchozí investiční vlny, která ve víře v zázraky „nové ekonomiky" vedla k tvorbě nadměrných kapacit. Kombinace těchto faktorů pomáhala udržovat dlouhodobé úrokové sazby klíčových měn na nízkých úrovních a tím zároveň přispěla v předchozích letech ke globálnímu „převisu likvidity". Zároveň se promítla do

výrazné nerovnováhy v platebních bilancích (viz Graf 2.3), která rovněž přináší nemalá rizika.

Graf 2.3: Běžný účet platební bilance v klíčových ekonomikách



Pramen: IMF International Financial Statistics CD-ROM

Mix finančních inovací a změněného makroekonomického prostředí se obvykle projeví v dynamické reakci finančních trhů. Ta v první fázi často vyvolá přehnanou investiční vlnu investic do aktiv, která nakonec může skončit finanční krizí. Na konci 80. let tak začalo období uvolnění kapitálových toků do rozvíjejících se ekonomik udržujících fixní měnové kurzy. Toto období skončilo měnovými a dlužnickými krizemi v letech 1997-1998.

Současné události nastartovala kombinace „nové" ekonomiky a technologické bubliny v 90. letech, integrace mezinárodního trhu zboží a služeb v důsledku globalizace a stabilizace světové inflace v první polovině této dekády vedoucí k výraznému poklesu úrokových sazeb. Neopomenutelným prvkem byla i reakce na obavy z důsledků 11. září 2001 a výrazný pokles reálné ekonomické aktivity v západních ekonomikách v letech 2002-2003 projevující se silnými desinflačními tlaky.

3 Jsou současné finanční turbulence překvapením?

Aktuální finanční nestabilita a její projevy nejsou až tak překvapivé. Ekonomové již delší dobu diskutovali otázku, kde skončilo riziko, které se banky snažily ze svých bilancí odstranit prostřednictvím sekuritizace. Nyní vidíme, že překvapivě významná část rizik se do bankovního sektoru vrátila zpět. Dostává se tam jinými kanály než dříve – zejména prostřednictvím velkoobchodních zákazníků (linek do SPVs, SIVs, ABCP conduits), obchodů

s hedgeovými fondy, private equity fondy apod. Bylo rovněž evidentní, že obecný pokles úrokových spreadů musí znamenat podcenění rizik některých segmentů trhu.

Není rovněž překvapením, že problémy přišly ze strany hypoték a trhu nemovitostí. Růst cen nemovitostí v USA v posledních deseti letech byl označován za potenciální zdroj potíží již řadu let. Řada zemí přitom vykazovala v tomto období mnohem vyšší nárůsty cen nemovitostí. Americký trh byl však specifický snadnou dostupností hypoték pro klienty z kategorie sub-prime, plovoucími úroky na tyto hypotéky a strategií lákat klienty na nízké počáteční úrokové sazby s krutě přesným označením „teaser rates".

Riziko poklesu cen nemovitostí a zhoršení kvality hypoték existuje i v řadě dalších zemí. Negativní efekt bohatství z poklesu cen nemovitostí je rizikem zejména pro Británii, pokles spotřebitelské důvěry však může vyvolat i jinde. Určité zpomalení tohoto segmentu ekonomiky naznačují i aktuální údaje ECB, podle nichž kleslo tempo růstu úvěrů na bydlení v Eurozóně z vrcholku 12 % v průběhu roku 2006 na 8 % v současnosti.

Navzdory tomu, že centrální banky a ekonomická komunita obecně si byly vědomy zranitelnosti finančního sektoru, nebyly současné turbulence a zejména jejich iniciace prostřednictvím trhů peněz předvídány a zapracovány do makroekonomických projekcí a makrozátěžových testů. Mnohokrát publikovaný příběh spojující sekuritizaci sub-prime hypoték, ABS, CDOs, SPVs, SIVs a následnou krizi likvidity vypadá velmi jednoduše a zdá se podivné, že na tento mechanismus nikdo dříve nepřišel. V realitě je odhalení takového mechanismu velmi obtížné.

Většina krizí byla v minulosti tušena, nicméně nepředvídána. Jedná se o málo pravděpodobné události, u nichž je velmi obtížné odhadnout načasování, iniciační segment finančního trhu, způsob projevu a reakci centrálních bank, dohledových autorit a vlád. Proto je nesmírně složité transformovat riziko zranitelnosti do předpovědí a testů. Centrální banky i z tohoto důvodu v posledních letech kladou zvýšený důraz na analýzy finanční stability, které se kromě jiných aspektů zabývají právě extrémními událostmi s poměrně malou pravděpodobností výskytu. Tvorba metodologie a nástrojů v této oblasti je však stále v počátcích a nelze předpokládat, že by v brzké době dosáhla rigoróznosti, kterou vidíme u makroekonomických modelů centrálních bank.

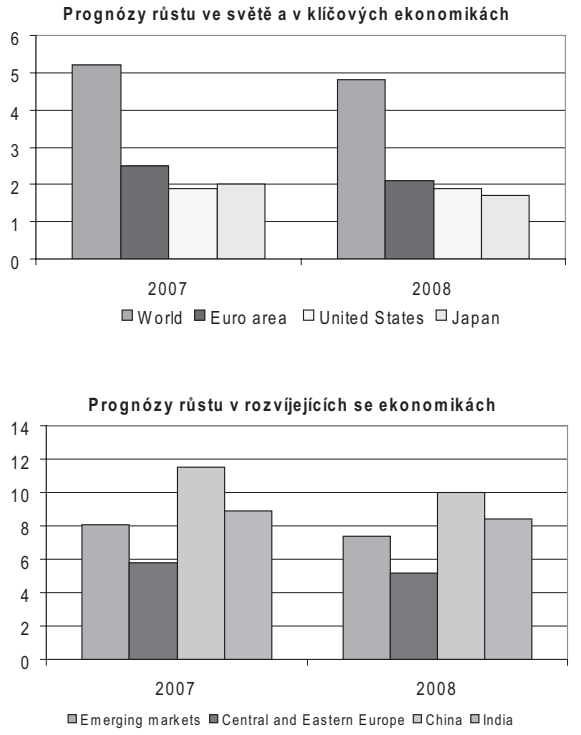
Současné problémy amerického trhu sub-prime hypoték a jeho překvapivě silný dopad na americké a evropské finanční instituce může být pouze začátkem série událostí. Finanční krize nicméně bývají zároveň příležitostí pro finanční trhy i regulační autority zlepšit na základě získaných zkušeností řízení rizik a eliminovat přístupy vedoucí k rozsáhlým finančním ztrátám. Rozvíjející se ekonomiky, na které by uprostřed krize v roce 1998 vsadil málokdo, představují v současnosti výrazně stabilizující prvek. Lze předpokládat, že současná lekce výrazně pozitivně změní přístup finančních institucí a jejich regulátorů k sekuritizaci, strukturovaným produktům a jejich oceňování. Významnou skutečností je to, že v současnosti zaváděný nový kapitálový akord Basel 2 reaguje právě na ty typy finančních inovací, které jsou v pozadí současných rizik. Jeho třetí pilíř požaduje informování o rizikovém profilu bank včetně úvěrové kvality mimobilančních položek. Špatnou zprávou je to, že cesta od lekce k ponaučenému chování trvá často dlouho a je nákladná.

Dobrou zprávou je, že růst světové ekonomiky v současnosti nezávisí jako v minulosti pouze na USA, Japonsku a západní Evropě, ale je podporován i rozvíjejícími se ekonomikami v Asii nebo bývalé SVE.

4 Finanční turbulence a reálná ekonomika

Finanční turbulence pravděpodobně ovlivní světový hospodářský růst. Celkový výhled je však stále velmi pozitivní, zejména díky příspěvku rozvíjejících se ekonomik. Nový IMF World Economic Outlook (October 2007) reagoval na finanční potíže snížením odhadu světového růstu pro rok 2008 o 0,4 p.b. oproti červencové verzi projekce, přičemž ve vyspělých zemích je pokles výraznější (o 0,6 p.b.). Americká ekonomika by v roce 2007 i v roce 2008 podle nové projekce měla vzrůst o 1,9 % (oproti červenci pokles o 0,9 p.b.). Růst eurozóny by měl z 2,5 % v roce 2007 klesnout na 2,1 % (oproti červenci pokles o 0,4 p.b.). Rovněž v komentářích dalších mezinárodních institucí (např. hodnocení ekonomické situace OECD z konce září) i analytiků se začíná prosazovat výhled zhoršeného výkonu americké ekonomiky v roce 2008 spojený se vznikem negativního output gapu a umírněný pohled na ekonomiku eurozóny v roce 2008, která by měla z vrcholku cyklu v roce 2007 klesat pozvolna.

Graf 4.4: Výhled světového hospodářského růstu



Pramen: IMF World Economic Outlook (October 2007)

Značná rizika může přinést vývoj v samotné americké ekonomice. Spotřeba zde klesne z několika důvodů, kterými jsou očekávaný pokles tempa růstu příjmů (odraz poklesu očekávaného trendového růstu HDP a vzniku negativní mezery výstupu), zhoršující se směnné relace, efekt bohatství spojený s poklesem cen nemovitostí, zvýšené reálné úrokové sazby (bez ohledu na způsob měření vzrostly za poslední rok reálné sazby oproti období 2002-2005 o minimálně 1 p.b.) a snížení dostupnosti úvěru kvůli změně úvěrových standardů i poklesu hodnoty dostupného kolaterálu (hlavně domů). Tyto faktory pravděpodobně začaly ovlivňovat ekonomiku až ve druhé polovině roku 2007 a maximální efekt lze očekávat až v roce 2008. Pokud by to podpořilo další výrazné oslabení dolaru, mohlo by to dále zvýšit rizika na finančních trzích.

Z hlediska naší ekonomiky je důležitá možnost, že Evropa (eurozóna) by mohla vystřídat USA ve funkci lokomotivy – tj. generovat ve prospěch zbytku světa rychlý hospodářský růst hnaný domácí poptávkou (zejména spotřebou, ale i investicemi). Tento názor je akceptován již od článku Obstfelda a Rogoffa (2004). Autoři v něm tvrdili, že značné reálné znehodnocení dolaru a přesun poptávky k americkému exportu na úkor exportu neamerických ekonomik by pro ně neměl být katastrofální. Globální přesun poptávky by totiž měl vést v neamerických ekonomikách nejen k poklesu čistého exportu, ale také k nárůstu domácí poptávky po nontradeables.

Tento scénář však čelí podle mě nemalým překážkám. Klíčovou z nich je vysoká zadluženost domácností a firem eurozóny, která může začít vytvářet významné rozpočtové omezení. V eurozóně vzrostla zadluženost korporací k úrovni 80 % HDP, zatímco na počátku dekády činila dvě třetiny HDP. Prudce vzrostl rovněž poměr dluhu korporací k jejich ziskům. Podobně se vyvíjela zadluženost domácností eurozóny, která nyní dosahuje 90 % disponibilního důchodu (60 % HDP), zatímco ve druhé polovině 90. let se pohybovala kolem jeho dvou třetin (mírně přes dvě pětiny HDP). Úrokové splátky domácností se v současnosti blíží 4,5 % disponibilního důchodu, což je při zohlednění nízkých úrokových sazeb jednoznačně vysoké číslo (v ČR např. tento ukazatel v roce 2007 stále nedosáhne ani 2 %). Dalším rizikem pro vyspělé západní ekonomiky jsou probíhající celosvětové změny relativních cen, které se mohou promítnout v poklesu ziskovosti řady průmyslových odvětví.

Rovněž Zpráva o finanční stabilitě 2006 publikovaná ČNB, která se zabývala vývojem českého finančního sektoru v roce 2006 a na počátku roku 2007, identifikovala určitá rizika spojená s trhem nemovitostí a jeho úvěrováním. Vývoj v dalších čtvrtletích roku 2007 existenci těchto rizik nevyvrátil. Prozatím by bylo předčasné hovořit o významných rizicích. Je obtížné odhadnout dopad očekávané změny sazby DPH a zejména jejich finální formy na poptávku po bydlení a úvěrech na jejich financování především ve smyslu jejich „frontloadingu" z budoucnosti do roku 2007. Z pohledu finanční stability lze najít ve schválené daňové reformě stabilizující prvek ve formě snížení podnětů pro domácnosti zadlužovat se – zejména reálný pokles odečtu úroků z úvěrů na bydlení z daňového základu. Bylo by žádoucí vést v ekonomické komunitě obecnou diskusi o daňových i dotačních podnětech státu pro financování bydlení, které mohou ve svém důsledku motivovat domácnosti k podceňování břemene budoucích dluhových splátek a nadměrnému zadlužování.

5 Místo závěru

Na závěr svého příspěvku bych rád zdůraznil, že vývoj v současné dekádě je velkou výzvou pro komunitu centrálních bank. Významnou otázkou je, zda je měnová politika stabilizující inflaci dostačující k udržení finanční stability. Ekonomové Banky pro mezinárodní platby (viz Borio a White, 2004 nebo White, 2006) např. již delší dobu vyjadřují názor, že poptávkové tlaky se mohou relativně dlouhou dobu akumulovat, aniž se tyto tlaky projeví ve skutečné inflaci nebo v růstu inflačních očekávání. Z tohoto důvodu doporučují měnovou politiku zaměřenou na cenovou stabilitu propojit s makroprudenční politikou orientovanou na finanční stabilitu. Taková politika se musí více zabývat sklonem finančního systému k nadměrné procykličnosti a jeho implikacemi pro ekonomickou dynamiku a makroekonomickou stabilitu. Významnou složkou makroprudenční politiky je přitom opět měnová politika, neboť je to koneckonců bankovní sektor, který vytváří likviditu a poskytuje rozhodující část externího financování. V tomto smyslu by měly být centrální banky připraveny zpřísnit politiku v situaci, kdy se začínají akumulovat finanční nerovnováhy a zároveň nejsou generovány inflační tlaky. Právě měnová politika orientovaná na prosazování simultánní cenové a finanční stability v delším horizontu spolu s dalšími prvky makroprudenční politiky by měla poskytnout vzájemně se podporující kotvy, které zajistí vyšší míru makroekonomické stability. Mezi centrálními bankéři a v ekonomické komunitě však ohledně této představy neexistuje shoda a diskuse na toto téma bude zřejmě důležitým prvkem v následujících letech.

Souhrn

Článek se zabývá finančními turbulencemi, které zasáhly mezinárodní finanční trhy v létě 2007, a hodnotí jejich rizika pro vývoj světové ekonomiky. Nejprve diskutuje zdroje těchto turbulencí, které nachází zejména v uvolněné měnové politice klíčových centrálních bank po celosvětové stabilizaci inflace ve druhé polovině 90. let. Tyto politiky přispěly k úvěrovému boomu, který se projevil v bublinách na trzích aktiv. Řada ekonomů si zranitelnost spojenou s tímto vývojem uvědomovala, nicméně je vždy velmi obtížné odhadnout způsob, jakým se zranitelnost působením šoků přenese do turbulencí a krizí. Současné finanční turbulence se pravděpodobně promítnou do změn regulačního rámce finančních trhů. Nyní zaváděný nový regulační rámec pro banky Basel II nicméně na řadu slabin, které jsou v pozadí aktuálních turbulencí, již reaguje. Významné výzvy stojí rovněž před centrálními bankéři, kteří by měli měnovou politiku zaměřenou na cenovou stabilitu více propojit s makroprudenční politikou orientovanou na finanční stabilitu.

Klíčová slova

měnová politika, finanční stabilita, úvěrový boom, likvidita, krize, sub-prime hypotéky

Abstract

The paper deals with the financial turbulences that hit the international financial markets in Summer 2007 and evaluates associated risks for the developments in the world economy. The sources of the turbulences are discussed first. They are found among other things in loose monetary policy that followed the world-wide stabilization of the inflation in the 2nd half of 1990s. These policies contributed to the credit boom that supported the build-up of bubbles in the asset markets. The economists were generally aware of the vulnerabilites. However, it is always rather difficult to estimate the way how the fragility

is transformed via shocks to turbulences or crises. Current financial turmoil will probably impact on the regulatory framework for financial markets. The new regulatory accord for banks labelled Basel II which is being implemented just now nevertheless adresses number of weaknesses staying behind the actual problems. The important challenges have also been created for the central bankers. They should align more strongly the monetary policy focusing on the price stability with the macroprudential policy oriented towards financial stability.

Keywords
monetary policy, financial stability, credit boom, liquidity, crisis, sub-prime mortgates

Kontaktní adresa / Contact address
prof. Dr. Ing. Jan Frait
Česká národní banka; Ekonomická fakulta VŠB-TU v Ostravě.
(e-mail: jan.frait@cnb.cz)

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1st Place – Profesor František Vencovský Award
1. místo – Cena profesora Františka Vencovského

Three Indirect Effects of Foreign Direct Investment: Evidence from the Czech Republic
Tři nepřímé efekty přímých zahraničních investic: evidence z České republiky

ADAM GERŠL*

1 Introduction

The Czech Republic, similarly to other Central and Eastern European (CEE) countries, has attracted foreign direct investment (FDI) successfully during 1990s, mainly thanks to privatization, the lack of domestic capital needed for economic transition and EU accession prospects. Later, mainly after 2000, other determinants of FDI, such as wage cost factors, the size and location of the market and FDI policies have gained in importance. Within the economic globalization process, a number of important foreign and multinational firms have selected the Czech Republic as a country to which to relocate the production, logistics and in some cases also some parts of research and development.

Cross-border capital flows in today's globalized world create a number of important challenges for both academic economists as well as policymakers. In general, FDI can bring substantial benefits to the host economy (Jones and Colin, 2006). Looking at the firms level, a foreign-owned company, usually being part of a multinational enterprise, is larger, more capital intensive, has more skilled labour, higher technological knowledge and a greater productivity level compared to domestic companies. In addition, foreign firms have usually better access to financing, either from the parent company or from the banks given their superior performance. Finally, firms that were established within the relocation process in order to supply to parent companies abroad increase export performance of the host country. Thus, attracting FDI brings benefits for the host economy in terms of higher investment, employment and output of these firms, with resulting effect on the overall GDP growth. These effects have been labeled direct effects of FDI.

However, FDI can also have some indirect effects on the host economy, namely on local (i.e. domestically-owned) companies. These indirect effects, in the literature labeled "spillovers",

* *Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague and Czech National Bank, Economic Research Department. Contact: adam.gersl@cnb.cz.* *The author would like to thank Ieva Rubene and Tina Zumer for helpful comments and the help with data. The findings, interpretations and conclusions expressed in this paper are entirely those of the author and do not represent the views of any of the above-mentioned institutions.*

emerge due to interactions of foreign and local (i.e. domestic) firms both within an industry as well as across industries, along the production chain. Available evidence and academic literature focuses mainly on productivity spillovers (Blomstrom and Kokko 1998). Productivity spillovers refer to transfer of technology in a broader sense, including organizational and managerial practices and know-how, from foreign firms to domestic firms. Nevertheless, there are additional at least two important spillovers from foreign to domestic firms: the so-called market access spillover and the "financing" spillover.[1] Market access spillover can be found if increased foreign presence in the corporate sector leads to an increase of export performance of domestic firms. Under financing spillover we understand a situation where entry of foreign firms facilitates the access of local firms to external financing.

Foreign direct investment can also introduce some risks into the economy. Companies established within the relocation of production process strengthen the export orientation of the economy and thus increases the dependence of the domestic development on the external environment, which may lead to higher volatility in the economy's performance (Bergin et al., 2006). In addition, transfers of profit from foreign-owned corporations may put pressure on current account and exchange rate of the host economy (Geršl 2007). Moreover, existing empirical literature on productivity spillovers often finds negative effects, suggesting that inflow of FDI can have also detrimental impact on performance of local firms. As regards the impact on financial sector, subsidiaries of foreign firms may rely more on intra-group finance than on financing from local banks, effectively slowing down the development of local financial sector and the depth of domestic financial intermediation (Geršl and Hlaváček 2007).

In this paper, we analyze the three indirect effects (spillovers) of FDI mentioned above, i.e. productivity, market access and financing spillover, using firm-level data on manufacturing industries of the Czech Republic. The motivation to look more in detail into spillovers from FDI helps us understand the results of interaction between foreign and domestic companies, and thus possible consequences of huge inflow of FDI that the CEE countries have been experiencing so far.

In comparison to existing studies on spillovers in the CEE countries (Jarolím 2000; Kinoshita 2001; Javorcik and Spatareanu 2003; Damijan et al. 2003; Javorcik 2004; Merlevede and Schoors 2005, 2006), this paper offers value added in two main areas: first, it analyzes the most recent data, over the period 2000-2005, while most of the available literature focused on the late 1990s. Second, it does not analyze only productivity spillovers as the mentioned studies, but focuses also on the other two spillovers, the market access and the financing spillover. While the former has been already partly researched and discussed in the literature (Aitken et al. 1997), we are not aware of any study focusing on the latter. Thus, this study provides the first attempt to analyze empirically the effect of FDI on financial structure of local companies.

The paper is structured as follows: Section 2 provides an overview of the FDI inflows and FDI inward positions in the Czech Republic in comparison with selected countries of the region. Section 3 reviews the channels through which the three spillovers can work. Secti-

1 *There might be some other "indirect" effects as well: Ayygari and Kosova (2006), for example, look at whether inflows of FDI facilitate domestic entrepreneurship.*

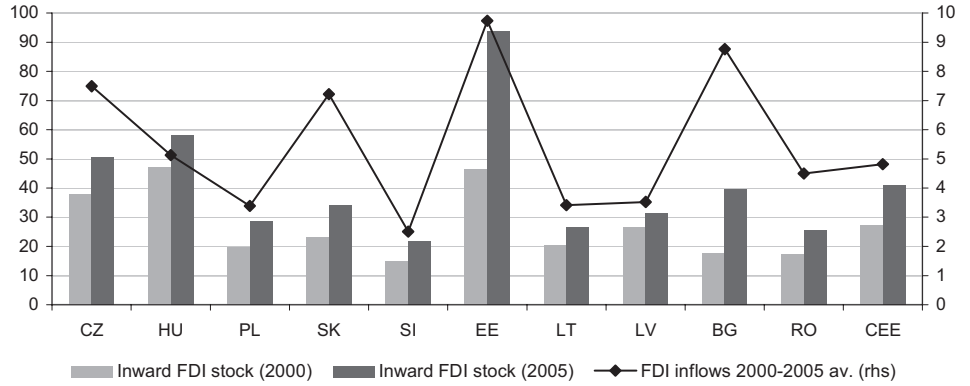
on 4 presents the firm-level data used for the analysis and analyzes the foreign presence in the manufacturing sector. Section 5 reveals the estimation strategy and describes the construction of variables of foreign presence used in the subsequent estimations. Section 6 attempts at estimating the productivity spillovers, using the Levinsohn and Petrin (2003) methodology. Section 7 estimates the extent of market access spillover, taking into account the data limitation. Section 8 focuses on analysis of financing spillover, looking at the effect of foreign presence on the degree of external financing and the level of financing costs of domestic companies. Section 9 concludes.

2 FDI inflows: international comparison and industrial structure

Existing literature identifies two main motives for FDI: market seeking motive and efficiency seeking motive. Market seeking motive means that foreign firms establish their subsidiaries in the host country in order to be closer to potential customers and take advantage of rapidly growing markets. On the other hand, efficiency seeking motive means that foreign companies look for those territories to establish their production units in order to economise on costs. The CEE countries have attracted both types of investments, given the rapid growth of their internal markets as well as wage and other costs advantages relative to developed Europe.

The Czech Republic has been one of the most important target countries to attract foreign direct investment. The stock of FDI as a percentage of GDP increased from around 35% in 2000 to 50% in 2005, a third highest figure in relative terms among CEE countries (after Estonia and Hungary). The inflow of FDI has been on average 7.5% of GDP annually over the period 2000-2005 (Chart 2.1).

Chart 2.1: Inflow of FDI and inward FDI stock in CEE countries (in % of GDP)



Source: WIIW, Geršl et. al (2007)

As Geršl et al. (2007) describe, the majority of FDI to CEE countries went into services. This holds also for the Czech Republic. Table 2.1 shows that the industrial structure of the stock of FDI in the Czech Republic corresponds to the structure of total FDI in the CEE countries.

Financial intermediation, trade, real estate and business services and transport and communication account for around 50% of the total FDI inward stock in the Czech Republic, similarly as in total CEE. Inflow of FDI into the services sector was usually motivated by market seeking and supplying cost optimisations, but outsourcing and FDI in export oriented services seem to have become an important factor as well. Most of the FDI in services can be related to past privatisations in the banking sector or telecommunications.

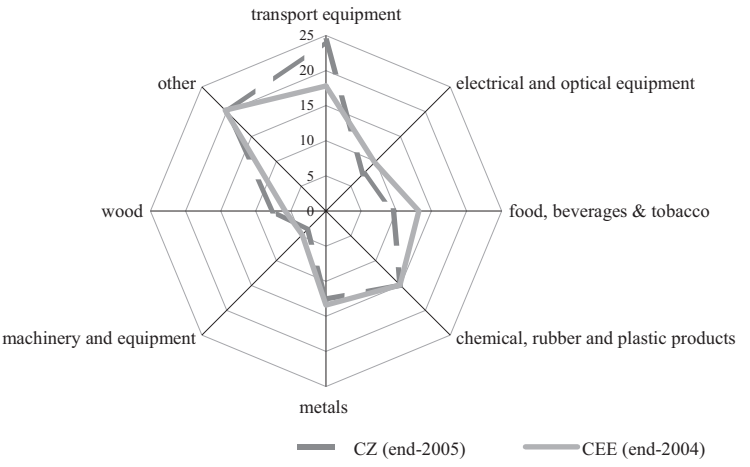
Table 2.1: Industrial structure of the stock of inward FDI
(in % of total inward stock of FDI; Czech Republic as of end-2005, CEE total as of end-2004)

	Czech Republic	CEE total
manufacturing	38.1	40.0
financial intermediation	18.8	16.1
wholesale, retail trade	9.8	14.3
real estate and business activities	12.3	12.1
transport, communication	12.1	7.9
electricity, gas and water supply	5.7	4.9
other	3.2	4.7

Source: WIIW, CNB, Geršl et. al. (2007)

Manufacturing accounts for around 40% of total FDI inward stock both in the Czech Republic and in the CEE total. Inflow of FDI into this sector has been mainly motivated by low input costs and production cost economisation. It is also a sector where the most green-field investments were made. However, some FDI in manufacturing has also been driven by privatization and the market-servicing motive.

Chart 2.2: FDI in manufacturing by sub-industries (in % of total FDI in manufacturing)



Source: WIIW, CNB, Geršl et. al. (2007)

The structure of existing FDI in manufacturing sector in the Czech Republic corresponds to a large extent to the structure across the whole CEE region, the only exception being a relatively important position of motor vehicles and other transport equipments. This is a result of the past privatizations, but also several new, green-field investments in this sub-sector including a number of foreign sub-suppliers to the automotive industry.

3 Channels of indirect effects of FDI on domestic firms

Available literature on spillovers differentiates between horizontal and vertical spillovers (Javorcik 2004; Merlevede and Schoors 2005). If local firms benefit from the presence of foreign companies in their sector, we refer to horizontal spillovers, while if local firms benefit from interaction with foreign firms upstream or downstream in the production chain, we refer to vertical spillovers. In this sense, backward spillovers denote spillovers from the foreign firm to its local sub-supplier (upstream – or backward - in the production chain), while forward spillovers refer to the spillovers from foreign firms to their local customers (downstream – or forward - in the production chain).

Majority of literature on spillovers deals with productivity spillovers (Schoors and van der Tol 2002; Javorcik and Spatareanu 2003; Damijan et al. 2003; Javorcik 2004; Merlevede and Schoors 2005, 2006; Geršl et al. 2007). In this stream of literature, three main channels for horizontal spillovers are identified: demonstration channel, labour market channel and competition channel (Kokko 1992).

Within the demonstration channel, local firms may try to imitate foreign firm's technology. Of course, informed foreign companies will try to prevent technology leakage to the local competitors, so that the potential for the spillover running via this channel may be limited. Another strategy of foreign firms to prevent imitation by local competitors is not to bring their state-of-the-art technologies, but those technologies that are only slightly more advanced than those of the local firms (Glass and Saggi 1998). This would also adversely affect the potential for horizontal spillovers. The labour market channel works via labour turnover from foreign firms' trained workers to local firms (Fosfuri et al. 2001). However, foreign presence can have also detrimental effect on the local firms through this channel, as it can brain drain local talents from the local firms to the foreign affiliates (Balock and Gertler 2004). Within the competition channel, entry of foreign firms increases competition in the host economy and forces local firms to use existing resources more efficiently and to adopt better technologies (Blomstrom and Kokko 1998). On the other hand, if the competition induced by the entry of foreign firms is too high, less productive local firms may be driven out of the market (market stealing effect, see Aitken and Harrison 1999).

Empirical evidence suggests that more potential for spillovers exists in interaction of local and foreign firms within the production chain (vertical spillovers). Backward vertical spillovers emerge when foreign firms intentionally assist local sub-suppliers to deliver high-quality inputs and share with them superior technology. The intentionality of transferring the knowledge and technology is a feature that makes vertical spillovers qualitatively different and in effect probably more powerful. As Geršl et al. (2007) argue, there are two conditions under which the incentive to help local sub-suppliers exists: first, the transportation costs between the home and the host country must be rather high so that the

foreign firm does not have incentive to source its inputs in its home country. Second, the foreign firm must refrain to induce sub-suppliers from its home country to invest in the host country as well, as this would create an isolated enclave of mutually linked foreign firms with limited interaction with the local firms and thus limited potential for spillovers. Being a sub-supplier to a foreign firm provides the local firm with a stable demand for inputs and allows the local firm to invest into appropriate physical capital, build up a stock of experienced workers and accumulate necessary experience, all prerequisites for increased productivity via usage of advanced technology (Merlevede and Schoors 2005). However, if local sub-suppliers are not able to maintain the quality standards for the inputs as required by the foreign customer, backward vertical spillovers may also be negative, as the foreign firm may turn back to its home country sub-suppliers.

Forward vertical spillovers appear when higher quality inputs produced by foreign firms are used in the production chain by the local firms. In principle, forward vertical spillover may be also negative. For example, if the inputs produced by foreign companies are more expensive and not adapted to the local conditions, in which case they are used only by more productive foreign enterprises that are better equipped to handle the high-quality inputs. This would increase the productivity difference between local and foreign companies.

Given the possible ambivalent net effect of horizontal and vertical productivity spillovers, some studies assume that the spillovers may be non-linear, meaning that the net effect on domestic companies' productivity changes with the degree of foreign presence (Damijan et al. 2003; Merlevede and Schoors 2005, 2006; Geršl et al. 2007). For example, relatively moderate presence of foreign companies may induce positive horizontal spillovers via demonstration channel, but further substantial increase of foreign presence may trigger brain drain and lead to market stealing effect, driving local companies out of the market, meaning negative horizontal spillovers. In other words, foreign presence contributes to an increase in domestic productivity, but if foreign presence increases beyond some threshold, its impact on local productivity turns negative. Recent literature focuses as well on conditions or characteristics that make domestic companies sensitive to spillovers, so-called conditional spillovers (Schoors and van der Tol 2002; Javorcik and Spatareanu 2003; Javorcik 2004; Merlevede and Schoors 2005, 2006). Main characteristics of a firm or industry that affect the conditional spillovers are absorptive capacity of a firm, export orientation, import competition, sectoral competition, firm size and the level and origin of foreign ownership.

Market access spillovers stands for a possibility for local firms to access new markets via marketing and business networks of foreign companies with which local firms interact. As Aitken at al. (1997) put it, "multinational corporations are a natural conduit for information about foreign markets, foreign consumers, and foreign technology, and they provide channels through which domestic firms can distribute their goods. To the extent that multinationals directly or indirectly provide information and distribution services, their activities enhance the export prospects of local firms". In this regards, two channels of market access spillovers might be identified: first, similarly to productivity spillovers, via labour market channel experienced workers from foreign firms may be attracted by local firms, bringing their knowledge and valuable contacts about the foreign distribu-

tion networks. This would hold mainly for horizontal spillovers, but available evidence suggests that labour turnover, especially in sale departments and distribution, occurs to a large extent also vertically. Second - and this holds primarily for backward market access spillovers - foreign companies may again intentionally assist domestic sub-suppliers, opening their home markets for the sub-supplies. Typical sequencing of such spillover is for a foreign company to start with supplies of inputs from a local firm, and after the quality is on a certain level, the foreign company invites the local firm to supply inputs also to the home production facilities or other subsidiaries in other countries.

Clearly, market access spillover may go hand in hand with productivity spillover and reinforce each other, as the chance to compete in the foreign markets puts pressure on the local firms to increase productivity. Moreover, export-oriented firms are used to higher competition on foreign markets and are usually more productive than firms serving only local markets. Thus, they may be better prepared to adapt advanced technologies (productivity spillover).

In contrast, financing spillover differs slightly from the two previous spillovers, as here it is not the foreign firm that transfers "finance" to local firms. However, local firms' interaction with foreign firms may influence the way local companies are financed. First, increased competition in the sector due to entry of foreign firms may put pressure on profitability and performance of local firms (brain-drain effect, competition effect), which would be immediately seen by creditors (banks), leading to either lower willingness to offer external financing or to more expensive financing (interest rate margin). Thus, we should observe negative horizontal spillovers in financing. Second, interaction between local and foreign firms along production chain, mainly via local firms serving as sub-suppliers, creates a need for local firms to invest into new and advanced technologies. However, new investments must be financed, and the fact that a foreign company provides the local firm with stable a large demand for inputs may help the local company to obtain credit from banks more easily or at least at a lower interest rate margin. Foreign company thus transfers a part of its "creditworthiness" onto the local sub-supplier, effectively providing an implicit guarantee to repay the debt if the investment has been relatively specific.[2]

On this issue, there is no theoretical of empirical literature. The impact if FDI inflows on financing of foreign-owned firms is analyzed in Geršl and Hlaváček (2007), who focus on the role of intra-group credit in financing subsidiaries across border. They also focus on general impact of FDI on the credit supply from local banks, arguing that the increased incentive of foreign-owned companies to use intra-group credit could lead local banks to turn to domestic firms often serving as sub-suppliers to foreign firms and thus to increase financing of local companies. Thus, on a more macro-level, they actually argue that there might be an indirect positive effect (spillover) from FDI on financing of local companies.

2 *Anecdotal evidence suggests that a very special relationship emerges between a foreign firm and its local sub-supplier if the local firm is investing into very special assets. Both parties have then interests to keep the business alive even if the local company gets into repayment problems. There have been cases where foreign client has in the end bought out the local sub-supplier in order to safeguard the regularity of needed inputs.*

4 Firm-level data on manufacturing in the Czech Republic

For the analysis of spillovers, we used the database Amadeus provided by Bureau van Dijk (September 2006 release). This database provides firm-level data on European corporate sector and we have extracted the data on Czech firms. The data on companies' balance sheet items, profit and loss account and ownership constitute an unbalanced panel over the period 2000-2005.[3] We focus on manufacturing companies (NACE Rev. 1.1 2-digit industries 15 – 36) with minimum of 10 employees and fixed assets and turnover of at least 10 thousand USD.

Table 4.2 shows the coverage of firms in Amadeus database in comparison to aggregate data on Czech manufacturing sector from WIIW (Vienna Institute for International Studies). The table shows that the Czech sample from Amadeus is a representative sample, as the total turnover from Amadeus reaches 100% of the total manufacturing production from WIIW and almost 90% of employment.[4] At the same time, the industry structure is relatively similar.

Table 4.2: Sample properties

Number of firms	5011	
o.w. foreign firms	618	
Turnover (Amadeus) in % of manufacturing production (WIIW)	104.2%	
Employees (Amadeus) in % of total employment (WIIW)	86.0%	
distribution of manufacturing turnover by NACE sectors in 2004 (in %; Amadeus versus WIIW)		
	Am	WIIW
DA Food products; beverages and tobacco	14.4	11.5
DB Textiles and textile products	2.5	2.8
DC Leather and leather products	0.1	0.2
DD Wood and wood products	1.5	1.9
DE Pulp, paper & paper products; publishing & printing	4.5	4.1
DF Coke, refined petroleum products & nuclear fuel	4.3	2.8
DG Chemicals, chemical products and man-made fibres	6.4	5.9
DH Rubber and plastic products	6.7	6.2
DI Other non-metallic mineral products	5.4	5.3
DJ Basic metals and fabricated metal products	10.9	15.3
DK Machinery and equipment n.e.c.	7.7	7.8
DL Electrical and optical equipment	15.8	15.1
DM Transport equipment	17.2	17.7
DN Manufacturing n.e.c.	2.6	3.4
Average absolute difference	0.9	

Source: WIIW industrial database, Amadeus.

3 *Unfortunately, a given release of the Amadeus database does not include history of ownership information, thus the most recent information about the ownership status is used (i.e. as of September 2006) and assumed to be valid over the whole period of analysis.*

4 *Figures higher than 100% are possible as the industrial manufacturing production in WIIW database includes only sales of goods classified as manufacturing, while the turnover data for firms in Amadeus represent total turnover, including also revenues from sales of non-manufacturing products and services.*

In the analysis, foreign companies are defined as companies with the global ultimate owner from a country outside the host country, or with immediate shareholders of the company from countries outside the host country which have a share of at least 51% of company's capital. This definition differs from traditional definition of FDI (10% of shareholder funds), but is in line with literature on spillovers. Moreover, empirical evidence shows that important foreign companies that could have some effect on local companies are in most emerging markets majority-owned (Geršl and Hlaváček 2007).

Foreign companies account for about 12 % of all firms, but their relevance in terms of total assets, turnover, investment and employment is much higher (Table 4.3). They account for around 40% of total manufacturing assets, turnover and investments and for around 25% of total manufacturing employment. This suggests that foreign companies are on average bigger, have higher stock of investments, more employees and higher turnover. The firm-level data from Amadeus also show that foreign companies are more productive (as measured by labour productivity) and more profitable. However, the gap in productivity and profitability between foreign and local companies is not that large.[5]

Table 4.3: Relevance of foreign firms in the Czech manufacturing sector (as of 2004)

% of foreign firms in no of firms	12.3%
% of foreign firms in total assets	38.9%
% of foreign firms in turnover	37.1%
% of foreign firms in stock of investment	41.3%
% of foreign firms in employment	23.4%

average total assets (in mil CZK)	foreign firms	887
	local firms	195
average stock of investment (in mil CZK)	foreign firms	463
	local firms	92
average employment (No of employees)	foreign firms	335
	local firms	155
average turnover (in mil CZK)	foreign firms	1348
	local firms	321
average RoE (return on equity, in %)	foreign firms	23.9
	local firms	19.4
average labour productivity (ln real value added on employee)	foreign firms	7.0
	local firms	6.6

Source: Amadeus

Given that we focus also on market access spillover and financing spillover, it might be interesting to look at the export performance and financial structure of the Czech corporate sector. Table 4.4 shows that out of total exports of manufacturing sector into EU25 countries, products from the sectors electrical and optical equipment as well as transport equipment are the most important export articles of the Czech Republic. This corresponds to the industry structure of inward FDI, suggesting that indeed a large part of inward FDI has been due to relocation of production and subsequent export of the output into

5 *Geršl et al. (2007) show that the relevance of foreign firms differs across CEE countries and that in some countries the gap in profitability is much bigger.*

foreign markets. However, exports represent also a large share of total output of other industries such as textiles and leather, machinery or chemicals.

Table 4.4: Distribution of exports to EU25 (as of 2004)

	in % of total exports to EU25	in % of sectoral output
DA Food products; beverages and tobacco	3.1	14.7
DB Textiles and textile products	5.3	103.4
DC Leather and leather products	0.5	125.3
DD Wood and wood products	1.5	42.6
DE Pulp, paper & paper products; publishing & printing	3.2	41.9
DF Coke, refined petroleum products & nuclear fuel	1.1	22.1
DG Chemicals, chemical products and man-made fibres	5.8	52.3
DH Rubber and plastic products	5.3	45.7
DI Other non-metallic mineral products	3.1	31.6
DJ Basic metals and fabricated metal products	13.6	47.3
DK Machinery and equipment n.e.c.	12.7	86.5
DL Electrical and optical equipment	21.4	75.8
DM Transport equipment	19.6	59.1
DN Manufacturing n.e.c.	3.7	58.4
Manufacturing total	100.0	53.5

Source: WIIW, Amadeus

Not all the exports of industries with high foreign relevance might be because of foreign firms if there are market access spillovers and local firms also increased their exports. Unfortunately, the Amadeus database does not include the data on export performance of individual companies in the Czech Republic. Thus, for estimation of market access spillovers we will have to find a proxy for export performance of local companies (see section 7).

Table 4.5 presents the financial structure of foreign versus local firms. Domestic companies are more indebted than foreign companies, which might reflect the initial capital provided to foreign subsidiaries by their parent companies. Nevertheless, foreign companies have on average more long-term debt in their liabilities, while domestic firms rely more on short-term debt (short-term loans and creditors).

Table 4.5: Financial structure of manufacturing firms (as of 2004)

	foreign companies	domestic companies
Capital (shareholder funds)	42.8%	40.4%
Debt	57.2%	59.6%
Long-term debt	9.4%	8.0%
Short-term loans	5.3%	5.9%
Creditors	15.7%	16.7%
Other liabilities	26.9%	29.0%

Source: Amadeus

5 Estimation strategy

The main objective of this study is to find out whether domestic companies benefit from foreign presence in the same sector (horizontal spillovers) and in the upstream or downstream sectors (vertical spillovers). Within the vertical spillovers, more emphasis is put on backward spillovers, as the channel of sub-supplier linkages might be more relevant given both the anecdotic evidence as well as some partial studies from automotive industry. Thus, we estimate the impact of appropriately defined "foreign presence" variables on several performance indicators of domestic firms, taking into account other factors of influence using a number of control variables.

As regards the performance variables, we have selected following dependent variables following the above discussion about three possible spillovers, i.e. productivity, export performance and financing. For productivity estimation we use as dependent variable the total factor productivity, for export performance we use exports to EU-25 countries, and finally for financing we use the ratio of debt to total assets as well as the interest rate paid by domestic corporations (detailed definitions are given in the respective Sections 6-8).

Unfortunately, available data do not include information about interaction between local and foreign companies. However, there is a way how to capture at least a "potential" or "probability" that there will be some interaction that would have effects on local firms. Foreign presence in the same sector is captured by the variable $horizontal_{jt}$ and it is defined as the share of foreign firms' output in total industry output:

$$horizontal_{jt} = \frac{\sum_{i \in j} foreign_{it}\, x\ \ turnover_{it}}{\sum_{i \in j} turnover_{it}} \qquad (1)$$

The variable *foreign* is a dummy variable that equals 1 if the company *i* is a foreign company, and 0 otherwise. The higher the value of output produced by foreign firms and the higher the number of foreign firms in the sector *j*, the higher is the variable *horizontal* and thus the potential for horizontal spillovers. Indeed, if a local firm produces in an environment where there are many other foreign firms in the same industry, some interaction is inevitable and the local firm will have to adapt (i.e. for example it will raise its productivity in order to withstand possible competitive pressure etc.).

As discussed, one of the most promising interactions that can lead to positive spillovers to local firms is via sub-supplier linkages. Ideally, one would need the share of local firm's output sold to foreign firms. As this information is not available, we follow the current practice in the literature on spillovers and use input-output tables to trace inter-industry supply linkages. Thus, we proxy the share of firm's output sold to foreign companies by the share of sector's output for intermediate consumption within the domestic economy sold to foreign companies in downstream sectors. The input-output tables reveal the information about the amount supplied by the sector *j* to its sourcing sector *k*. In addition, we

employ the information about the foreign presence in sector *k* (the variable *horizontal*). Thus, we define a variable $backward_{jt}$ as

$$backward_{jt} = \sum_{k\ if\ k \neq j} \gamma_{jkt} horizontal_{kt} \tag{2}$$

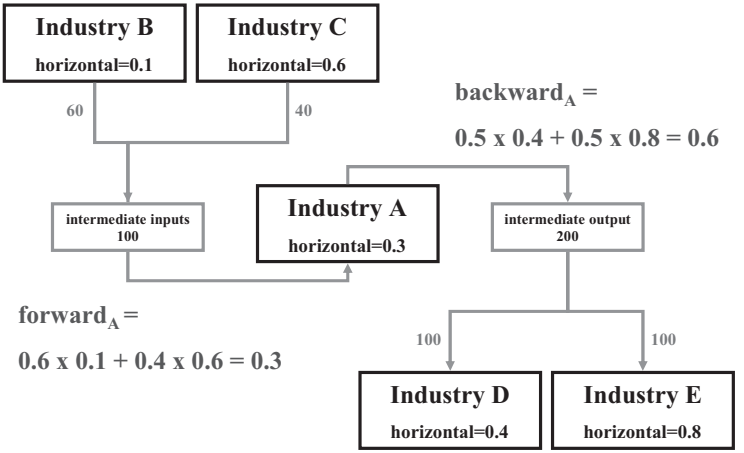
where γ_{jkt} is the proportion of sector *j*'s output supplied to sourcing sectors *k* and is calculated using the input-output table for domestic intermediate consumption (i.e. excluding imports).[6] In addition, intra-industry supplies are not accounted for, as this effect is captured by the variable *horizontal*. This proxy thus shows the "potential" or "probability" that a local firm will interact with (supply its inputs to) a foreign firm in the downstream sector.

Similarly, we define a variable $forward_{jt}$ that captures the potential for forward vertical spillovers to local firms that buy inputs from foreign firms. This proxy is defined as

$$forward_{jt} = \sum_{l\ if\ l \neq j} \delta_{jlt} horizontal_{lt} \tag{3}$$

where δ_{jlt} is the proportion of sector *j*'s inputs purchased from upstream sectors *l*. Nor in this case is it accounted for intra-industry supplies, as this effect is captured by the variable *horizontal*. Note that for both cases, the weights γ_{jkt} and δ_{jlt} are calculated using the proportion in total output for intermediate consumption (or total input used), not only the output (input) supplied to (bought from) the manufacturing sectors (thus, the sum of γ_{jkt} or δ_{jlt}, respectively, is not equal to 1). Chart 3 shows an illustrative example of how both proxies for vertical variables are computed.

Chart 3: Quantifying relevance of foreign firms in vertically-linked industries (example)



6 *Ideally, one should use a series of I-O tables to capture the dynamics of inter-industry trade. Due to data limitation, we employ the last available I-O table for domestic intermediate consumption for the Czech Republic, namely for the year 2003. As this year is actually in the middle of the time span of our firms' panel, it can be considered as a relatively representative picture of the inter-industry trade.*

In the following sections, we relate the performance indicator of a local firm *i* in the NACE 2-digit sector *j* and in the period *t* to the above constructed foreign presence variables (horizontal, backward and forward) and other control variables (determined separately for estimations of productivity, market access and financing spillover), estimating an unbalanced panel of local firms.[7]

$$performance\_\text{var}iable_{ijt} = \alpha_0 + \alpha_1 horizontal_{jt} + \alpha_2 horizontal^2_{jt} + \alpha_3 backward_{jt} + \\ + \alpha_4 backward^2_{jt} + \alpha_5 forward_{jt} + \alpha_6 forward^2_{jt} + control\_\text{var}iables_{ijt} + \varepsilon_{ijt} \quad (4)$$

6 Estimating productivity spillovers

Typical approach to an analysis of productivity is to estimate a production function and use the residuals not explained by the input factors (capital, labour) as a proxy for total factor productivity (Solow residuals). However, as Levinsohn and Petrin (2003) point out, when estimating the production function, one must account for the correlation between input levels and productivity. The reason is that profit-maximizing firms respond to increase in productivity by increased volume of factor inputs. Thus, methods that ignore this endogeneity (such as OLS or the fixed-effects estimator) inevitably lead to inconsistent estimates of the parameters of the production function.

In line with recent literature, we employ a semi-parametric approach suggested by Olley and Pakes (1996) and modified by Levinsohn and Petrin (2003). This method allows for firm-specific productivity differences that exhibit idiosyncratic changes over time. The technique is described in detail in the Box. Using this technique, we estimate a log-linear transformation of a Cobb-Dougals production function:

$$va_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it} \quad (5)$$

where va_{it} is log of value added of a firm *i*, l_{it} is log of labour input, k_{it} is log of capital. In order to be able to compare the resulting productivity across industries, the estimation is done using all domestic firms across individual 2-digit NACE industries.[8] Value added enters the equation as real value added, computed as real turnover minus real material costs. The data on operating turnover were deflated by the producer price index for the corresponding 2-digit NACE sector, while material costs were deflated by unweighted average of total manufacturing producer price index and import price index. Labour input refers to number of employees. For capital input, the stock of fixed assets was used, deflated by the average of the deflators for the following NACE sectors: machinery and equipment

7 *Most studies on spillovers use fixed effects estimator, both due to economic reasoning (heterogeneity among firms) and econometric assumptions (possible correlation between regressors and firm effects). A notable exception is Jarolím (2000) who uses random effects model. The appropriateness of using fixed-effects model has been tested for individual regressions via Hausman test.*

8 *Other studies such as Arnold et al. (2006) or Geršl et al. (2007) estimate the total factor productivity separately for individual industries, or group of similar industries. However, in such a setting the comparison across industries should be ideally made in terms of changes over time.*

(29), office machinery and computing (30), electrical machinery and apparatus (31), motor vehicles, trailers and semi-trailers (34) and other transport equipment (35).[9]

A measure of log of total factor productivity tfp_{it} - a performance variable that is subsequently used in the estimation of spillovers - is obtained as the difference between log of value added and log of capital and log of labour, multiplied by their estimated coefficients:

$$tfp_{it} = va_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it\,t} \qquad (6)$$

Box: The Levinsohn and Petrin (2003) estimator of productivity

The Levinsohn and Petrin (2003) technique assumes a Cobb-Douglas production technology:[10]

$$v_t = \beta_0 + \beta_l l_t + \beta_k k_t + \omega_t + \eta_t$$

where v_t is log of value added, l_t is log of freely variable labour input, k_t is log of the state variable capital. The error has two components, the transmitted productivity component ω_t and an error term η_t that is uncorrelated with input choice. The key difference between ω_t and η_t is that the former is a state variable and thus impacts the firm's choice of inputs. As ω_t is not observed by the econometrician but is known to the firm, it leads to the simultaneity problem in production function estimation and yields inconsistent results.

Olley and Pakes (1996) developed an estimator that uses investment as a proxy for this unobservable shock. However, Levinsohn and Petrin (2003) argue that investment is very lumpy and thus the investment proxy may not smoothly respond to productivity shocks under substantial adjustment costs. Instead of investment, Levinsohn and Petrin (2003) suggested that intermediate inputs can better serve as a proxy for productivity shocks, as they are not typically state variables and are easily available from computation of value added (while investment is often truncated to zero in many datasets and thus not available).

Levinsohn and Petrin (2003) assume that the demand for the (log of) intermediate input, materials m_t, depends on the firm's state variables k_t and ω_t:

$$m_t = m_t(k_t, \omega_t)$$

Making mild assumptions about the firm's production technology (Levinsohn and Petrin 2003, Appendix A), the demand function is monotonically increasing in ω_t. This allows inversion of the intermediate demand function, so ω_t can be written as a function of k_t and m_t:

$$\omega_t = \omega_t(k_t, m_t)$$

The unobservable productivity term is now expressed solely as a function of two observed inputs. Final identification restriction assumes that productivity follows a first-order

9 This approach follows Javorcik (2004). Alternatively, the capital could be deflated using the GDP deflator, see Damijan et al. (2003), or even capital stock deflator if available, see Arnold et al. (2006).

10 This part draws heavily from Levinsohn et al. (2003) and Geršl et al. (2007).

Markov process:

$$\omega_t = E[\omega_t \mid \omega_{t?1}] + \xi_t$$

where ξ_t is an innovation to productivity that is uncorrelated with k_t. Thus, the production function can be rewritten as)

$$v_t = \beta_l l_t + \varphi_t(k_t, m_t) + \eta_t$$

where

$$\varphi_t(k_t, m_t) = \beta_0 + \beta_k k_t + \omega_t(k_t, m_t)$$

By substituting a third-order polynomial approximation in k_t and m_t in place of $\varphi_t(k_t, m_t)$, it is possible to consistently estimate parameters of the production function using OLS as

$$v_t = \delta_0 + \beta_l l_t + \sum_{i=0}^{3}\sum_{j=0}^{3-i} \delta_{ij} k_t^i m_t^j + \eta_t$$

where β_0 is separately identified from the intercept of $\varphi_t(k_t, m_t)$. Out of this first stage of the estimation, an estimate of β_l and an estimate of $\hat{\varphi}_t$ (up to the intercept) are available. The second stage of the estimation begins by computing the estimated value for $\hat{\varphi}_t$ using

$$\hat{\varphi}_t = \hat{v}_t - \hat{\beta}_l l_t = \hat{\delta}_0 + \sum_{i=0}^{3}\sum_{j=0}^{3-i} \hat{\delta}_{ij} k_t^i m_t^j - \hat{\beta}_l l$$

For any candidate value β^*_k, one can compute (up to a scalar constant) a prediction for ω_t for all periods *t* using

$$\hat{\omega}_t = \hat{\varphi}_t - \beta_k^* k_t$$

Using these values, a consistent (non-parametric) approximation to $E[\omega_t \mid \omega_{t-1}]$ is given by the predicted values from the regression

$$\hat{\omega}_t = \gamma_0 + \gamma_1 \omega_{t-1} + \gamma_2 \omega_{t-1}^2 + \gamma_3 \omega_{t-1}^3 + \varepsilon_t$$

which will be called $\hat{E}[\omega_t \mid \omega_{t-1}]$. Given $\hat{\beta}_l$, β_k^*, and $\hat{E}[\omega_t \mid \omega_{t-1}]$, the estimate $\hat{\beta}_k$ is defined as the solution to minimization of squared sample residuals of the production function

$$\min_{\beta_k^*} \sum_t (v_t - \hat{\beta}_l l_t - \beta_k^* k_t - \hat{E}[\omega_t \mid \omega_{t-1}])^2$$

Standard errors are estimated via bootstrap procedure, but may be also derived analytically.[11]

We estimate the equation (4) via fixed-effects estimator. To capture possible non-linear impact of all three variables representing foreign presence on productivity of local firms (Merlevede and Schoors 2005), we in addition include squared *horizontal*, *backward* and *forward*. As control variables, we use firm and year fixed effects as well as the Herfindahl

11 *Levinsohn and Petrin (2003) methodology is available as an ado file for Stata program where a bootstrap technique is used to derive standard errors, see Levinsohn et al. (2003).*

index as a proxy for the level of concentration and thus competition within the sector.[12] Sectoral competition can also push firms to increase their productivity regardless whether the competitors in the sector are foreign-owned or not.[13]

In order to test the robustness of the estimation results, we also calculated the total factor productivity alternatively using real depreciation (deflated by the same price indices as capital stock) instead of stock of capital (Jarolím 2000) and real wage bill (deflated by consumer price index) instead of number of employees (Arnold et al. 2006). Table 6.6 shows the results:

Table 6.6: Productivity spillovers – estimation results

	(1)	(2)	(3)	(4)
horizontal	0.667*	0.667**	0.184	0.43
horizontal^2	-1.298***	-1.148***	-0.827**	-1.135***
backward	4.907***	5.055***	2.790*	3.065**
backward^2	-12.219***	-12.64***	-8.216**	-9.201***
forward	2.144**	2.379**	2.548***	2.704***
forward^2	-7.164**	-6.846**	-7.612**	-7.440**
hhi	0.522**	0.390*	0.521**	0.535**
constant	6.617***	6.212***	3.825***	3.592***
Observations	11386	11325	11910	11848
Firms	3850	3835	3925	3910
R-squared	0.01	0.01	0.01	0.01

Dependent variable: ln TFP; * significant at 10%; ** significant at 5%; *** significant at 1%.

Estimated with firm and year fixed effects.

Note: ln TFP (dependent variable) computed using (1) capital and labour, (2) depreciation and labour, (3) capital and wage bill, (4) depreciation and wage bill

Despite the low performance of the model as documented by low R-squared, the results in all specifications can be interpreted as follows: first, the productivity spillovers tend to be significant and positive, at least to some degree of foreign presence (positive sign of coefficients of horizontal, backward and forward). This has not been always found in the empirical studies on CEE countries. Geršl et al. (2007) who analyze ten CEE countries show that in many countries the spillovers are insignificant or even negative.[14] Second, the results suggest that vertical effects tend to be higher and thus economically much more important than horizontal effects. This is in line with findings by Geršl et al. (2007), Merlevede and Schoors (2005, 2006) or Javorcik (2004). Third, both horizontal and vertical spillovers tend to be highly non-linear. The effect is positive up to a certain level of foreign presence, but turns negative after the foreign presence exceeds a certain threshold (around 50%). Non-linear effects are reported also by Merlevede and Schoors (2005) and Geršl et al. (2007), but the latter find that in some

12 *Herfindahl index was computed as a sum of squared shares of individual firms in the sectoral output. It thus ranges from almost 0 (no concentration) to 10 000 (maximum concentration, i.e. one firm produces the whole sectoral output - 100% squared).*

13 *The Hausman test showed that the hypothesis of no correlation between regressors and individual effects can be rejected, thus fixed-effects model is appropriate.*

14 *Negative or insignificant spillovers have been found by Damijan et al. (2003) or Torlak (2004).*

countries, the effect is opposite to the effect found for the Czech Republic (i.e. the spillover is negative for low foreign presence and turns positive after a certain threshold level is reached). Our findings thus indicate a potential for the market stealing effect after 2000 and some crowding-out of the domestic firms, but they might also be reflecting continued FDI inflow in these countries (i.e. purchases of more productive local firms by foreign companies). The coefficient of concentration as measured by Herfindahl index is significant and positive, suggesting that higher concentration (i.e. lower competition) is – a bit counter-intuitively - beneficial for productivity.

The results also indicate the largest effect on productivity is due to being a sub-supplier to a foreign company, albeit the effect is positive only for sectors with relatively low foreign presence. This is in line with some anecdotic evidence about supply networks such as automotive or ICT industries in Central Europe (European Commission 2003).

7 Estimating market access spillovers

Market access spillover is difficult to estimate precisely given the unavailability of data on export performance of individual companies. Thus, we construct a proxy for export performance, assigning a share of total exports to EU25 to individual firms in the same proportion as their share in industry (2-digit NACE) output. Clearly, this proxy overestimates the export performance of local firms, as foreign firms will probably export more of their output than local firms if they cam out of the relocation of production motive.

We estimate the equation (4), using fixed-effects estimator. As control variables, we used imports as a share of industry output, turnover and year fixed effects. The results are shown in Table 7.7.

Table 7.7: Market access spillovers – estimation results

	(1)	(2)
Imports	0.729***	0.728***
Turnover	0.131***	0.131***
horizontal	496.6***	680.3***
horizontal^2		-365.9
backward	1235**	1366
backward^2		-2381
forward	81.69	615.3
forward^2		-1646
constant	-297.0***	-296.4***
Observations	17180	17180
Firms	4976	4976
R-squared	0.7	0.70

* significant at 10%; ** significant at 5%; *** significant at 1%.

Estimated via fixed-effect estimator.

The results suggest that to the extent our proxy is a reliable estimate of export performance, there might be important horizontal and backward market access spillovers. However, the bias introduced by our proxy should be counterbalanced by the coefficient for horizontal spillovers that captures the effect of foreign companies on export of the total sub-industry. Thus, the coefficient of the variables backward and forward should be less biased, indicating that being a sub-supplier has important foreign market access implications. The regression using also non-linear effects did not prove to lead to significant estimates.

8 Estimating financing spillovers

As discussed above, foreign firms may influence the prospects for local firms to get external financing. In order to test for this financing spillover, we estimate again the equation (4) on the panel of domestic companies, using fixed-effect estimator.[15] As dependent variable, we use three alternative variables for leverage, i.e. the degree to which a company uses external debt financing: (a) the total debt to total liabilities (total debt), (b) short-term loans and long-term debt (bank debt)[16], (c) bank debt. Total debt includes long-term debt, short-term loans, creditors and other liabilities. As control variables, we use standard variables that are frequently used in the capital structure literature (Rajan and Zingales 1995; Bauer 2004), such as size of the company (log of total assets and log of total sales), profitability (return on assets), tangibility (ratio of tangible assets to total assets) and non-debt tax shield (proxied by depreciation over total assets).[17]

Table 8.8: Financing spillovers (access to credit) – estimation results

	Total debt	Bank debt	Long-term debt	Liabilities to creditors
Log of turnover	0.00985***	-0.000623	-0.000998	0.00541*
Log of total assets	-0.00809	0.0269***	-0.000429	-0.000667
RoA	-0.00413***	-0.000936***	-0.000472***	-0.00110***
Tangibility	-0.0905***	0.0493***	0.0396***	-0.125***
Non-debt tax shield	1.707***	-0.0437	-0.0669**	0.655***
horizontal	-0.0608*	-0.0271	-0.0233	-0.0307
backward	0.807***	-0.0739	-0.158	0.482***
forward	-0.173*	-0.0425	-0.0284	-0.407***
constant	0.480***	-0.145***	0.107***	0.125**
Observations	18009	18009	18009	18009
Firms	4937	4937	4937	4937
R-squared	0.17	0.01	0.01	0.04

Estimated via fixed-effect estimator. * significant at 10%; ** significant at 5%; *** significant at 1%.

15 The Hausman test indicates that fixed-effect estimator is appropriate.

16 Bank debt can of course include loans and other loan-type instruments (including bonds issued) from non-bank financial institutions (financial leasing etc.) and non-financial corporations (intra-group loans); we label the variable bank debt as probably majority of such debt is bank credit.

17 We have also tested for non-linearity of spillovers by including squared variables of foreign presence.

The results indicate that there is a positive and significant effect on the total debt of being a sub-supplier to foreign firms (Table 8.9). Thus, the results partly confirm the hypothesis that local firms involved in interactions with foreign firms along production chain have easier access to credit.

However, the regressions using other definitions of dependent variable show that there is no significant effect on bank or long-term debt, i.e. credit that would be suitable for financing of long-term investments. Thus, the remaining part of the total debt, i.e. current liabilities to creditors, is driving the results. Local companies that sub-supply to foreign firms do much more use financing from creditors. That could indicate that being a sub-supplier to foreign firms does not help in obtaining long-term credit from banks, but because sub-suppliers have to invest in order to be able to stay in the business with foreign clients, they use to a large extent short-term sources of finance (liabilities to creditors) for financing their activities. At the same time, the results suggest that horizontal financing spillovers are negative. Thus, local companies that are exposed to increased competitive pressure and brain-drain effects can have difficulties with access to credit. Thus, we do not confirm the hypothesis raised by Geršl and Hlaváček (2007).

Even if the data do not reveal any significant spillovers in the area of the access to long-term credit, the effect might go via cost of credit. Sub-supplier to foreign firms might get cheaper financing on loans, benefiting from the fact that being a sub-supplier stabilizes the demand for local firm's output and provides the local firm with expert knowledge and assistance from the foreign firm. Moreover, if there is also an effect on productivity of the local firms (productivity spillover), banks might be ready to regard such a local firm as a less risky client.

Table 8.9: Financing spillovers (interest rate charged) – estimation results

	Interest rate (total debt)	Interest rate (bank debt)
Total debt	-0.00549***	9.194
Tangibility	0.0119***	9.17
Cash flow to assets	-0.00561***	-4.59
Debt structure	-0.00137	-5.773
horizontal	0.0123**	43.72
backward	0.231***	290.3
forward	-0.0355**	-59.44
constant	-0.00298	-43.87
Observations	10135	8101
Firms	3725	3205
R-squared	0.02	0.00

Estimated via fixed-effect estimator. * significant at 10%; ** significant at 5%; *** significant at 1%.

Thus, we estimate again the equation (4), using as a dependent variable the interest rate. As the data do not include the level of interest rate individual companies are charged, we use the implicit interest rate computed in two alternative specifications: (a) interest rate paid over total debt, (b) interest rate paid over bank debt (i.e. short-term loans and long-

term bonds). As control variables, we use the standard determinants from the corporate finance literature (Horváth 2006), such as the total debt, liquidity (cash flow over assets), debt structure (share of long-term debt in total debt) and the available collateral (tangibility). Table 9 shows the results.

The results of the first regression show negative horizontal and backward vertical financing spillovers, i.e. higher presence of foreign companies increases the interest rate paid by local firms. For horizontal effect, this might be explained by the increased competitive pressure and brain-drain effects. However, the results for backward spillovers are a bit counterintuitive. The reason could be that local firms that serve as sub-suppliers run certain risks that are reflected in the interest rate margin charged by banks, for example client concentration (supplying only one foreign customer that could, however, change the sub-supplier in later stages). Anecdotic evidence indeed suggests that supplying only limited number of firms with specific products can leads to over-specialization that might become a risky strategy in case the foreign company relocates the production to other countries, for example.

9 Conclusions

The objective of this study has been to analyze three types of possible indirect effects from FDI on local companies in the Czech Republic, namely productivity spillovers, market access spillovers and financing spillovers. The firm-level data on performance and financing of manufacturing companies from the database Amadeus were analyzed in order to detect whether foreign presence in the same sector and in the industries along the production chain has any impact on productivity, export performance, leverage and cost of finance of local firms. Existing literature offers contradictive results, often finding both positive and negative effects.

Our results show that there are important positive productivity spillovers to local firms, both on the horizontal level (in the same industry) as well as on vertical levels (along production chain), but they have a non-linear shape. After the foreign presence reaches a certain threshold, the effects turn negative, a sign of brain-drain or too-high-competition effects. In any case, the vertical spillovers seem to be much more important than horizontal, suggesting that being a sub-supplier pays off.

As to market access spillovers, taking into account the limited information on exports, the results indicate that especially backward market access spillovers are significant. Thus, again, local companies that are engaged in providing supplies and inputs to foreign companies could access new markets via marketing and business networks of their clients.

Finally, we found that foreign presence does not increase the prospects of local companies to access long-term credit or get cheaper financing. On the contrary – foreign presence in the same sector as well as in downstream sectors increases the reliance of local companies on short-term finance (especially liabilities to creditors) and increases the cost of finance. Thus, we do not confirm the hypothesis of Geršl and Hlaváček (2007) that FDI inflows may help local firms to get external finance more easily.

However, all results are of course subject to caution, given the firm-level data limitations as well as imperfect capture of interaction between local and foreign firms. Thus, the effects of FDI inflows on the host economies remains a topic to be further researched more in detail and stays in the agenda of policymakers and economists in today's globalized world.

Abstract

Foreign direct investment has been one of the main drivers of economic developments over the past few years in Central and Eastern Europe (CEE). Within the ongoing globalization and international division of labor, a large number of foreign companies have established production units in CEE countries to benefit from low labor costs and other advantages. This study looks both in theoretical and empirical terms at whether large foreign presence has also affected domestic firms. Foreign firms might both intentionally and unintentionally influence the productivity, financing and export performance of local firms within the same industry or across industries along the production chain via sub-supplier and client linkages. Economic theory does not suggest unambiguous answer to a question whether the influence is positive or negative. For answering the question, both firm-level and industry-level data on performance, financing and exports and interactions of firms within production chain in the Czech Republic are analyzed.

Keywords

foreign direct investment; productivity; corporate finance; export performance

JEL classificiation / JEL klasifikace

F21, D24, L60, G32, F40

Souhrn

Přímé zahraniční investice jsou jedním z hlavních faktorů pozitivního ekonomického vývoje v zemích střední a východní Evropy v posledních letech. V rámci postupující globalizace a mezinárodní dělby práce přesunula řada zahraničních firem své produkční kapacity do zemí střední a východní Evropy, aby využila nižších mzdových nákladů a dalších výhod tohoto regionu. Tato studie se teoreticky i empiricky zabývá nepřímými dopady silného zahraničního zastoupení v podnikovém sektoru na domácí podniky. Zahraniční firmy mohou záměrně i nezáměrně ovlivnit produktivitu, exportní výkonnost i financování domácích firem ve stejném odvětví i v odvětvích propojených prostřednictvím dodavatelsko-odběratelských vztahů. Ekonomická teorie však nedává jednoznačnou odpověď na to, zdali je výsledný efekt pozitivní či negativní. Pro zodpovězení této otázky jsou analyzována data na podnikové i odvětvové úrovni zachycující výkonnost, financování a vzájemnou propojenost podniků v ČR.

Klíčová slova

přímé zahraniční investice; produktivita; podnikové financování; exportní výkonnost

Kontaktní adresa / Contact address

PhDr. Adam Geršl, Ph.D.
Institut ekonomických studií FSV UK v Praze a Česká národní banka.
(e-mail: adam.gersl@cnb.cz)

PhDr. Adam Geršl, Ph.D.
Vystudoval ekonomii na Fakultě sociálních věd Univerzity Karlovy, kde také v roce 2006 obhájil doktorát.

Od roku 2001 působí v České národní bance, v současnosti jako hlavní ekonom v samostatném odboru ekonomického výzkumu a finanční stability. Je držitelem Ceny Karla Engliše, což je Cena rektora Univerzity Karlovy v Praze pro nejlepší absolventy společenskovědních oborů.

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1st Place – Profesor František Vencovský Award
1. místo – Cena profesora Františka Vencovského

The Exchange Rate Adjustment Role in Imperfect Competition: the Case of the Czech Republic

Přizpůsobovací role měnového kurzu v prostředí nedokonalé konkurence: na příkladu České republiky

FILIP NOVOTNÝ*

Introduction

A flexible exchange rate is perceived by the traditional economic theory to be an inherent market mechanism of the economic adjustment in the case of an external imbalance. Depreciation of the exchange rate leads to elimination of a trade balance deficit and conversely appreciation of the exchange rate is associated with suppression of a trade balance surplus. The neoclassical theory assumption of perfect competition in international trade which means that exporting firms are not able to affect prices of their production is in the background of this mechanism.

Contrary to this assumption, we observe in reality the propagation of imperfect competition market structures in international trade which enables firms to set prices of their production above the level of marginal costs. For that reason the theory of intraindustry trade (Krugman, 1980, 1981, 1983) became an important enhancement of existing theories of international trade at the beginning of 1980's. The contribution of Obstfeld and Rogoff (1995) was another turning point which enriched traditional models of open economies with microeconomic assumptions of imperfect competition and nominal rigidities. They have been followed by many authors whose work is usually classified as new open economy macroeconomics.

Conclusions of new open economy macroeconomics tell mostly against the exchange rate adjustment mechanism of the goods and services balance because they are skeptical to the capability of the nominal exchange rate to effectively determine real exports and imports. Alternatively, exchange rate fluctuations are absorbed in profit margins of monopolistic firms [Betts & Devereux (2000), Corsetti & Pesenti (2005)]. Furthermore, growing importance of multinational companies in the world economy which is associated with the propagation of imperfect competition market structures contributes evidently to weakening of the exchange rate adjustment mechanism. Imperfect competition thus becomes the most frequent market structure in the globalized economy.

* *The Czech National Bank and the University of Economics in Prague. The opinions in this article are of the author and are not necessarily endorsed by the above mentioned institutions.*

The Czech Republic has been practising the flexible exchange rate of the Czech crown since 1997 and at the same time its economy is characterized by a great openness with significant activities of multinational companies. These are the main reasons why it represents the appropriate example for an analysis of prevailing role of a flexible exchange rate in the global economy. Additionally, the Czech Republic is in the process of preparations for the euro adoption. The analysis of benefits and costs of a flexible exchange rate could therefore enrich the discussion about timing of the Euro-Area entry.

In this article, I test the hypothesis whether fluctuations of the nominal exchange rate of the Czech crown are absorbed in profit margins of Czech exporting firms. This would imply weakening of the exchange rate adjustment mechanism of the goods and services balance. Simultaneously, I examine possible differences between firms which are possessed by residents (domestic private firms) and firms which are possessed by non-residents (firms under foreign control[1]). Differences in reactions of domestic private firms and firms under foreign control may reveal the effects of globalization on market adjustment mechanisms of a small open economy.

The article is divided into five chapters. After the initial definition of the problem, the attention is in the second chapter devoted to effects of imperfect competition on the exchange rate adjustment role. The third chapter provides the analysis of the Czech crown nominal exchange rate fluctuations impacts on the profitability of exporting firms which operate on the territory of the Czech Republic. Subsequently in connection with realized findings, the fourth chapter deals with a particular character of international trade which proceeds within a multinational company. The fifth chapter then summarizes the achieved results.

1 Imperfect competition in international trade

Four possible mechanisms which deal with market balancing of trade balance disequilibrium can be found in the economic literature.[2] These possibilities comprise the price adjustment mechanism, the income adjustment mechanism, the exchange rate adjustment mechanism and the monetary approach to the balance of payments. These mechanisms mostly complement each other in reality. It is therefore very difficult to explore them in a pure theoretical form. In the case of an economy with a flexible exchange rate regime, it is obviously supposed that the exchange rate adjustment mechanism plays a key role.[3]

The exchange rate adjustment mechanism is based on the assumption that nominal exchange rate fluctuations change accordingly relative export and import prices and as a consequence there is the adjustment of demanded and supplied goods. Consequently, it leads to the equilibration of a possible external economic imbalance. Depreciation of the domestic currency leads to a decline of export prices which are denominated in the foreign currency and conversely to an increase of import prices which are denominated in

1 *A firm under foreign control is a firm where foreign investors control at least 50 % of its equity capital.*

2 *Dunn & Mutti (2000), Krugman & Obstfeld (1999), Gandolfo (1995), Baker (1995) and the others.*

3 *A flexible exchange rate which effectively equilibrates the external position of an economy enables domestic monetary policy to be fully concentrated only on conducting the internal price stability.*

the domestic currency. Depending on the elasticity of demand and supply it increases the real amount of exports and at the same time it decreases the real amount of imports.[4]

The exchange rate adjustment mechanism is considered to be the important channel of the external economic imbalance remedy especially in the case of inelastic domestic prices and wages – ineffectiveness of the price adjustment mechanism. If domestic prices were as flexible as exchange rates, it would be irrelevant whether the adjustment come up through exchange rate changes or equivalent changes in internal prices (Friedman, 1953).

Nevertheless similarly to the price adjustment mechanism, the exchange rate adjustment mechanism has also certain limitations. According to Mundell (1960)[5] the effectiveness of the flexible exchange rate adjustment depends on the value of two parameters. Firstly, it depends on the sensitivity of capital flows on interest rates and secondly it depends on the sensitivity of trade balance on terms of trade. Considering the balance of goods and services, the second condition is particularly important.[6]

The assumption of prevailing imperfect competition in international trade represents the important restriction for the exchange rate adjustment mechanism of the goods and services balance. Krugman (1986) affirms the capability of firms to keep different prices of their production on different foreign markets (pricing-to-market) in relation to particularities of individual industrial branches.[7] Microeconomic assumptions of imperfect competition therefore gradually became the integral part of new models of open economies (Lane, 2001). Models became more complex but on the other side these models drew near the observed reality.[8]

The embedment of the imperfect competition assumption enabled the straight analysis of firms' pricing behavior as opposed to the neoclassical assumption of perfect competition in international trade where all firms are price takers. Monopolistic firms are able to set prices of their products above the level of marginal costs in these models. They attain a certain profit margin which enables them, at least partially, to absorb potential nominal exchange rate fluctuations without changing prices of their products on foreign markets.

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4 The exchange rate adjustment mechanism is also denoted as the elasticity approach. The balance of goods and services is improved only if the sum of demand elasticity in foreign trade – the elasticity of domestic demand for imports and the elasticity of foreign demand for imports – is higher that one in absolute value (the Marshall-Lerner condition).

5 Mundell built up his approach on the basis of the Keynesian IS-LM model.

6 The empirically observed short-term insensitivity of trade balance on nominal exchange rate fluctuations is so called the J-curve effect which consists in short-term price inelasticity of supply and demand curves in international trade. The remediation of the balance of goods and services therefore come on mostly after a certain time lag due to this effect.

7 A monopolistic firm which has destination markets in different countries can price discriminate among individual countries by offering its production for lower prices in a low income country and on the contrary it can offer the same production for higher prices in a high income country.

8 One of the objectives of new approaches was to provide the decision making analytical system with a better alternative to the traditional Mundell-Fleming model.

Let's imagine that an exporting firm attains simultaneously same profit margins on both a domestic and a foreign market in the period before a nominal exchange rate swing. The firm then absorbs a potential nominal exchange rate fluctuation in its profit margin without changing prices of exported production which is denominated in the foreign currency. Thus exchange rate fluctuations do not affect terms of trade between a domestic and a foreign country and either they do not affect the real amount of export production.

If for instance the domestic country currency appreciates, it will not imply a proportional growth in prices of exported production which is denominated in the foreign currency as it is supposed by the neoclassical theory. On the contrary, an exporting monopolistic firm will react by lowering prices of its export production which is denominated in the domestic currency in order to retain the same price which is denominated in the currency of a foreign market. In this way, a firm does not loose its current foreign market share. A monopolistic firm behaves accordingly in spite of it causes a decline in its profitability.[9]

As a result, the price of same production which is denominated in one currency will be different on a domestic market and on foreign markets due to the restricted international arbitrage and the effort of monopolistic firms to differentiate their production from a similar production of their competitors. We then observe systematic deviations of the law of one price in tradable goods contrary to the traditional economic theory which associates sources of nominal exchange rate deviations from the purchasing power parity only with the existence of a certain group of internationally non-tradable goods (Betts & Devereux, 2000).

Summarizing the above paragraphs, if firms price their production in the currency of a destination market (local-currency-pricing), the exchange rate adjustment role is disturbed because foreign prices are not affected by nominal exchange rate fluctuations. Local-currency-pricing is thus in the direct contrast to the strategy of producer-currency-pricing which is consistent with a flexible exchange rate regime [Obstfeld (2002), Corsetti & Pesenti (2005)].

Firms that operate in large economies such as the United States or the Euro-Area can be characterized by producer-currency-pricing. Firms in small economies like the Czech Republic are probably more characterized by local-currency-pricing. It can be assumed the asymmetric impact of the exchange rate in the case of small open economies which trade predominantly with one important trade partner. Exchange rate fluctuations are in this case entirely reflected in domestic import prices while foreign export prices are sticky.

According to Otani (2002), Japanese firms absorb approximately one-half of all exchange rate fluctuations in their profit margins while in the case of American firms the transmission of exchange rate fluctuations into foreign prices is complete. In other words, American firms prefer the strategy of producer-currency-pricing.

The exchange rate volatility, together with the relative size of a domestic and a foreign

9 *Profit margins will increase if the exchange rate depreciates and vice versa. Changes of the exchange rate do not cause expenditure switching but the income effect on the reported profitability of exporting firms.*

economy, depends on the ratio of domestic and foreign firms which prefer the pricing-to-market strategy. The exchange rate between a small and a large economy becomes more volatile proportionally with the number of firms in a relatively smaller economy which apply the pricing-to-market strategy. If firms in a relatively smaller economy use the currency of a relatively larger economy as a unit of account, the volatility of the exchange rate between these two countries is high.[10]

The effects of exchange rate appreciation and depreciation can on average compensate each other. However, firms and even individuals prefer stability of their income before income fluctuations. The increased exchange rate volatility can thus force exporting firms to charge higher prices. These prices include a risk premium. Higher prices however cause a decrease in consumer surplus because less output is produced for higher prices (Obstfeld, 2001).

2 The impact of exchange rate fluctuations on Czech exporters

Similarly to Otani (2002) in the case of Asian economies I suppose asymmetric effects of the exchange rate even in the case of the Czech Republic. I proceed from the assumption that exporting firms in the Czech Republic apply the pricing-to-market strategy and nominal exchange rate fluctuations are therefore not reflected in foreign prices of their products. In this way, firms stabilize their real exports regardless of nominal exchange rate fluctuations because exchange rate fluctuations are absorbed in profit margins.

2.1 Tested hypothesis

The indicator of the operational profitability of sales is used to demonstrate immediate effects of exchange rate fluctuations on the profitability of exporting firms:

$$\pi_t = \frac{\Pi_t}{S_t}, \tag{1}$$

where π_t is the operational profitability of sales, $\prod_t$ is the operational profit in the nominal value, S_t are sales in the nominal value and t indicates time in quarters.

The operational profit in the absolute value can be expressed as:

$$\Pi_t = S_t - L_t - K_t - M_t, \tag{2}$$

where L_t is for labor costs, K_t represents the amortization of fixed assets and M_t indicates the production consumption. All quantities are in nominal values. The equation 1 can be therefore broken down in this way:

$$1 - \pi_t = \frac{L_t}{S_t} + \frac{K_t}{S_t} + \frac{M_t}{S_t}. \tag{3}$$

We get three relative indicators on the right side of the equation 3 which determine the

10 This assumption is empirically applicable on the exchange rates between the United States and Asian economies or between the Euro-Area and eastern European economies.

operational profitability of sales (profitability). They are the ratio of labor costs on sales *(L/S)*, the ratio of the capital consumption (amortization) on sales *(K/S)* and the ratio of the production consumption on sales *(M/S)*.

The basic tested hypothesis is a linear dependence of year-on-year changes of the operational profitability of sales in exporting industries

$$\Delta\pi_t^{ex} = \pi_t^{ex} - \pi_{t-4}^{ex} \tag{4}$$

on year-on-year changes of the nominal effective exchange rate of the Czech crown Δz_t:

$$\Delta\pi_t^{ex} = \beta_0 + \beta_1 \Delta z_t + \varepsilon_t \ . \tag{5}$$

The same equation (5) is then tested by replacing the indicator of the operational profitability $\Delta\pi_t^{ex}$ with the partial indicators $\Delta(L/S)_t^{ex}$, $\Delta(K/S)_t^{ex}$ and $\Delta(M/S)_t^{ex}$. In this way, I examine the channels through which nominal exchange rate fluctuations affect the operational profitability.

2.2 Data

A freely available database of selected financial indicators of non-financial enterprises with more than one hundred employees which is published by the Czech Statistical Office was used.[11] These financial indicators are available partly according to particular industrial branches (OKEČ/CZ-NACE) and partly according to particular institutional sectors with the division into firms under foreign control, domestic private firms and public firms. The indicators are expressed in millions of Czech crowns and are published quarterly. They were available for the period beginning in 1998 until the end of 2006. This period is consistent with the flexible exchange rate regime of the Czech crown.

Only industrial branches with at least 60 % proportion of direct sales coming from exports were selected from all industrial branches of non-financial enterprises. They comprise manufacturing of textiles, textile products and clothing industry (DB), manufacturing of leather and leather products (DC), manufacturing of wood and wood products out of furniture (DD), manufacturing of chemicals, chemical products and man-made fibers and pharmaceuticals (DG), manufacturing and repairs of machinery and equipment (DK), manufacturing of electrical and optical appliances and equipment (DL), manufacturing of transport vehicles and equipment (DM) and manufacturing of unclassified products (DN). The share of value added of exporting industrial branches on total value added of the manufacturing industry was 55 % in 2006.

2.3 Estimation results

Considering all exporting industrial branches regardless of the property structure of particular firms, there was not detected any significant dependence between exchange

11 CSO: Economic Results of Non-financial Enterprises.

rate fluctuations and the indicator of the operational profitability. Similarly, there was not detected any significant dependence in the case of public firms. It could be however related to a non-exporting character of public firms' production. A statistically significant dependence was detected in the case of domestic private firms and firms under foreign control.

In the case of exporting domestic private firms, the exchange rate fluctuations are immediately reflected in the reported profitability. It is in accordance with the assumptions included in chapter two.

Figure 2.1: Development of profitability indicators of private domestic firms in the dependence on the nominal effective exchange rate of the Czech crown

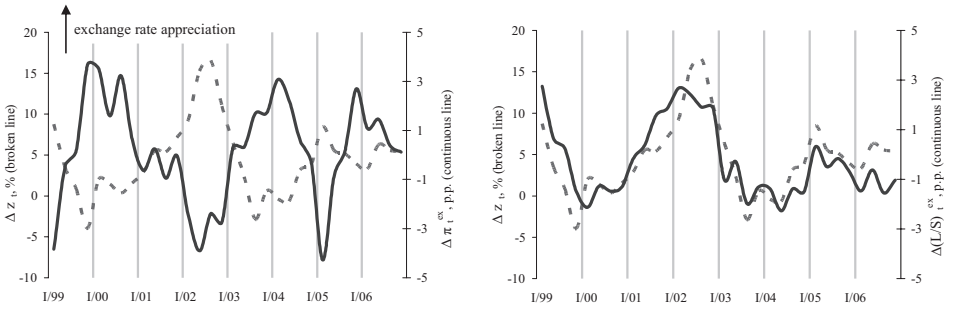


Table 2.1: Estimated parameters of linear regression (domestic private firms)

	β_0	β_1	Number of observations	Adjusted R^2
$\Delta\pi^{ex}$	1.88^{***} (0.32)	-0.38^{***} (0.05)	32	0.64
$\Delta(L/S)^{ex}$	-1.39^{***} (0.24)	0.25^{***} (0.04)	32	0.58

*Note: Standard errors are given in parentheses. The stars denote significance as follows: *** 1%, ** 5 % and * 10%. The granger causality test confirms the dependence of the operational profitability and of the partial indicator of labor costs on sales on nominal effective exchange rate fluctuations of the Czech crown.*

Nominal effective exchange rate fluctuations of the Czech crown are in the case of exporting domestic private firms reflected in the operational profitability *(π^{ex})*. One percent year-on-year nominal exchange rate appreciation implies the year-on-year decrease in the operational profitability of sales of about 0.38 percentage points. Domestic private firms thus absorb a relatively high portion of nominal exchange rate fluctuations in their profit margins.

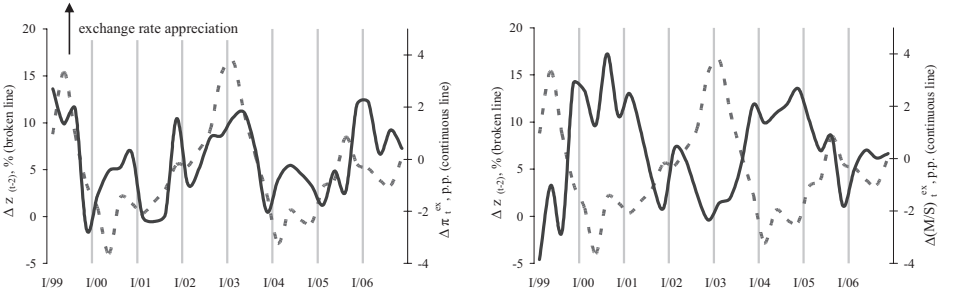
This hypothesis is also supported by a positive (statistically significant) dependence of the partial indicator of labor costs on sales $(L/S)^{ex}$.[12] Because I suppose nominal stickiness of labor costs I ascribe all fluctuations of the mentioned indicator to changes in sales. In the short-term, I also do not suppose changes in the real amount of export production. Consequently, changes in sales are attributed to changes in prices which are denominated in the Czech currency. Production prices which are denominated in the foreign currency are stable at the same time. It is a classical example of the local-currency-pricing strategy which is described in chapter two.

It seems that a great part of the production consumption is imported (imported inputs) and its price is determined by the exchange rate while the final production (exported output) is priced in the foreign currency and therefore it is not affected by nominal exchange rate fluctuations.

The statistically significant coefficient β_0 is probably related to trend nominal exchange rate appreciation of the Czech currency which is associated with the real convergence of the Czech economy. According to Podpiera & Raková (2006), trend appreciation of the domestic currency increases the degree of competition which is perceived by exporting firms because it causes diminishing profit margins from export markets.

In the case of firms under foreign control, there is no evidence of immediate impacts of the Czech crown nominal effective exchange rate fluctuations on the examined indicator of the operational profitability. A statistically significant dependence is visible only with the exchange rate lagged for two quarters. But contrary to domestic private firms, exchange rate fluctuations affect the operational profitability of firms under foreign control in the opposite direction. The exchange rate appreciation which is lagged for two quarters is associated with the profitability growth of exporting firms under foreign control. Even if with the distinctively lesser intensity compared to domestic private firms (see estimated parameters in the table 2.1 and 2.2).

Figure 2.2: Development of the profitability indicators of firms under foreign control in the dependence on the nominal effective exchange rate of the Czech crown (the exchange rate is lagged for two quarters)



12 *The other partial indicators were not statistically significant.*

The exchange rate fluctuations are mostly reflected in the partial indicator of the production consumption on sales in the case of firms under foreign control. It indicates that firms under foreign control are able to manage prices of inputs (intermediate products) and outputs (final products) on international markets much better than domestic private firms. Due to this fact, we do not observe significant fluctuations of the operational profitability in relation to exchange rate fluctuations and neither have we observed more significant effects of exchange rate fluctuations on the partial indicator of labor costs on sales.

Table 2.2: Estimated parameters of linear regression (firms under foreign control)

$\Delta \mathbf{z}_{t-2}$	β_0	β_1	Number of observations	Adjusted R^2
$\Delta\pi^{ex}$	-0.89^{***} (0.31)	0.17^{***} (0.05)	32	0.30
$\Delta(M/S)^{ex}$	1.61^{***} (0.33)	-0.27^{***} (0.05)	32	0.49
$\Delta(L/S)^{ex}$	-0.38^{**} (0.15)	0.06^{**} (0.02)	32	0.17

*Note: Standard errors are given in parentheses. The stars denote significance as follows: *** 1%, ** 5 % and * 10%. Based on the granger causality test we can reject the hypothesis that the Czech crown nominal effective exchange rate fluctuations which are lagged for two quarters do not affect the operational profitability of sales. The same holds for the indicator of the production consumption on sales.*

It seems that firms under foreign control are able to keep prices of their final export products stable in the Czech currency whereas the crown price of imported inputs *(VS)* is determined by the exchange rate (asymmetric behavior of the exchange rate).

Table 2.3: Mean values of the quarterly indicators in the observed period (1.Q 1998 – 4.Q 2006)

	Mean		Standard Deviation	
	SD	PZK	SD	PZK
Operational Profitability of Sales	5.0	5.8	2.7	1.8
Labor Costs on Sales	20.2	9.1	1.5	0.6
Capital Costs on Sales	4.8	4.9	0.8	0.6
Production Consumption on Sales	70.0	80.3	2.2	2.0

Note: SD - domestic private firms, PZK - firms under foreign control. The volatility of the indicators is lower in the case of firms under foreign control.

Subsidiary firms of multinational companies have probably guaranteed their foreign sales and they can afford to reflect changes of the exchange rate in their foreign prices. Hence, they can easily adopt the strategy of producer-currency-pricing (see chapter two). Guaranteed foreign markets in the case of multinational companies imply weakening of the exchange rate adjustment mechanism. The reason is a non-elastic foreign demand for products of a subsidiary firm.

It seems that the management of a multinational company controls prices of inputs and outputs that are exchanged within a multinational company in order to optimize the global (total) profitability independent of the profitability of particular subsidiary firms which operate in different host countries. Contrary to a subsidiary firm of a multinational company, a domestic private firm is forced to absorb exchange rate fluctuations in its profit margins to sustain its current foreign market share.

3 The intrafirm trade of multinational companies

Firms under foreign control have a unique position due to their property interconnection abroad. One of the possible channels through which the management of a multinational company can affect financial results of particular subsidiary firms is exactly the intrafirm trade within a multinational company.

Hipple (1990) defines several levels of the intrafirm trade. The widest definition of the intrafirm trade of a multinational company comprises business transactions when every home firm of a multination company or subsidiary firms of a multinational company perform as importers or exporters. On the other hand the narrowest (clear) intrafirm trade is considered to comprise business transactions only between a home firm and its subsidiary firms. It is obvious from the definition of the intrafirm trade that it is affected by different factors compared to factors which affect foreign trade between mutually independent business partners.[13]

If an economy is characterized by a high share of the economic activity which is generated by foreign direct investment, the analysis of its foreign trade becomes more complex and some business relations should be interpreted with additional explaining factors (Benvignati, 1990).

Neighbour (2002) and Ernst&Young (2005-2006) confirm a high proportion of the intrafirm trade on the total world trade. Clausing (2003) estimates the share of the intrafirm trade on the total foreign trade of the United States to about 40 %. Due to growing importance of the intrafirm trade, the OECD introduced guidelines which regulate international transfers of goods and services within a multinational company.[14]

The simplest solution for the management of a multinational company is to use market prices when intrafirm transactions are priced. Nevertheless, this solution is effective only if market

13 Rugman (1996) interprets the rise and functioning of multinational companies by the endeavor of firms to replace external markets by intrafirm transactions.

14 OECD (2001) Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrators.

prices are determined on perfectly competitive markets. In the case that firms operate on imperfectly competitive markets or if a relevant market for a given transferred product do not exist then the optimal intrafirm price should be set at the level of marginal costs of a subsidiary firm. Such an intrafirm price corresponds to a decentralized or arm's length[15] price (Hirshleifer, 1956).

Nevertheless, intrafirm prices are often different from arm's length prices in reality. Tax optimization and minimization of customs duties represent fundamental motives for multinational companies to centrally manage prices of intrafirm transactions [Horst (1971), Copithorne (1971)].

If tariff barriers or international differences in profit taxation exist, the management of a multinational company sets the intrafirm price in order to maximize the global net profit adjusted for effects of customs duties and differences in tax rates irrespective of the profitability rate of particular subsidiary firms which are located in different countries.

There are generally three basic possibilities of the internal prices determination. The first possibility is the already mentioned basic example with no customs duties and same effective taxation home and abroad. In this case, the optimal solution is to set the internal price of an exchanged product at the level of marginal costs[16] of an exporting subsidiary firm (decentralized arm's length transaction).

The second possibility is the case when a relative difference in tax rates of the two countries under consideration is zero or at least it is lower than customs duties. A multinational company chooses the lowest possible intrafirm price under these conditions and subsequently it repatriates high dividends. Even if a subsidiary firm of a multinational company is in a loss, it will be maintained in the operation because of minimization of customs duties. A multinational company will be importing at the intrafirm price which is under the level of a market price.[17]

In the case of no customs duties or in the case when customs duties are lower than a relative difference in tax rates between the two countries, a multinational company will choose the strategy of the internal price maximization. Higher internal prices raise paid customs in the case of positive customs duties but, on the other hand, a multinational company avoids high taxes.[18]

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15 Arm's length transaction is a transaction between two related or affiliated parties that is conducted as if they were unrelated, so that there is no question of a conflict of interest. Or sometimes, a transaction between two otherwise unrelated or affiliated parties.

16 Or setting the internal price at the level of market prices in the case of perfect competition.

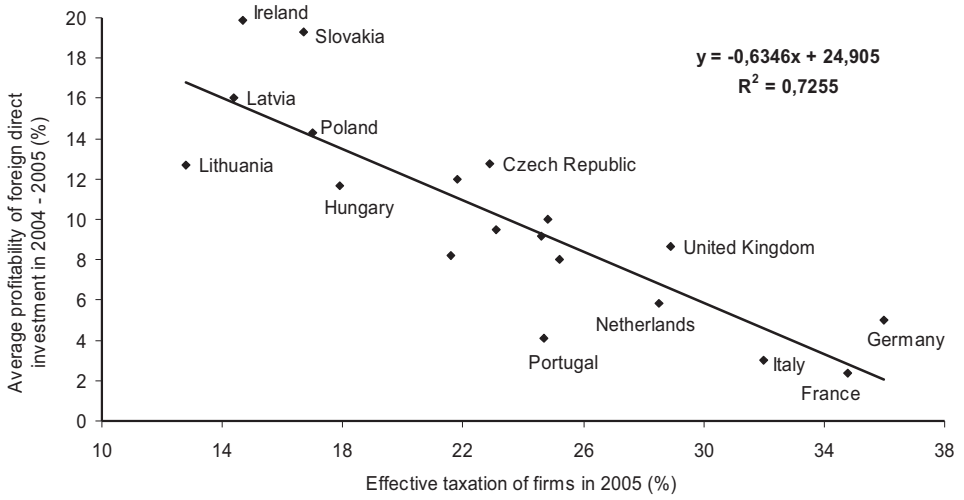
17 Multinational companies will choose the strategy of transfer price minimization when tax rates converge across particular countries in order to minimize customs duties.

18 This is a likely situation for the Czech Republic where foreign investors were motivated through the implementation of tax holidays to set maximum prices of products which are assembled in the Czech Republic and exported in developed countries. Profits gained in the Czech Republic are then transferred abroad as dividends or are reinvested.

The economic policy of high tariffs paradoxically enables price discrimination across countries and it causes ineffectiveness of the national tax policy. Countries which are characterized by high import tariffs can raise taxation of firms above the level of taxation in other countries without causing a replacement of local production by intrafirm imports.

Even if profits of a multinational company are taxed on the consolidated basis[19] in a home country of a foreign investor, there exists a possibility how to avoid higher taxes in a home country. A multinational company can simply retain (reinvest) all profits in its subsidiary firm. That's why foreign activities of multinationals are in a large extent financed by reinvested profits. The policy of repatriated dividends taxation leads multinationals to prefer financing of subsidiary firms by the equity capital before the debt capital. It discourages multinational companies from the repatriation of foreign profits (Horst, 1977).[20]

Figure 3.3: Dependence of the average profitability of foreign direct investment on taxation in EU countries



Source: Eurostat and ZEW (author's calculations)
Note: The profitability of foreign direct investment in selected countries is calculated as a ratio of the debit size of the foreign direct investment income balance in time t on the stock of foreign direct investment in time t-1. Selected countries comprise Austria, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden and the United Kingdom.

19 *There are in general two alternative ways of multinational company taxation. The one is known as income taxation on the consolidated basis and the other one is known as income taxation on the territory basis. The first alternative is characterized by taxation of all profits of a multinational company irrelevant the country of their origin and afterwards taxes which have been already paid abroad are deducted. The second alternative is to tax profits which have been generated on the territory of a certain country.*

20 *Subsidiary firms which operate in high tax countries are financed by the intrafirm loan instead of the equity capital.*

The linear regression indicates a significant dependence between the profitability of foreign direct investment (firms under foreign control) and the effective rate of profit taxation. Both estimated parameters in the equation are statistically significant.[21]

Low tax countries are in the upper left corner of the figure 3.3. These countries have a relatively high profitability of foreign direct investment. They comprise Ireland, Slovakia and Latvia. On the other hand, high tax countries are in the lower right corner of the figure 3.3. These countries are characterized by a relatively lower profitability of foreign direct investment. They comprise particularly France, Italy and Germany which has the highest effective taxation (36 %). Firms in the Czech Republic are taxed by the effective tax rate of 22.9 % and they reach the average profitability of 12.8 %.

Except low taxation, some countries apply the economic policy of investment incentives which also include tax holydays for several years. Multinational companies have thus sufficient motives to artificially increase value added and gross profits through internal prices in these countries.[22]

The difference between internal prices and common arm's length prices leads to distortions on the macroeconomic level in the case of small open economies which are characterized by a significant role of multinational companies. Barry (2005) demonstrates the effects of price strategies of multinationals in the case of the Irish economy. He argues that gross value added per employee is higher in Ireland compared with other EU countries whereas the ratio of labor costs on production attains a substantially lower level in Ireland. He therefore warns against an excessive reliance on the indicators of value added in countries which are characterized by a significant role of multinational companies.

Based on the empirical analysis of the foreign trade of the United States, Clausing (2003) concludes that in the case of low tax countries export prices of the American intrafirm trade are lower and import prices of the American intrafirm trade are higher compared to arm's length prices. Similarly Bartelsman & Beetsma (2003) argue that the tax motivated manipulation of intrafirm prices affects the reported firm productivity because sales in low tax countries can be overvalued and the production consumption undervalued. The manipulation of intrafirm prices can cause growth in the measured productivity in countries which lower taxation even without a technological change.

The Czech Republic is a typical country where value added can be overvalued by firms under foreign control due to a relatively lower effective taxation and investment incentives in the Czech Republic.[23] The share of firms under foreign control on total value added

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21 If the effective taxation were zero, then the annual profitability of foreign direct investment would reach nearly 25 %.

22 Multinational companies concentrate their production into countries which have the lowest production costs and final products are then sold on foreign markets where a multinational company reaches the highest price.

23 The manipulation with prices of the internal trade may be the reason of a markedly faster growth in value added of the manufacturing industry which is export oriented in comparison with the remainder of the economy.

of the manufacturing industry is more than 50 % in the Czech Republic. The industrial branch with the highest contribution of multinational companies to value added is manufacturing of transport vehicles and equipment (84 %).[24]

Moreover, the production of firms under foreign control is mainly export oriented. With the knowledge of additional data[25] I estimate the export share of firms under foreign control to about one-half of total exports of the Czech Republic while the share of sales from direct exports of goods and services of firms under foreign control on total sales from direct exports of industrial firms reached approximately 70.2 % in 2004.

International trade between mutually independent business partners was gradually decreasing during the period from 1999 when it was approximately 65 % until 2004 when it was approximately 50 %. When interpreting the Czech foreign trade, it is therefore necessary to apply the above mentioned findings of optimization strategies of multinational companies besides the traditional economic theory of international trade.

Conclusion

On the basis of the assumption of prevailing imperfect competition in international trade which is, apart from other things, intensified by an increasing role of multinational companies, the effects of nominal effective exchange rate fluctuations of the Czech crown on the profitability indicators of exporting industrial branches in the Czech Republic were analyzed. It seems that non-financial firms which are possessed by Czech residents apply the strategy of local-currency-pricing. Therefore, the exchange rate fluctuations are absorbed in profit margins. Consequently, nominal exchange rate fluctuations do not cause adequate changes in relative foreign prices. No adjustment of real amount of exports and imports then occurs.

Contrary to domestic private firms, firms under foreign control respond to nominal exchange rate fluctuations differently. The behavior of firms under foreign control indicates the application of specific pricing strategies which are applied within subsidiary firms of a multinational company. One of the incentives for a multinational company is the tax optimization which leads to a purpose-build influencing of financial results of subsidiary firms. A multinational company maximizes its total (consolidated) net profit regardless of the profitability rate of particular subsidiary firms. The way which the intrafirm transactions are priced is thus in a large extent dependent on centralized decision making of the management of a multinational company. Through the manipulation of intrafirm prices, multinationals transfer profits from countries with higher taxation to countries with lower taxation of incomes. There really exists the dependence between the level of effective taxation of firms and the reported profitability of firms under foreign control on a sample of EU countries.

Both local-currency-pricing in the case of domestic private firms and optimization strategies of multinational companies imply weakening of the exchange rate adjustment

24 CSO: Industry in the Czech Republic: Economic Results in 2000-2004.

25 The Czech National Bank publishes the Annual Report on Foreign Direct Investment which includes among other things selected indicators of firms under foreign control. The Czech Statistical Office publishes the statistics of industry and construction.

mechanism of the goods and services balance. In the case of small open economies, arguments in favor of a flexible exchange rate regime are therefore weakening with increasing globalization and imperfect competition in international trade.

Abstract

One of the approaches to an international trade analysis is the assumption of prevailing imperfect competition where monopolistic firms determine prices of their production on segmented foreign markets. Based on aggregate data of quarterly financial indicators of non-financial enterprises, the hypothesis was tested whether producers based in the Czech Republic absorb nominal exchange rate fluctuations in their profit margins. Estimated results indicate that domestic private firms absorb a substantial part of exchange rate fluctuations whereas the impact on firms under foreign control is ambiguous which implies application of optimization strategies in the case of multinational companies. These strategies are associated with pricing of intrafirm transactions. Tax optimization of multinational companies causes the dependence of the profitability of firms under foreign control on the level of effective taxation in EU countries. Both local-currency-pricing strategy (domestic private firms) and optimization strategies of multinational companies (firms under foreign control) lead to weakening of the exchange rate adjustment mechanism. In the case of small open economies, arguments in favor of a flexible exchange rate regime are therefore weakening with increasing globalization and imperfect competition in international trade.

Keywords

exchange rate, foreign market, imperfect competition, multinational company, pricing-to-market, profit margin

JEL classification / JEL klasifikace

F12, F23, F41, L11

Souhrn

Jedním z přístupů k analýze mezinárodního obchodu je předpoklad o převažující nedokonalé konkurenci, kde monopolistické firmy ovlivňují cenu své produkce na segmentovaných zahraničních trzích. Na základě agregovaných dat čtvrtletních finančních ukazatelů nefinančních podniků byla testována hypotéza, zda výrobci v ČR absorbují pohyby nominálního měnového kurzu ve svých ziskových maržích. K absorpci kurzových pohybů dochází zejména v případě domácích soukromých firem, zatímco v případě firem pod zahraniční kontrolou je tento dopad nejednoznačný, což ukazuje na uplatňování optimalizačních strategií nadnárodních společností při oceňování vnitrofiremních transakcí. Díky daňové optimalizaci nadnárodních společností existuje závislost mezi vykazovanou ziskovostí firem pod zahraniční kontrolou a výší efektivního zdanění firem v zemích EU. Jak strategie oceňování produkce v měně cílového trhu (domácí soukromé firmy), tak optimalizační strategie nadnárodních společností (firmy pod zahraniční kontrolou) vedou k oslabování kurzového vyrovnávacího mechanismu. S rostoucí globalizací a nedokonalou konkurencí v mezinárodním obchodě proto oslabují argumenty ve prospěch režimu flexibilních měnových kurzů v malých otevřených ekonomikách.

Klíčová slova
měnový kurz, nadnárodní společnost, nedokonalá konkurence, „pricing-to-market", zahraniční trh, zisková marže

Kontaktní adresa / Contact address
Ing. Filip Novotný
Czech National Bank, Na Příkopě 28, 115 03 Praha 1, Czech Republic
(e-mail: filip.novotny@centrum.cz)

Ing. Filip Novotný
Vystudoval obor Hospodářská politika a správa na Národohospodářské fakultě VŠE v Praze.

V současné době zde také studuje doktorský studijní program Hospodářská politika a správa. Ing. Filip Novotný se zúčastnil několika odborných soutěží pořádaných VŠE v Praze a Univerzitou Tomáše Bati ve Zlíně. Od roku 2002 působí jako analytik ekonomiky v sekci měnové a statistiky České národní banky v Praze.

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3rd Place – Profesor František Vencovský Award
3. místo – Cena profesora Františka Vencovského

Interaction between Monetary and Fiscal Policy in a Small Open Economy with Autonomous Monetary Policy and Fiscal Policy Rule

*Interakce měnové a fiskální politiky v malé otevřené ekonomice v systému s autonomní měnovou politikou a fiskálním pravidlem**

DAVID PRUŠVIC**

1 Introduction

Fiscal policy, as well other economic policies, is not in the system of economic policies alone and doesn´t react quite independently. It is affected and at the same time affects other policies of the state, whether social policy (interaction in the field of social benefits or ways of motivation and labour incentives through the tax system), or the environmental policy, where for example it can determine and control the contamination level, along with other policies and their tools, way of internalization etc. There is also interaction between monetary and fiscal policy. These two fundamental "macro-policies" can influence each other or they can reduce their reciprocal actions, they can be in the position of dominant and inferiority policy. Creating economic policy mix these and surely other reasons must be well-considered in advance, particularly when the both policies are carried out by independent institutions. Then it is appropriate to decide, which one will follow the decisions of the other one or specify a space for its function that doesn't damage slightly function of the dominant policy. Fiscal policy rules could play this role.

The European Union (EU) in the Treaty establishing the European Community delegated the task of monetary policy in the area called Economic and Monetary Union (EMU) to a European Central Bank (ECB) and monetary-policy strategy to a European System of Central Banks. ECB controls reference interest rate in the countries with common currency, on the other hand fiscal policy is provided by each single member state separately. Optimal Currency Area theory considers as important so that in these countries fiscal policy might have the opportunity to respond to local asymmetric shocks, whereas monetary policy to the shocks affecting the whole single currency area. However, when economic systems are not sufficiently harmoni-

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** *Department of Public Finance, Faculty of Finance and Accounting, University of Economics, Prague; and Ministry of Finance of the Czech Republic.*

zed, common monetary policy can rather cause damage than help to the economy and fiscal policy won't be able to solve these non-synchronous shocks effectively.

On the contrary there are disadvantages of too autonomous fiscal policies. Firstly they can restrain effects of monetary policy and secondly problem of "free rider" could arise due to single currency and single reference interest rate. Thus there is an effort to backward this adverse consequence of non-coordinated "split" fiscal policies through a fiscal policy rule (an example of this rule in the European Union is known under the label "the Stability and Growth Pact").

The Czech Republic, as an EU member, is subordinate to the Stability and Growth Pact as well and some information and other duties against EU institutions results from it. Conversely the Czech economy is affected by central bank, which is still national economic-policy institution, however its primary objective is price stability through the Bank board agreed regime inflation targeting. The Czech National Bank is perceived as a relatively high autonomy (especially instrumental one) moreover.

Therefore it is convenient to study reaction functions of both economic-policy authorities in a small open economy and to monitor how one authority's decision about intervention effects the other authority's decision. Eventually observe when one of the policies "has to" react to the action and when just "can". These central bankers and governments "games" then have of course different impacts on the economy in the terms of output gap or inflation rate change.

The plan of the study is following. At first a model is developed, which partly follows other authors studies. Being modified by external influences the model is step by step transformed through the central banker's and fiscal authority's loss functions into the central bank's and fiscal authority's reaction functions. The process of adjustment is shown in the model of central bank's and fiscal authority's reaction functions together with the conditions under they lead to convergence and steady state and when conversely divergent. There are also discussed the influences of exogenous shocks on individual reaction functions. Final analytical chapter solves the question how the monetary policy reaction function will change, when the Czech Republic enters the Economic and Monetary Union.

2 A model construction

The basic version of this model comes out from the work of Buti, Roeger, Veld (2001). In this study we "open" it and consider influences that might be fatal for small open economies. Authors like Ball (1998) or Svensson (1998) have dealt in the model applied on open economies, mainly in the view of monetary authorities. Their pieces of knowledge are also used.

2.1 Presumptions of the model

The model is based on the following assumptions. Demand side of the economy is characterised by IS curve for the open economy, its functional record is:

$$y = \beta_B B - \beta_r \left(i - \pi^e \right) + \beta_R R + \varepsilon_1 \quad , \tag{1}$$

where:

y	symbolizes output gap, i.e. the difference between real product (Y) and its potentional level (Y^*),
B	public finance deficit, defined as the difference between government expenditures and revenues ($G - T$), or as a difference between structural budget deficit component (CAB)[1] and its cyclical part: $B = CAB - \alpha y$, where α denotes the budget deficit sensitivity to output gap ($0 < \alpha < 1$)[2],
$i - \pi^e$	expression of real interest rate as a difference between nominal and expected inflation rate (here it is considered traditional simplification , when under the condition of low nominal interest rates and expected inflation rates values it is possible to abstract from term $r\pi^e$ in expression: $i = r + \pi^e + r\pi^e$,
β_B, β_r, β_R	are appropriate coefficients, and
ε_1	represents other demand factors (especially exogenous shocks)

Modified version of the Phillips curve represents the supply side. Modelling the supply side we can start from an original Phillips curve designed by Professor Phillips (1958) on the basis of empirical tests of annual data time series of the Great Britain:

$$\frac{W_t - W_{t-1}}{W_{t-1}} = w_t = \alpha + \beta u_t^{-c} \, , \tag{2}$$

This expression Samuelson and Solow (1960) adjusted by replacing wage rate growth by inflation rate. They supposed that the inflation rate grows if the wage growth exceeds labour productivity growth at the same time:

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}} = \frac{W_t - W_{t-1}}{W_{t-1}} - \frac{Q_t - Q_{t-1}}{Q_{t-1}} \, , \tag{3}$$

where:

π_t	means inflation rate in time t,
P_t	price level in time t, and
Q_t	labour productivity in time t.

Friedman (1968) and Phelps (1967, 1968) Phillips curve enrichment consist in categories like natural unemployment rate (u*) and expectation π_t^e:

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1 In this study the abbreviation "CAB" indicates the structural part of the budget deficit, not budget balance.

2 The values of budgetary sensitivities vary from 0,27 (Lithuania) to 0,65 (Denmark) in EU-25. Unweighted arithmetical mean is 0,44 in EU-25, the new EU countries (EU-10) reach on average lower budgetary sensitivity (0,36). Budgetary sensitivity of the Czech public finance was estimated as 0,37. (For details see European Commission (2005)).

$$\pi_t = \pi_t^e - \eta\left(u_t - u^*\right). \tag{4}$$

Next we extend the equation No. 4 by supply shocks (ε_2), add the difference between real and natural unemployment rate and from the Okun's law relationship

$$\left(u_t - u^*\right) = -\phi\left(\frac{Y_t - Y_t^*}{Y_t^*}\right)$$

we obtain formula No. 5[3]:

$$y_t = \beta_\pi\left(\pi_t - \pi_t^e\right) + \varepsilon_2. \tag{5}$$

By adding the change of exchange rate between two periods we receive extended Phillips curve for open economy, where β_π and γ and are coefficients implying influence of the expected inflation rate on output gap and of the import prices on the inflation rate and output gap:

$$y_t = \beta_\pi\left(\pi_t - \pi_t^e\right) + \gamma\Delta R_t + \varepsilon_2 \ . \tag{6}$$

For estimation of the fiscal authority reaction function let's simply modify equation No. 1, where we input decomposition of budget deficit to its cyclical and structural part:

$$y = \frac{1}{1-\beta_B\alpha}\left(\beta_B CAB - \beta_r\left(i - \pi^e\right) + \beta_R R + \varepsilon_1\right). \tag{7}$$

The reason of this step is a fact that we will study the effect of discretionary component of the budget deficit on output gap.

For further analysis a "loss" function of fiscal policy authority must be specified. Loss functions have been occurred as minimization of the second power of difference between selected variables and their targeted or claimed values. In this respect it is often used term "central bankers' loss function" that will be discussed in the next part of this paper. Of course, it is possible to develop fiscal authority loss function, e.g. to minimize output gap and structural deficit:

$$L\left(FP\right) = \left(CAB - CAB^*\right)^2 + \Theta\left(Y - Y^*\right)^2. \tag{8}$$

Before deriving own fiscal authority loss function it is convenient, for the purpose of our study, to analyze the European Union fiscal framework briefly.

2.2 European Union fiscal framework

All EU member countries must fulfil the Stability and Growth Pact (Pact) claiming not to exceed 3% reference value, in the case of government deficit (ESA 95 methodology), and 60% of government debt to GDP ratio (the same methodology). The numerical values are

3 Equation No. 5 expresses common formula for Lucas supply curve. See e.g. Hallett, Libich (2007).

determined by Protocol No. 20 on the Excessive Deficit Procedure (annexed to the Treaty on European Union).

EU countries, especially EMU countries, use fiscal rules for security against "free rider" behaviour of their neighbour countries. Without fiscal policy restraint (specifically deficits and debts) in the areas with common monetary policy the "free rider" is able to avoid higher costs – higher interest rates – or the possibility not to borrow (markets would expect too high interest rate or nobody would be willing to lend this government). Every member of the monetary union would fall for an "international moral hazard" – i.e. expectation that other member countries, in case of "free rider" insolvency, would make lend him owed money in order to maintain monetary union. There is also worth mentioning different influence on the common interest rate from economically different powerful member countries. The influence would by higher if the borrower is economically stronger than of economically "weaker" one. Briefly, fiscal policy rule restrains overflowing of negative externality effect.

Generally fiscal rule should serve most of all as framework for politicians, that reduces their behaviour during various phases of the political cycle and thus eliminates their impact on a business cycle. This should result into the public finance and economic stabilisation.

The three and sixty per cent upper limits of the Pact can be considered only as a short flexibility rule demonstration. In the Resolution of the Amsterdam European Council on the Stability and growth pact there is another measurement of the fiscal target – "close to balance or surplus" of the government sector budget. Further since 2005 there has been statement in the Council Regulation[4] about country-difference middle-terms goals[5] effective for those countries that accepted common currency or for ERM 2 members. Specific values of middle-term budget targets vary from -1% GDP to balance or surplus budget (after deduction of temporary and one-off measures).

Another flexibility expression seems to be a duty to take a cyclical position of the economy during excessive deficit procedure into account. In the original Pact statement[6] there was a decline in annual GDP considered as an exception only if the annual real GDP decrease was at least 2%, eventually if the decrease was lower the cumulated GDP loss or the intensity of decrease was considered.

In the "new Pact" there is considered every annual real GDP decrease or accumulated loss during long time period the economy operating under the potentional product as escape clause. [7]

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4 Council regulation 1055/2005 amending Regulation (EC) No 1466/97 on the strengthening of the surveillance of budgetary positions and the surveillance and coordination of economic policies.

5 Revision of the medium term fiscal framework is possible only if crucial structural reforms have been taken place in the observed economy, otherwise once a four years.

6 Article No. 2, Council Regulation (EC) No. 1467/97 on speeding up and clarifying the implementation of the excessive deficit.

7 Council Regulation No. 1056/2005, amending Regulation (EC) No 1467/97 of 7 July 1997 on speeding up and clarifying the implementation of the excessive deficit procedure.

Moreover in both Pact versions there are mentioned following escape clauses[8]: any unusual event that has negative impact on "government budgets financial situation" and that wasn't be able to change in any way or which was caused by "serious economic downturn" or when the European Commission finds breach of the 3% ceiling as temporary.
New version of the pact includes these additional escapes:

- adverse impact on public finance budgets caused by high cofinance of the European Union structural funds aid,
- whether the excess is temporary and deficit still remains close to 3% value,
- whether the country introduce pension system reform from PAYG scheme to fully funded (net pension reform costs can be "equivalently dissolved" during 5 years).

2.3 Derivation of the reaction functions

For simplicity we suppose that the 3% reference level value for deficit-to-GDP ratio is firstly the "entrance ticket" into excessive deficit procedure, which is ended by either deficit decrease back below 3% limit or, otherwise, by imposing the sanction (see box No. 1), secondly it is a signal towards financial markets, whose possible negative impact governments would like to avoid, and thirdly it is a short-term fiscal rule that is subject of our attention.

BOX No. 1 – Mechanism of the sanctions under the Stability and Growth Pact

Sanction mechanism is a part of the excessive deficit procedure (see table No. 1), whose basic mechanisms are described in article No. 104 of the Treaty on European Union establishment (Treaty) and closer developed in Council Regulation (EC) No. 1467/97 of 7 July 1997 on speeding up and clarifying the implementation of the excessive deficit procedure, amended by Council Regulation (EC) No. 1056/2005.

Table No. 1: Excessive deficit procedure in EU-25 (2002 – 2006)

Country	2002	2003	2004	2005	2006
Austria					
Belgium					
Cyprus	-	-			x
Czech Republic	-	-	x		
Denmark					
Estonia	-	-			
Finland					
France		x	x		
Germany	x		x		x
Greece			x	x	

8 *For various types of escape clauses see e.g. Pružvic (2005).*

Country	2002	2003	2004	2005	2006
Hungary	-	-	x	x	x
Ireland					
Italy					x
Latvia	-	-			
Lithuania	-	-			
Luxembourg					
Malta	-	-	x		
Netherland			x	x	
Poland	-	-	x		
Portugal	x				x
Slovakia	-	-	x		
Slovenia	-	-			
Spain					
Sweden					
United Kingdom			x	x	x
Total	2	1	10	4	6

Note: x denotes country where excessive deficit according to EU Council occurred; – mark for those countries that were not members of the EU in the observed year.
Source: European Commission (2006). Own adjustments.

In the paragraph No. 11 of the mentioned article No. 104 of the Treaty there are enumerated measures that EU Council can use according to its consideration (however till 4months since last EU Council call aimed at the member country to take corrective measures):

- "to require the Member State concerned to publish additional information, to be specified by the Council, before issuing bonds and securities;
- to invite the European Investment Bank to reconsider its lending policy towards the Member State concerned;
- to require the Member State concerned to make a non-interest bearing deposit of an appropriate size with the Community until the excessive deficit has, in the view of the Council, been corrected;
- to impose fines of an appropriate size."

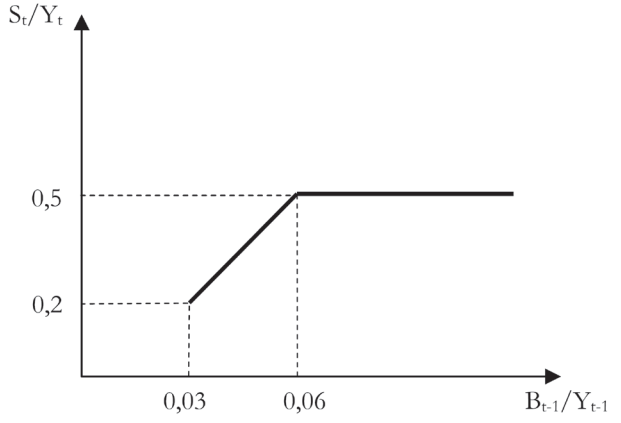
The EU Council should generally ask for non-interest bearing deposit in accordance with Council regulation (ES) No. 1467/97 (article 11).

The height of non-interest bearing deposit is then calculated as percentage of GDP, when no single sanction can exceed 0,5% GDP. The first imposed sanction equals to the sum of a fixed part (0,2% GDP) and flexible sanction part, which measures the degree of reference value exceed (deficit-to-GDP ratio in the last year, when excessive deficit occurred, is taken from 3% reference value and the difference is multiplied by coefficient 0,1). Algebraically speaking:

$$\frac{S_t}{Y_t} = \begin{cases} 0,2 + 0,1 \cdot \left(\frac{B_{t-1}}{Y_{t-1}} - 0,03 \right) \cdot 100 & pro \quad 0,03 \le \frac{B_{t-1}}{Y_{t-1}} \le 0,06 \\ 0,5 & pro \quad \frac{B_{t-1}}{Y_{t-1}} > 0,06 \end{cases}, \tag{9}$$

Picture No. 1 illustrates a development of the potential sanction (non-interest bearing deposit or fine) expressed as GDP ratio in relation to deficit-to-GDP ratio. Substituting maximal possible value of one sanction (0,5% GDP) for S_t into equation No. 9 it is obvious that the sanction corresponds to double deficit value than Stability and Growth Pact allows.

Picture No. 1: Relationship between first sanction and deficit



Source: Cabral (2001), p. 150. Own adjustments.

Next year the Council can decide after imposition of the non-interest bearing deposit sanction to tighten the sanction up as long as the member state donesn´t take adequate corrective measures according to Council requests. This additional deposit is than equal only to the flexible part, however the maximum limit is still valid. If the excessive deficit is not eliminated after two years of this kind of sanction, the Council can convert the deposit into a fine.

Only the Council can call off all above mentioned measures, if it comes to the conclusion that all necessary measures to eliminate the excessive deficit were done, however the deposit converted into the fine is not returnable.

All deposits are invested and interests, as well as fine eventually, are divided among other member countries without excessive deficit. The key for yields allocation is each member state share in total GDP of countries without excessive deficit.

There is no record in the Stability and Growth Pact history that a deposit, much less fine, was applied.

From the text above follows that governments should try to control public finance deficit (B_t) under specific reference value ($\overline{B}$), i.e. $B_t \leq \overline{B}$. Again, by reformulating overall government deficit by its cyclical and structural component we obtain $CAB_t - \alpha y_t \leq \overline{B}$, rearranging this equation we receive coveted fiscal authority loss function:

$$CAB_t \leq \overline{B} + \alpha y_t . \tag{10}$$

Thus governments should make an effort with their structural part of deficit not to exceed a sum of the reference value and cyclical deficit component.

Substituting equation No. 7 in the loss function equation (No. 10) we receive fiscal authority reaction function formula:

$$CAB \leq \overline{B} + \frac{\alpha}{1-\beta_B \alpha}\left[\beta_B CAB - \beta_r \left(i - \pi^e\right) + \beta_R R + \varepsilon_1\right], \tag{11}$$

subtracting CAB on the right equation side:

$$CAB \leq \frac{1-\beta_B \alpha}{1-2\beta_B \alpha}\overline{B} + \frac{\alpha\beta_R}{1-2\beta_B \alpha}R - \frac{\alpha\beta_r}{1-2\beta_B \alpha}\left(i - \pi^e\right) + \frac{\alpha}{1-2\beta_B \alpha}\varepsilon_1 . \tag{12}$$

Simplifying the term No. 12:

$$CAB \leq \rho\left(\frac{1}{\alpha} - \beta_B\right)\overline{B} + \rho\beta_R R - \rho\beta_r \left(i - \pi^e\right) + \rho\varepsilon_1 , \tag{13}$$

where $\rho = \frac{\alpha}{1-2\beta_B \alpha}$.

The term No. 13 is basic for fiscal authority reaction function illustration in the diagram of two instrumental variables of the economic policy: nominal interest rate and structural government budget deficit. A slope of fiscal authority reaction function is determined by fraction

$-\frac{1}{\rho\beta_r}$ and is negative if $\beta_B < \frac{1}{2\alpha}$.

The formula No. 13 shows that increment of the interest rate leads to decrease in structural budget deficit part (or to increase in structural surplus). Conversely, decline of nominal interest rate means possible raise (inequality in the term) of structural deficit component or increase of "manoeuvre" fiscal policy space. Fiscal authority reaction function also quantifies, how much lower must the structural part be to maintain deficit on its reference value (line), supposing it has reached this value, after the interest rate climbed up. An increase in a nominal interest rate by 1 p.p. must be compensated by decrease of *CAB* by

$\frac{\alpha\beta_r}{1+2\alpha\beta_B}$ units.

With similar adjustment we derive monetary authority reaction function. Our starting point is again to find the appropriate monetary policy loss function. According to literature surveys it is often defined as

$$L\left(MP\right) = \varpi_\pi \left(\pi_t - \pi^T\right)^2 + \varpi_E \left(E_t - E_{t-1}\right)^2$$

(see Mandel, Tomšík (2003), or Svensson (1999)), where ϖ_{π} and ϖ_{e} are weights expressing stress put by central bank on inflation target (π^T) or exchange rate, eventually on its change. In the economy with monetary policy strategy of targeting inflation (e.g. the Czech National Bank), we simply assume that such bank prefers to minimize gap of the inflation rate (π_t) and its targeted value (π^T):

$$L(MP) = \left(\pi_t - \pi^T\right)^2 \tag{14}$$

Having specified the loss central banker function let's start with further equation adjustments. At first we put to the equation No. 6 equation No. 7:

$$\varpi\left(\pi - \pi^e\right) + \gamma\Delta R + \varepsilon_2 = \frac{1}{1-\beta_B\alpha}\left(\beta_B CAB - \beta_r\left(i - \pi^e\right) + \beta_R R + \varepsilon_1\right) . \tag{15}$$

A follow up adjustment, interest rate subtracting to the right side and after loss function embody we receive equation No. 16:

$$i = \frac{1}{\beta_r}\left(\beta_B CAB + \varepsilon_1\right) + \frac{\left[\beta_R - \gamma\left(1-\beta_B\alpha\right)\right]R_t + \gamma\left(1-\beta_B\alpha\right)R_{t-1}}{\beta_r} + \\ + \pi^e\left(1 + \frac{\omega\left(1-\beta_B\alpha\right)}{\beta_r}\right) - \frac{1-\beta_B\alpha}{\beta_r}\left(\omega\pi^T + \varepsilon_2\right) \tag{16}$$

Making term No. 16 easier, where $\frac{1-\beta_B\alpha}{\beta_r} = \varphi$, we gain monetary policy authority reaction function:

$$i = \frac{1}{\beta_r}\left(\beta_B CAB + \varepsilon_1\right) + \left(\frac{\beta_R}{\beta_r} - \gamma\varphi\right)R_t + \gamma\varphi R_{t-1} + \pi^e\left(1 + \omega\varphi\right) - \varphi\left(\omega\pi^T + \varepsilon_2\right) \tag{17}$$

A slope of this function is positive, because $\beta_B > 0 \wedge \beta_r > 0$ that's way

$\frac{\beta_B}{\beta_r} > 0$.

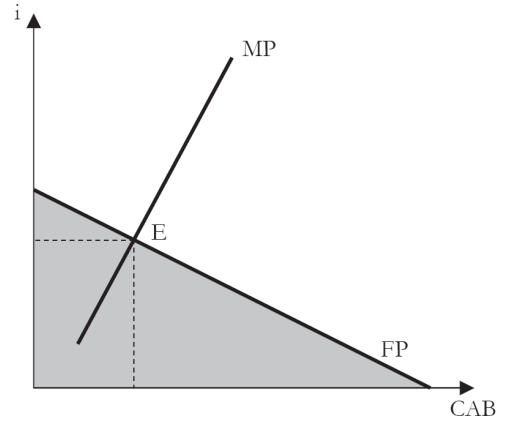
Equation No. 17 postulates that increase in structural budget deficit by one unit leads central bank to increase its interest rate by

$\frac{\beta_B}{\beta_r}$.

Central bank's reaction extent depends on the budgetary sensitivity and real interest rate sensitivity parameter.

Drawing both functions into one graph (picture No. 2) we can see positively sloped monetary policy reaction function and negatively sloped fiscal policy authority reaction function. The intersect of the both curves is an equilibrium E, which means there is no need to change a "policy" of any of the authorities, i.e. nominal interest rate and structural budget deficit of public finance as tools of the both policies are constant. Fiscal and monetary policy are in "steady state".

Picture No. 2: Fiscal and monetary policy reaction functions in a two instrumental variable graph ($\beta_B < 1/3\alpha$)

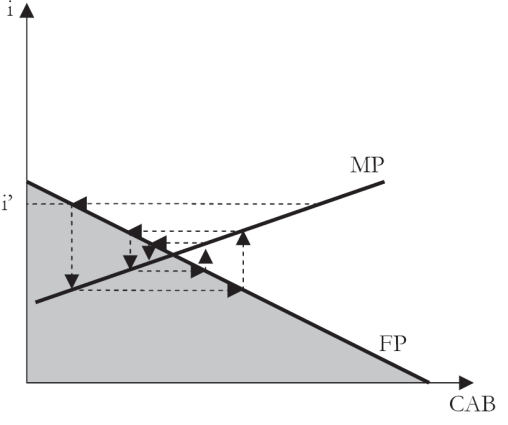


Source: Own.

3 The process of adjustment in the monetary and fiscal policy authority reaction functions model

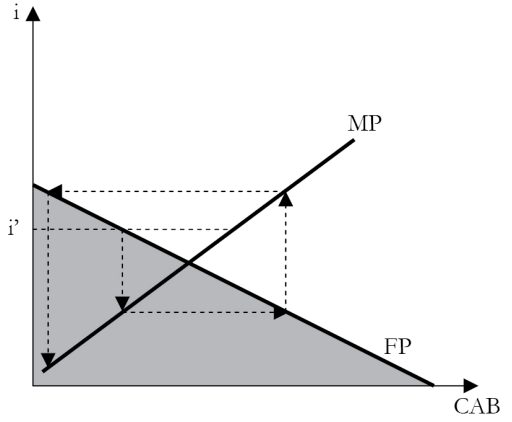
Before determination of the own adjustment process it is appropriate to compare slopes of the both reaction functions, while as we can see in picture No. 3 in this case the process of adjustment leads to the steady state point, on the other hand picture No. 4 shows the diverge process. Main difference between these two graphs is miscellaneous absolute value of the reaction function curve slopes. If the absolute value of the fiscal authority reaction function slope is higher than the monetary one, then the process converges, otherwise diverges.

Picture No. 3: Adjustment process in fiscal and monetary policy reaction functions in a two instrumental variable graph ($\beta_B < 1/3\alpha$)



Source: Own.

Picture No. 4: Adjustment process in fiscal and monetary policy reaction functions in a two instrumental variable graph ($1/3\alpha < \beta_B < 1/2\alpha$)



Source: Own.

Now let's compare the reaction functions slopes and let ask when the absolute value of the fiscal authority reaction function is higher than the monetary one:

$$\left| -\frac{1+2\alpha\beta_B}{\alpha\beta_r} \right| > \frac{\beta_B}{\beta_r} \quad . \tag{18}$$

Solving No. 18 term we achieve this result:

$$\beta_B \in \left(-\infty; \frac{1}{3\alpha} \right) \cup \left(\frac{1}{\alpha}; \infty \right) . \tag{19}$$

On the basis of empirical studies we can assume that $0 < \alpha < 1$, precisely that its value lies somewhere between one third and one half of this interval (see footnote above). The fiscal authority reaction function slope is thus higher provided that β_B parameter takes values between minus infinity and $1/3\alpha$, while in this interval the curve's slope is descending (proof:

$-\frac{1+2\alpha\beta_B}{\alpha\beta_r} < 0$, which is $\beta_B < \frac{1}{2\alpha}$,

whose value exceed the first interval value of the No. 19 term), or values between $1/\alpha$ and plus infinity, where the slope is positive (the proof is analogous with opposite inequality sign).

In the other cases, i.e. $\beta_B \in \left\langle \frac{1}{3\alpha}; \frac{1}{\alpha} \right\rangle$,

the result is divergent and whatever deflection from the steady state doesn't lead to this equilibrium again.

Let's briefly describe a hypothetical adjustment process in the picture No. 3. If central bank raises nominal interest rate above the equilibrium ones, for example because of target

overshooting expectation, government would decline the structural budget component, if limited (our case) by deficit fiscal policy rule and simultaneously if it lies on the limit border. The decrease of the structural deficit part provokes cut in nominal interest rate, which is now higher than equilibrium interest rate. Fiscal policy authority can react (the word "can" represents inequality sign in the term No. 13) by increasing structural deficit component (extension of "manoeuvre government space"). Growing structural deficit part induces in central bank's "mechanism" a need to increase interest rate being afraid of inflation rate growth; however the interest rate rise is not as robust as in the first case. The adjustment process still repeats, while "instrumental variables" values continuously approximate to i and CAB values of the steady state. There is only one point in the graph where no variable tends to change – E.

4 Exogenous variables impact

Table No. 2 sums up impacts of various exogenous variables from the model on the fiscal authority reaction functions.

Table No. 2: Exogenous variables impact on fiscal policy authority decision on structural deficit change

	ε_1	**R**	Π^E
FP	ρ	$\rho\beta_R$	$\rho\beta_r$

Note: For an increase in structural deficit component holds $\beta_B < 1/2\alpha$.
Source: Own.

There is obvious according to signs at single "shocks" from the table that exchange rate depreciation, expected inflation rate growth or exogenous positive demand shock influence public finance positively – they increase manoeuvre space for fiscal policy, eventually allow the government deficit to growth. But this conclusion is valid only if

$$\beta_B < \frac{1}{2\alpha} \ .$$

Otherwise the impact of exogenous variables is inverse.

Next there are shortly described channels, which exogenous variables change causes the fiscal policy instrumental variable change through. The real exchange rate affect through the net export – change of the real exchange rate causes multiplied change of the real product, i.e. change of the output gap that has an effect on cyclical part of public budgetary deficit. The same channel is used by demand shocks. Expected inflation rate influences the structural deficit through the real interest rate and then investments expenditures and product.

Table No. 3 presents, what level and direction of change of the nominal interest rate is caused by exogenous factors in central bank reaction function.

Table No. 3: Exogenous variables impact on monetary policy authority decision on nominal interest rate

	ε_1	ε_2	R_T	R_{T-1}	Π^e
MP	$\frac{\beta_B}{\beta_r}$	$-\varphi$	$\frac{\beta_R}{\beta_r}-\gamma\varphi$	$\gamma\varphi$	$1-\varphi\omega$
Valid for	always	$\beta_B < \frac{1}{\alpha}$	$\beta_B > \frac{1}{\alpha}\left(1-\frac{\beta_R}{\gamma}\right)$	$\beta_B < \frac{1}{\alpha}$	$\beta_B > 1-\frac{\beta_r}{\omega\alpha}$

Note: Positive value means increase in nominal interest rate; negative its decline, however always under the valid condition in the last row of the table.
Source: Own.

The negative supply shock means nominal interest rate growth as we can see in the table, identically depreciation of the exchange rate in the last period (influence of imported goods prices), holding

$$\beta_B < \frac{1}{\alpha} \ .$$

But at the current real exchange rate and expected inflation rate there is a complication, because of too many unknown parameters that don´t allow precisely to determine the direction of change. A real impact is not obvious. Appreciation of the current real exchange rate would reduce nominal interest rate, if

$$\beta_B > \frac{1}{\alpha}\left(1-\frac{\beta_R}{\gamma}\right) \ .$$

Similarly smaller inflation expectation would have the same direction of change if

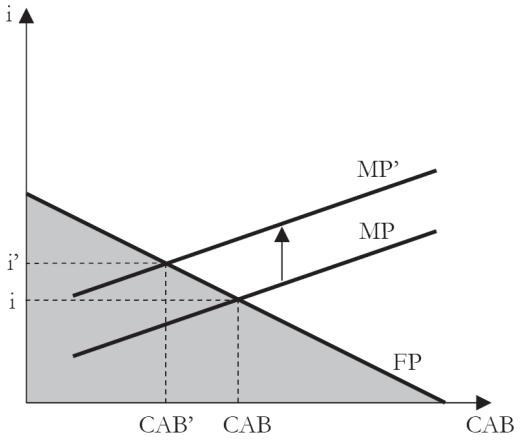
$$\beta_B > 1-\frac{\beta_r}{\omega\alpha} \ .$$

On the other hand the demand shock seems to be least problematic, because $\beta_B > 0 \wedge \beta_r > 0$ then

$$\frac{\beta_B}{\beta_r} > 0 \ .$$

Negative demand shock would press central bank to decline nominal interest rate, whereas positive one to raise it.

Picture No. 5: Negative supply shock in fiscal and monetary policy reaction functions in a two instrumental variable graph ($\beta_B < 1/3\alpha$)



Source: Own.

It is possible to summarize that all exogenous variables affecting fiscal reaction function and supply shock and real exchange rate from previous period affecting monetary policy authority reaction function have the direction of variable change indicated by corresponding sign always, when the fiscal policy reaction function curve is negatively sloped.

5 Interaction between common monetary and national fiscal policy

After the entrance into the Economic and monetary union the economy obtains except common currency common monetary as well. Article No. 2 of the Treaty on European Union establishment among others defines that "The Community shall have as its task … to promote … sustainable and non-inflationary growth…". Monetary policy is then closer specified in the Head VII. of the Treaty ("Economic and monetary policy"), chapter II. ("Monetary policy"), article No. 105, paragraph 1 says that "the primary objective of the ESCB shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community…". The Governing Council of the European Central Bank approved price stability criteria: "Price stability shall be defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%" (ECB (1998)). In 2003 Governing Council monetary policy strategy reconfirmed and added a request to "maintain inflation rates close to 2% over the medium term" (ECB (2003)).

Putting aside main pillars of the ECB monetary-policy strategy and its tools let's discuss targeted aggregate HICP. Harmonised index of consumer prices is a Laspeyer's kind which compares prices of constant consumer basket in time. Harmonisation of various national consumer price indices has unified internationally different product groups or representative products and their weights. HICP for the whole euro zone is then calculated as a sum of the weighted HICP, where weights are member country´s final monetary expenditures of households to total euro zone final monetary households' expenditures ratios:

$$\pi_{EUR} = \sum_{i=1}^{n} \frac{C_i}{\sum_{i=1}^{n} C_i} \pi_i \ , \qquad (20)$$

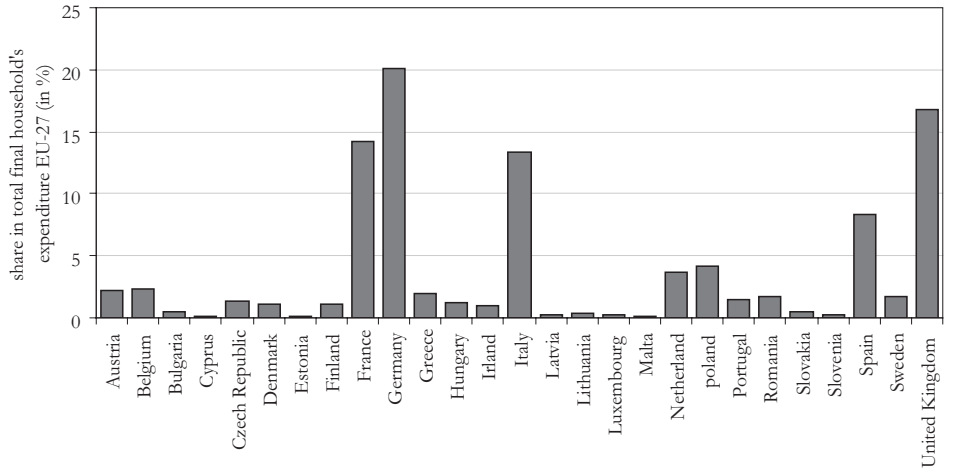
where:

π_{EUR} is harmonised consumer prices index in the euro zone,
π_i harmonised consumer prices index in the i-th euro zone's economy,
C_i final monetary households' expenditures of the i-th euro zone's economy,
n number of countries in the euro zone.

Next two pictures display the European Union weights in HICP calculated for the whole EU-27 and for EU-13 plus the Czech Republic (note: weights relates to 2006). The Czech Republic participates in total EU-27 HICP with only 1,31% (see picture No. 6). The highest shares belongs to German economy (20,1%), then the United Kingdom (16,7%), France (14,2%) and Italy (13,3%); lowest shares to Estonia, Lithuania, Latvia and "island states" Cyprus and Malta. This picture also shows that EU-27 can be separated into 2 groups – those that affect total HICP noticeably and those that have only insignificant influence. Realizing high correlation between final consumption expenditure ratio and shares in total EU-27 GDP (coefficient of correlation: 0,99), final partitions are not surprise.

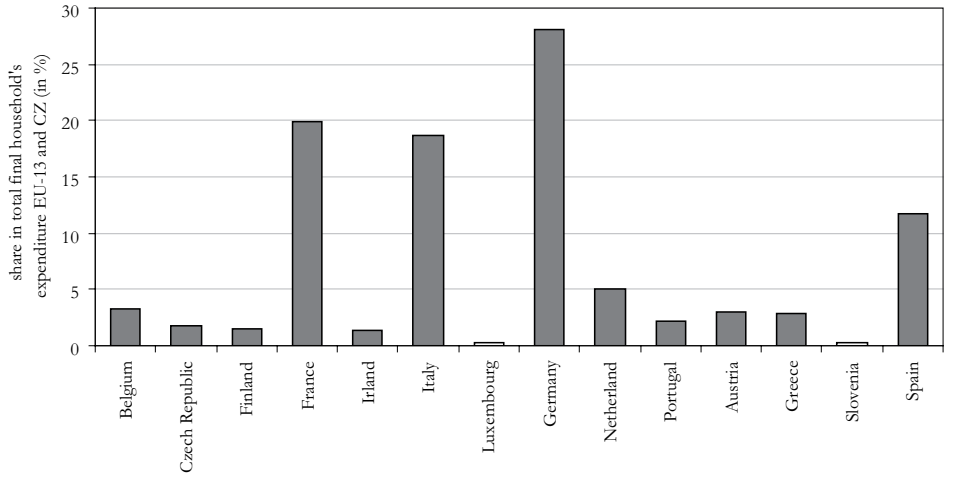
Second picture (No. 7) shows the hypothetical Czech Republic share in euro zone HICP, if the Czech Republic had already participated in the common currency project in 2006. Nor in this case the influence of the Czech inflation rate measured by HICP is high (1,8%). This short analysis can be finalized by partial conclusion about Czech inflation rate taken into account by the European central bank's reference interest rate. The Czech Republic can't expect considerable ECB reaction on domestic inflation development after enter the Economic and monetary union. Instead, reference interest rate will be conformed to inflationary and economic development in the largest and economically strongest euro zone economies.

Picture No. 6: The EU member countries HICP shares in the EU-27 total (2006)



Source: European Commission (2007). Own calculations and adjustments.

Picture No. 7: The EU-13 euro zone member countries´ and the Czech Republic's HICP shares in the euro area plus (2006)



Source: European Commission (2007). Own calculations and adjustments.

Now we can come to derive the European Central Bank loss function formula:

$$L(ECB) = \left(\pi_{EUR} - \pi^{T}\right)^{2}, \tag{21}$$

substituting π_{EUR} for decomposition of the Harmonised index of consumer prices and special expression of inflation rate in the Czech Republic:

$$L(ECB) = \left(\left(\sum_{i=1}^{n-1} \frac{C_i}{\sum_{i=1}^{n} C_i} \pi_i + \frac{C_{CZ}}{\sum_{i=1}^{n} C_i} \pi_{CZ} \right) - 2 \right)^{2} . \tag{22}$$

Thanks to the first derivation of the ECB loss function (equation No. 22) we find out minimum of this function and by expressing the Czech inflation rate we receive No. 23 term:

$$\pi_{CZ} = \left(2 - \sum_{i=1}^{n-1} \frac{C_i}{\sum_{i=1}^{n} C_i} \pi_i \right) \frac{\sum_{i=1}^{n} C_i}{C_{CZ}} . \tag{23}$$

This is again the initial expression for the construction of common monetary authority reaction function. Progress is similar to No. 16 term derivation. But in the first place we

have to distinguish national effects from other euro zone member countries effects (ε_3) on the European reference interest rate:

$$i_{EUR} = \frac{\beta_B}{\beta_r}\frac{Y_{CZ}}{\sum_{i=1}^{n} Y_i} CAB_{CZ} + \frac{1}{\beta_r}\frac{Y_{CZ}}{\sum_{i=1}^{n} Y_i}\varepsilon_1 + \left(\frac{\beta_R}{\beta_r} - \gamma\varphi\right)\frac{X_{CZ}}{\sum_{i=1}^{n} X_i} R_t + \gamma\varphi\frac{X_{CZ}}{\sum_{i=1}^{n} X_i} R_{t-1} +$$

$$+\left(1+\omega\varphi\right)\frac{C_{CZ}}{\sum_{i=1}^{n} C_i}\pi^e_{CZ} - \varphi\omega\left(2 - \sum_{i=1}^{n-1}\frac{C_i}{\sum_{i=1}^{n} C_i}\pi_i\right)\frac{\sum_{i=1}^{n} C_i}{C_{CZ}} + \varphi\frac{Y_{CZ}}{\sum_{i=1}^{n} Y_i}\varepsilon_2 + \varepsilon_3 \qquad (24)$$

We suppose in the ECB's reaction function equation from the „Czech economy view" that its reaction on government sector deficit/surplus is given by the size of the economy, the same assumption we have introduced at demand and supply shocks (ε1 and ε2). The exchange rate of each economy is weighted by its share in the euro zone total export to non-euro zone member countries. And the inflation rate, as well as the expected inflation rate, is according to mechanism of the HICP calculation weighted by their final monetary household consumption expenditure shares in the euro zone total. For simplicity we have concentrated the influences of the other euro area member countries variables including their weights into one summary variable ε3, because they are not a primary subject of our interest.

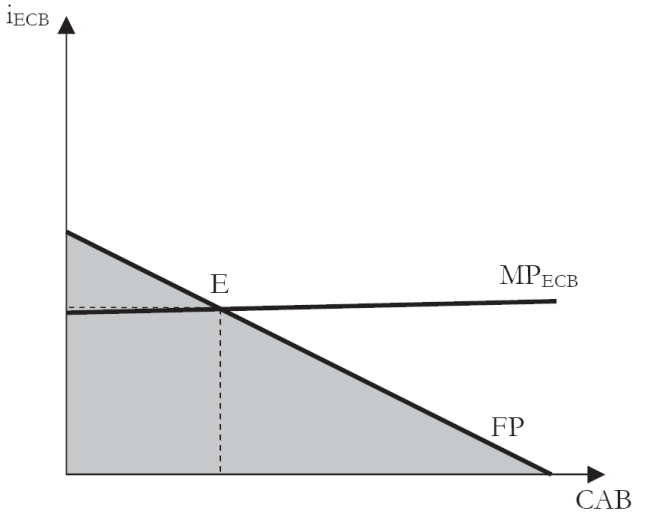
5.1 Interaction of current monetary policy and national fiscal policy in a two instrumental variables model

Drawing derived ECB's reaction function, converted into a relationship of euro zone reference interest value and the Czech national macroeconomic aggregates, together with the Czech national fiscal policy authority into two instrumental variables graph we obtain a similar picture to the interaction between national fiscal and national monetary policy one. At the first sight there is significant difference in the European monetary authority reaction function slope, which is much flatter than in the picture No. 2, because

$$Y_{CZ} < \sum_{i=1}^{n} Y_i ,$$

i.e. the Czech GDP to euro zone GDP ratio is lower than 1. Generally the higher the country's share in euro zone GDP total, the more intensive European Central Bank reaction on the changes in public finance balance of the specific economy will be. If for example this share of the Czech economy equals to less than 1% (in EU-27) or 1,3% (in EU-13 plus Czech Republic), it can't be expected more powerful reaction from the ECB. That's way common monetary authority reaction curve is drawn as nearly parallel to x axis in the picture No. 8.

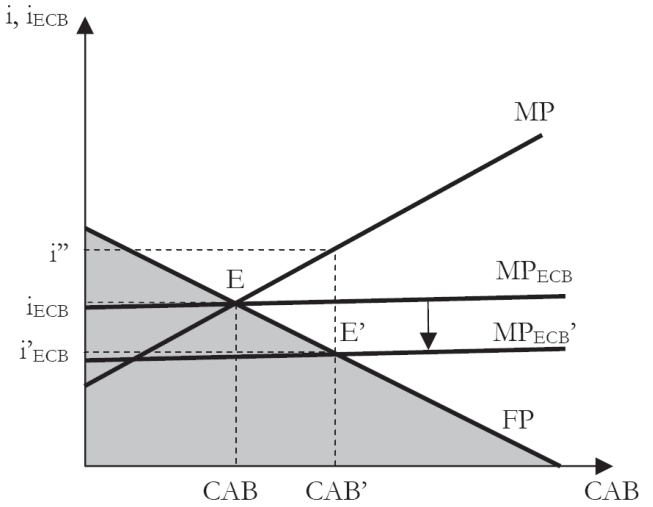
Picture No. 8: National fiscal and common monetary policy reaction functions in a two instrumental variable graph in a small economy ($\beta_B < 1/3\alpha$)



Source: Own.

If the central bank doesn't follow conditions in the small economies, it is necessary either their business cycle to be sufficiently harmonised with the largest economies or the fiscal policy must have sufficient space for business cycle corrections. Even though loosen "leading-reins" of the national fiscal policy is twofold. Let's imagine small open economy as a part of a monetary union. Common monetary policy authority decides on the basis of large economies fiscal positions assessment to decrease reference interest rate. This in our graph of one national and the second supranational reaction function causes a shift of common monetary authority reaction function curve down. Next suppose that monetary policy is effective and that reference interest rate decrease leads to the drop of the market interest rate in the monetary union. Under the "ordinal" circumstances, when the monetary policy is just national not supranational and would target only the domestic inflation rate, the interest rate wouldn't decline. New (lower) interest rate thus enables governments to increase their deficit due to reduction of the debt service costs. In the former graph the central bank would raise interest rate till i" as a reaction on the higher deficit (CAB') and gradually, through the adjustment process described above, the instrumental variables values would tend into the original steady state E. But in the case of supranational common monetary authority the new equilibrium point is E', which allows, thanks to i', all governments to increase their deficits just because they are part of the monetary union. Our case, illustrated in picture No. 9, has the advantage that this possible "free rider" problem of the small economies is reduced by introduced fiscal policy rule and supposing governments strictly keep in line it the risk of inappropriate deficit behaviour of the fiscal authorities is limited.

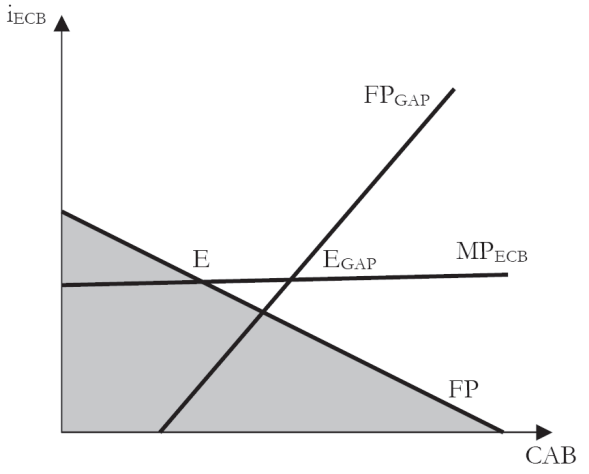
Picture No. 9: Impact of large economies´ government deficits decrease in monetary union in a graph of two instrumental variables of national fiscal authority reaction function and common monetary policy authority reaction function ($\beta_B < 1/3\alpha$)



Source: Own.

Also it is possible to illustrate the situation without fiscal rule. The last picture (No. 10) indicates possible development of the fiscal authority reaction function, if the authority reacts on the output gap deviation (this case in detail analyses the already mentioned study of Buti, Roeger, Veld (2001)) and is not restricted by a fiscal policy rule (FP_{GAP}). For the comparison purpose we let drawn the original fiscal policy reaction function (note: the development of the curves is only illustrative). We would like to demonstrate the fact that without a rule restraint fiscal policy in a small economy can reach by the nearly constant (or independent on the domestic market economy development) interest rates the sizeable deficit volumes without credit sources becoming more expensive.

Picture No. 10: Graph of the national fiscal authority output gap reaction function, the national fiscal authority reaction function with a fiscal rule and the common monetary authority reaction function in a small economy



Source: Own.

6 Conclusion

This study was a view of the world of interaction between two "non-crown economic policy queens" – fiscal and monetary policy. For study of their interaction we developed model for open economies, because we wanted to describe the Czech economy features better, and that illustrates reactions of each authority based on their loss functions. In the case of monetary authority there is an effort of the central banker to minimize the difference between the true inflation rate and the targeted one (loss function was chosen according to monetary policy regime of the Czech National Bank). The government, on the other hand, must in our model follow the rules of the Stability and Growth Pact. Taking into account especially the short-run, its loss function can be determined as an attempt not to exceed maximal 3% reference value given by the Stability and Growth Pact. We suppose that government uses structural deficit component as a tool.

Derived curves of the fiscal and monetary policy reaction functions were illustrated in the graph of the instrumental variables (i.e. structural deficit and nominal interest rate), where was shown under what condition the adjustment process will converge or diverge. It was demonstrated that the explanation lays in the comparison of the authority reaction functions slopes – if the absolute value of the fiscal authority reaction function is higher than the monetary one, the process will converge, in all other case diverge. Thanks to reaction functions coefficients we could calculate intervals giving answers where the absolute value of fiscal reaction function slope is higher or lower.

Also exogenous variables from the reaction functions have an important impact. In the graph of the two instrumental variables we could demonstrate their impact as a shift

of the curve. The fiscal reaction function exogenous variables impact specified by the concrete sign is valid when the fiscal reaction function curve is negatively sloped. Similar conclusion is drawn on the supply shocks and the previous period exchange rate, which both affect monetary authority reaction function. Negative demand shock cuts down the nominal interest rate and on the contrary. The direction of other exogenous factors impact can't be simply identified without knowledge of all parameters.

After enter the Economic and monetary union the Czech Republic will have to accept, except the common currency, the common monetary policy as well, which means to take over the reference interest rate determinated for the whole zone. Even if the monetary policy strategy of the common monetary policy performed by the European Central Bank is also based on inflation targeting, closely specified as maintaining of the year-to-year harmonised index of consumer prices below but close to 2%, it can't be expected that the intensity of ECB reaction on any another development taking place only in the Czech economy will have the same intensity as nowadays. The common monetary policy reaction function curve thus becomes nearly horizontal in the graph of two instrumental variables, i.e. nearly insensitive to changes in the Czech public finance. Next this kind of economy can profit by the interest rate decline in such an union. These two arguments are justification for a fiscal policy rule introduction that partly reduces the problems of "free rider" and moral hazardous of the economies.

However, the interaction between fiscal and monetary policy is effective just at that time, when authorities' reaction functions or authorities' loss functions are effectively followed. Without the rules observation, reaction function changes itself and equilibrium variable values including the process of adjustment become different.

Abstract

The study discusses central bank's and government's behaviour in a small open economy with a strong autonomous monetary policy and fiscal policy restricted by fiscal policy rule.

Composed model thus fully corresponds to the Czech reality, where the Czech National Bank's independency is evaluated as a very strong one, its monetary-policy regime is inflation targeting and Czech public finance, or the General Government Sector's finance (according to the system of national accounts ESA 95), must follow fiscal policy rules of the Stability and Growth Pact. It simply claims deficits not to exceed the 3% level of GDP and public debt should remain below the 60% of GDP limit. Because the Czech economy is not confronted with the "excessive debt" problem and it seems it won't be for a few years, the analysis focuses an attention especially on deficit limit criteria. The last part of the study is denoted to the common monetary policy and individual fiscal policy problematic, again from the small open economy point of view.

The study could contribute to solution of the question, what fiscal policy should be practiced before and after the Economic and Monetary Union entrance.

Keywords

Fiscal Policy, Monetary Policy, Fiscal Policy Rule, Monetary Policy Rule, Interaction, Open Economy, Inflation Targeting

JEL classification / JEL klasifikace
E52, E58, E61, E62

Souhrn
Studie se zabývá chováním centrální banky a vlády v malé otevřené ekonomice s výrazně autonomní měnovou politikou a fiskální politikou omezenou fiskálním pravidlem. Sestavený model tak plně koresponduje s českou realitou, kdy nezávislost České národní banky je hodnocena jako poměrně vysoká, jejím měnově-politickým režimem je cílování inflace, a české veřejné rozpočty, respektive finance sektoru vládních institucí, v terminologii systému národních účtů, podléhají fiskálním pravidlům Paktu stability a růstu, jenž ve zjednodušené formě požaduje vyvarovat se nadměrným deficitům stanoveným na úrovni 3 % HDP a nepřekročit hodnotu dluhové kvóty ve výši 60 %. Protože česká soustava veřejných financí není v současné době konfrontována problémem překročení referenční hodnoty podílu dluhu na HDP a zřejmě několik let nebude, soustřeďuje se analýza zejména na kritérium deficitní. Poslední část je věnována problematice interakce společné měnové politiky Hospodářské a měnové unie a individuální politiky fiskální, opět z pohledu malé ekonomiky.

Výstup studie může přispět k řešení otázky, jakou fiskální politiku provádět před a po vstupu do Hospodářské a měnové unie, ve které Evropská centrální banka plní pro všechny členské státy shodnou měnově-politickou úlohu.

Klíčová slova
Fiskální politika, měnová politika, fiskální pravidlo, monetární pravidlo, koordinace, otevřená ekonomika, cílování inflace

Kontaktní adresa / Contact address
Ing. David Prušvic
Katedra veřejných financí, Fakulta financí a účetnictví, Vysoká škola ekonomická v Praze, a Výzkumný ústav práce a sociálních věcí.
(e-mail: prusvicd@vse.cz)

Ing. David Prušvic
Je absolventem oboru Hospodářská politika a správa na Fakultě národohospodářské VŠE v Praze. Od roku 2004 je studentem doktorského studia oboru Finance na katedře veřejných financí Fakulty financí a účetnictví Vysoké školy ekonomické v Praze. Do července t. r. působil jako výzkumný pracovník v odboru příjmové a mzdové politiky ve Výzkumném ústavu práce a sociálních věcí. V současné době pracuje jako analytik na MF ČR, odbor finanční politiky, odd. makroekonomických predikcí.

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4. místo – Cena profesora Františka Vencovského

Monetary Policy Stance and Future Inflation: The Case of Czech Republic

Měnová politika a budoucí inflace: Evidence pro Českou republiku

ROMAN HORVÁTH*

1 Introduction

Inflation targeting regimes are increasingly popular around the world. For example, regarding the Central and Eastern Europe while the first two countries adopted explicit inflation targeting regime in 1998, there are already seven countries conducting inflation targeting in 2006 and others are contemplating to do so (International Monetary Fund, 2006).[1] A characteristic feature of inflation targeting is that central banks set short-term nominal interest rate in the way to get inflation and output at their targeted levels. The level of interest rates that is associated with this objective is often labeled as policy neutral rate.

In this regard, Woodford (2003) notes that central banks should on average track policy neutral rate to stabilize the economy. In a similar fashion, Taylor (1999) emphasizes that the measurement of policy neutral rate is one of key issues for countries targeting inflation. In this respect, it is of great importance for central banks to identify as precisely as possible the policy neutral rate. This is quite intricate exercise, as the policy neutral rate is unobservable; however its mis-measurement is high-priced, as it likely results in over- or undershooting the inflation target.

In this light, it is quite striking that remarkably little evidence is available for Central and Eastern European Countries (CEECs) on the estimation of policy neutral rate. While there are dozens of studies on *equilibrium exchange rates* in the EU new members, there is surprisingly very little evidence on *equilibrium interest rates* (Brzoza-Brzezina, 2006, seem to the only exception with evidence on Poland). This imbalance is rather paradoxical, as half of EU new members target inflation (Czech Republic, Hungary, Poland, Romania and Slovakia), for which the concept as well as measurement of policy neutral rate is of primary importance for the conduct of monetary policy.[2] Consequently, this paper tries to bridge this gap.

* *Czech National Bank and Institute of Economic Studies, Charles University (Prague). All remaining errors are entirely my own. The views expressed in this paper are not necessarily those of the Czech National Bank.*

1 *Czech Republic and Poland adopted inflation targeting in 1998, followed by Hungary in 2001, Romania and Slovakia in 2005 and Armenia and Serbia in 2006 (note this is an updated list of Table 1 in IMF, 2006). Ukraine is likely to adopt inflation targeting in near future (IMF, 2006).*

2 *See Coats et al. (2003) and Kotlan and Navratil (2003) on Czech monetary policy.*

This paper addresses the issue of policy neutral rate estimation in one of EU new member states, the Czech Republic, based on various specifications of simple Taylor-type monetary policy rules. Former transition country provides an interesting case to evaluate policy neutral interest rate, as one can expect certain pattern in the path of nominal and real equilibrium interest rates over longer time horizon (note that policy neutral rate is in fact short-term nominal equilibrium interest rate, more on definitions below).

Lipschitz et al. (2006) points out that at the outset of transition the capital/labor ratios were much lower than those in Western Europe and therefore the marginal product of capital and for that reason real equilibrium interest rate was rather high. Given the capital accumulation over the course of transition, there should be tendency for the real equilibrium interest rate to decrease. From open economy perspective, EU new members exhibited a fall of exchange rate risk premium during their transition process to market economy (Beneš and N'Diaye, 2004), which also puts a downward pressure on real equilibrium interest rates (Archibald and Hunter, 2001). Analogously, it is a well-documented empirical regularity that these countries exhibit real equilibrium exchange rate appreciation (see Égert et al., 2006 for a comprehensive survey of the sources of appreciation). A decrease in foreign equilibrium interest rate, which is reported by several authors for the euro area (e.g. Wintr et al., 2005), may, especially in small open economy, reduce the level of domestic equilibrium interest rate as well. Additionally, the path of nominal equilibrium interest rates should reflect not only the decrease of real equilibrium rates, but also successful disinflation in transition countries (see Korhonen and Wachtel, 2006). All in all, aforementioned arguments provide rationale to model policy neutral rate as time-varying.

In this paper we provide first the estimation of monetary policy rules with time-varying intercept to assess the fluctuations of policy neutral interest rate over time. The novelty of our approach lies in estimation of policy neutral rate by the time-varying parameter model with endogenous regressors (Kim, 2006).[3] Unlike 'conventional' time-varying parameter model, this approach is robust to endogeneity of explanatory variables, which is indeed relevant when estimating the monetary policy rules. Additional feature of this paper is that we utilize ex-post as well as real-time based data (see e.g. Orphanides, 2001, on real-time data analysis within monetary policy rules framework), specifically the real-time output gap and real-time inflation forecast of Czech National Bank's (CNB) to estimate the monetary policy rules.

One of our primary policy applications, except for measuring policy neutral rate by the novel technique, is also proposing a measure of monetary policy stance based on a deviation of actual interest rate from policy neutral rate. Anticipating our results, we find this measure of monetary policy stance quite useful in predicting both the level as well as change of future inflation rate.

The paper is organized as follows. Section 2 discusses the related literature. Section 3 describes our data and empirical methodology. Section 4 gives the results on the estimation of time-varying estimates of policy neutral rate as well as analysis of ability of monetary

3 Note that in working paper version of Kim (2006), this procedure is also labeled as augmented Kalman filter.

policy stance to predict future inflation developments. Section 5 concludes. Appendix with additional results follows.

2 Related Literature

2.1 Methodological Background

It has been acknowledged in monetary economics for a long time that there exists some unobservable real interest rate that equilibrates aggregate demand and aggregate supply (Woodford, 2003). When actual real interest rate is equal to the unobservable, price stability is achieved. This unobservable rate is often labeled as natural rate of interest or equilibrium interest rate. Equivalently, it has been noted that equilibrium interest rate is the real interest rate that prevails, when prices are fully flexible in all markets (Neiss and Nelson, 2003; Woodford, 2003).

Consequently, equilibrium interest rate or natural rate of interest is fairly general concept and in principle, it may be well associated both with short-term, medium-term or long-term interest rates. In this context, it is worth pointing out that the determinants of equilibrium interest rate are likely to differ according to time horizon (different frequency movements). In the long-term, the level of equilibrium interest rate is influenced by supply-side structural characteristics of economy such as long-run growth potential, which in turn depends on technological progress, population growth and inter-temporal substitution of consumption (Crespo-Cuaresma et al., 2005). In the medium-term, equilibrium interest rate is associated with business cycle. In the short-term, equilibrium interest rate is linked merely to demand factors related to monetary policy and its targeting horizon (Archibald and Hunter, 2001). Here monetary policy may systematically effect inflation expectations and in turn the level of short-term nominal equilibrium rate.

For the purposes of monetary policy conduct, it is vital to know which level of interest rate monetary authority should set in order to achieve price stability (i.e. neutral policy stance). As the primary monetary policy instrument is the level of short-term interest rate, equilibrium interest rate in this context is rather short-term concept and is often labeled as policy neutral rate (Coats et al., 2003; Lam and Tkacz, 2004; Beneš et al., 2005). Policy neutral rate thus represents nominal equilibrium interest rate and is defined as real equilibrium interest rate plus expected inflation (Coats et al., 2003). In other words, policy neutral rate is linked to short-term nominal interest rate over which central bank has substantial control and thus, policy neutral rate may be understood as a bit narrower concept in comparison to equilibrium interest rate and natural rate of interest.[4]

Shall interest rate policy of monetary authority strictly follow the neutral rate, when targeting inflation? Not necessarily. First point is that obviously there is uncertainty in policy neutral rate measurement. Second, more importantly, there are shocks to which is suboptimal for the authority to react. More specifically, central banks deliberately do not react

4 *For convenience, we use policy neutral rate, natural rate of interest and equilibrium interest rate in the following text interchangeably to a certain extent. However, when we want to emphasize the short-run concept of it, we always use the term policy neutral rate.*

to the first-round effects of cost-push shocks, as this can be destabilizing the economy in the short run. This may however alter inflation expectation of economic agents, if some fraction of them is myopic, and as a result, induce a change in policy neutral rate. In such case, central bank interest rate policy may temporarily deviate from policy neutral rate.

2.2 Methods for Natural Rate of Interest Estimation

Generally, there are several main methods to estimate the natural rate of interest (see e.g. Giammarioli and Valla, 2004, for survey).[5] The simplest is to assume that the equilibrium is captured reasonably well by some univariate trend such as HP filter. Nevertheless, a number of papers document that the estimates based on these filters is often misleading (Clark and Kozicki, 2005). In general, the limitations of the univariate methods have been pointed out by many authors (e.g. Canova, 1998).

Another method to derive equilibrium interest rates is based on the estimation of simple monetary policy rule of central bank (Taylor, 1993). The reaction function typically associates short-term interest rates to its lagged value, a difference between inflation (forecast) and its target, and output gap. The intercept of the estimated reaction function can be interpreted as the nominal equilibrium interest rate (this is, the interest rate that would prevail when inflation and output are at their targeted values). This method has been applied to estimate the equilibrium interest rates by e.g. Clarida et al. (1998, 2000) and Orphanides (2001) for the United States and Germany, Adam et al. (2005) for the United Kingdom and Gerdesmeier and Roffia (2004, 2005) for the euro area. Nevertheless, the assumption of constant equilibrium interest rates is often found too restrictive over the longer-term horizon (for example, when there is a change in monetary policy strategy). Consequently, it is possible to model the equilibrium interest rate, or more generally monetary policy rule as time-varying (see Plantier and Scrimgeour, 2002, Elkhoury, 2006 and Kim and Nelson, 2006). Typically, these studies find rationale to model the rule as time-varying, given that the equilibrium interest rate sometimes fluctuates considerably over longer time horizons (as well as other parameters in policy rule). Generally, the monetary policy rules approach measures the behavior of central bank and assumes that central bank estimates equilibrium interest rates correctly. In case of central bank's systematic mis-measurement of equilibrium rates, it is likely that equilibrium rates retrieved from the estimation of reaction function are mis-measured as well.

Structural time series models represent another common method to measure equilibrium interest rates as well. The primary contribution in this area is Laubach and Williams (2003), who formulate a simple empirical model containing IS curve, Phillips curve and an equation linking equilibrium interest rate to trend growth, and model equilibrium interest rates and potential output as unobserved components. Their method has gained popularity recently and has been applied by Manrique and Marques (2004) for the U.S. and Germany, Mesonnier

5 *Note that we do not present the exhaustive list of methods for equilibrium interest rate estimation, e.g. Brzoza-Brzezina (2006) proposes structural vector autoregression model in this regard. In general, the role of equilibrium interest rate for monetary policy conduct is discussed extensively by Taylor (1993), Woodford (2003) or Amato (2005).*

and Renne (2007) for the euro area and Wintr, Guarda and Rouabah (2005) for the euro area[6] and Luxembourg as well. In principle, the joint estimation of equilibrium interest rates and output gap is an advantage of this approach; however it also reduces the degrees of freedom, which may be an issue for transition countries with rather short time series.

Equilibrium interest rates can also be estimated within stochastic dynamic general equilibrium models. The advantage of this type of literature is that it specifies the structure of economy and thus in principle allows an identification of variety of shocks hitting the economy. On the other hand, Levin et al. (1999) find that more complex models seem to be less robust to model uncertainty (see also Giammarioli and Valla, 2004). Consequently, these model outcomes may be quite sensitive to model assumptions. The recent examples of this approach to estimate equilibrium interest rates include Giammarioli and Valla (2003), Neiss and Nelson (2003) and Smets and Wouters (2003).

The last major stream of literature estimates equilibrium interest rates from the yield curve and asset pricing models. Bomfim (2001) uses inflation linked bonds in order to eliminate the distortions from inflation expectations and retrieves equilibrium interest rates from the realized yields on U.S. Treasury inflation-indexed securities. In this regard, Giammarioli and Valla (2004) discuss equilibrium interest rate estimates in relation to consumption capital asset pricing models. In general, this stream of literature hinges on a notion of liquid financial markets and thus this approach is viable especially for countries with developed financial markets.

3 Data and Empirical Methodology

In this part, we discuss the methodology and dataset we employ to evaluate the policy neutral rate fluctuations in the Czech Republic. Concretely, we estimate a variety of backward or forward looking monetary policy rules with time-varying policy neutral rate.

3.1 Monetary Policy Rules

A starting point for a formal derivation of monetary policy rule is a reasonable assumption that central bank targets to set nominal interest rate in line with the state of economy (see Clarida et al., 1998, 2000), as postulated in Eq. (1):

$$r_t^* = \bar{r} + \alpha\left(E\left\{\pi_{t+i}\middle|\Omega_t\right\} - \pi_{t+i}^*\right) + \beta E\left\{x_t\middle|\Omega_t\right\} \tag{1}$$

r_t^* denotes the targeted interest rate, $\bar{r}$ is the policy neutral rate, π_{t+i} stands for the central bank forecast of yearly inflation rate i periods ahead, π_{t+i}^* is the central bank's inflation target. x_t represents a measure of output gap. $E(.)$ is the expectation operator and Ω_t is the information set available at the time when interest rates are set. Hereinafter, we set i either equal to 12 months to reflect the CNB's actual targeting horizon[7] or alternatively

6 *See Crespo-Cuaresma et al. (2004) on related estimates on Euro area using somewhat different methodology.*

7 *This in line with the CNB main forecasting model – Quarterly Prediction Model; see Coats et al., 2003. The actual targeting horizon is 12-18 months, but due to data limitations we prefer to work with 12 months. In general, see Batini and Nelson, 1999, for contributions on optimal targeting horizon. Note also that policy*

to 0, i.e. using the current inflation for sensitivity analysis. Therefore, Eq. (1) links targeted nominal interest rates to a constant (i.e. interest rate – policy neutral rate – that would prevail, when expected inflation is at the target and output gap is null), the deviation of expected inflation from the target and output gap.

Nevertheless, Eq. (1) is often argued to be too restrictive, as it does not account for interest rate smoothing of central banks. Clarida *et al.* (1998) assume that central bank adjusts the interest rate sluggishly to the targeted value. This is so for a number of reasons. For example, Goodfriend (1991) puts forward the concerns over the stability of financial markets. Sack (1997) highlights uncertainty about the effects of interest rate changes on the economy.[8] Instead of explicit listing of various factors behind the interest rate smoothing, Clarida *et al.* (1998) assume for simplicity that actual policy interest rate is a combination of its lagged value and the targeted policy rate as in Eq. (2).

$$r_t = \rho r_{t-1} + (1-\rho) r_t^* + \nu_t \qquad (2),^{9}$$

where $\rho \in [0,1]$. In line with Clarida *et al.* (1998), substituting Eq. (2) into Eq. (1) and eliminating unobserved forecast variables results in Eq. (3):

$$r_t = (1-\rho)\left[\bar{r} + \alpha\left(\pi_{t+i} - \pi^*_{t+i}\right) + \beta x_t\right] + \rho r_{t-1} + \varepsilon_t \qquad (3)$$

Note that disturbance term ε_t is a combination of forecast errors and is thus orthogonal to all information available in time t (Ω_t).

Next, in order to estimate time-varying neutral policy rate we apply structural time-varying coefficient model with endogenous regressors. Kim (2006) shows that conventional time-varying parameter model delivers inconsistent estimates, when explanatory variables are correlated with the disturbance term, which is indeed relevant, when estimating policy rules. It is interesting to note that the correlation of π_{t+i} and x_t with ε_t in Eq. (3) is almost always taken into account in empirical work on time-invariant rules (as typically estimated by the GMM), while it is almost never considered in literature on time-varying monetary policy rules (Kim and Nelson, 2006, seem to be the exemption). So, Kim (2006) derives a consistent estimator of time-varying parameter model, when regressors are endogenous. In line with Kim (2006), we estimate the following empirical model:

neutral rate is defined as the real rate plus the expected inflation in period t+k, where k is given by the maturity of interbank rate (in our case k=3). k is thus different from forecasting horizon i. As argued by Clarida et al. (2000), this is not very relevant in practice, as the short-term interbank interest rates at various maturities are strongly linked together. Indeed, the correlation of 3M PRIBOR and 12M PRIBOR – to reflect that i=12 – stands at 0.991 in our sample.

8 *Nevertheless, Rudebusch (2006) recently questioned the extent of monetary policy inertia and argued that the inertia is rather low.*

9 *We have estimated the monetary policy rules including higher lags of interest rates, but failed to find it significant.*

$$r_t = (1-\rho)\left[\bar{r}_t + \alpha\left(\pi_{t+i} - \pi^*_{t+i}\right) + \beta x_t\right] + \rho r_{t-1} + \varepsilon_t \tag{4}$$

$$\bar{r}_t = \bar{r}_{t-1} + \vartheta_t,\ \vartheta_t \sim i.i.d.N\left(0, \sigma^2_\vartheta\right) \tag{5}$$

$$\pi_{t+i} = Z'_{t-j}\xi + \sigma_\varphi \varphi_t,\quad \varphi_t \sim i.i.d.N(0,1) \tag{6}$$

$$x_t = Z'_{t-j}\psi + \sigma_\nu \nu_t,\ \nu_t \sim i.i.d.N(0,1) \tag{7}$$

he measurement equation (4) is Taylor rule with policy neutral rate, $\bar{r}_t$, as outlined above. However, we relax here the assumption of constant policy neutral rate and let it vary over time, $\bar{r}_t$, as specified in the transition equation (5). We assume that $\bar{r}_t$ follows random walk without drift.[10] Given the data limitations and the fact that our sample is characterized by relatively stable institutional structure and actual conduct of monetary policy, we do not allow α, β and ρ being time-varying. The 'first-stage' equations (6) and (7) lay out the relationship between endogenous regressors (π_{t+i} and x_t) and its instruments, Z_t . The list of instruments, Z_{t-j} , is as follows: π_{t-1}, π_{t-2}, x_{t-1}, x_{t-2}, r_{t-1} and r_t^+ (foreign interest rate – 1YEURIBOR). We assume that the parameters in the Eqs. (6) and (7) are time-invariant. Next, the correlation between the standardized residuals φ_t and ν_t with ε_t is $\kappa_{\varphi,\varepsilon}$ and $\kappa_{\nu,\varepsilon}$, respectively (note that σ_φ and σ_ν are standard errors of φ_t and ν_t , respectively). The consistent estimates of coefficients in the equation (4) are then obtained in two steps. In the first step, we estimate the equations (6) and (7) and save the standardized residuals φ_t and ν_t. In the second step, we estimate Eq. (8) along with Eq. (5) using maximum likelihood via the Kalman filter. Note that (8) now includes bias correction terms, (standardized) residuals from Eqs. (6) and (7), to address the aforementioned endogeneity of regressors. Consequently, the estimated parameters in Eq. (8) are consistent, as ι_t is uncorrelated with the regressors.

$$r_t = (1-\rho)\left[\bar{r}_t + \alpha\left(\pi_{t+i} - \pi^*_{t+i}\right) + \beta x_t\right] + \rho r_{t-1} + \kappa_{\nu,\varepsilon}\sigma_{\varepsilon,t}\nu_t + \kappa_{\varphi,\varepsilon}\sigma_{\varepsilon,t}\varphi_t + \iota_t,$$

$$\iota_t \sim N\left(0, (1-\kappa^2_{\nu,\varepsilon} - \kappa^2_{\varphi,\varepsilon})\sigma^2_{\varepsilon,t}\right) \tag{8}$$

Several authors (see for example Gerdesmeier and Roffia, 2004) include additional economic variables such as (real) exchange rate or money growth in Eq. (3) trying to capture the state of economy in a fuller manner. Nevertheless, this is typically done in an *ad hoc* manner. On the other hand, when literature assumes that interest rates depend only on inflation and output, obviously it does not mean that there the other variables are completely neglected. As Taylor (2001, p. 266) puts it for exchange rate: *"Although the policy rule ... may not appear to involve interest rate reaction to exchange rate, it implies such a reaction. What might appear to be a closed economy policy rule is actually just as much as open*

10 We also experimented with AR(1) structure in the equation (5), but it just marginally reduced the likelihood and the estimated AR parameter has been very close to one, anyway.

economy rule as if the exchange rate appeared directly." In other words, additional variables that do not enter Taylor rule directly, may influence inflation and output and therefore the interest rate setting *indirectly*. It is also important to emphasize that CPI inflation targeting, as opposed to domestic inflation targeting, has an implicit concern for foreign shocks given the composition of consumer basket (Svensson, 2000). Therefore, in our paper we do not introduce foreign disturbances explicitly in the monetary policy rule, but we will employ them as the instruments in our empirical specification.

Additionally, in a book describing the current forecasting and policy analysis process in the CNB, Coats *et al.* (2003) report that no other variables than inflation and output gap enter into the monetary policy rule in the CNB Quarterly Projection Model (QPM hereinafter). In particular as regards exchange rate fluctuations the CNB has stated several times that it does not directly react to them. It acknowledged that exchange rate plays important role for inflation developments in small open economies and that it might react indirectly to exchange rate fluctuations, if they jeopardize the inflation developments (Kotlán and Navrátil, 2005). Regarding money aggregates, one can expect that inflation targeting central bank in general views it as only supplementary information about the degree of economic activity and/or inflationary pressures, and also does not directly react to it.

Originally, the design of Taylor rule lacked forward-looking element characteristic for the modern monetary policy conduct. Additional way to assess the sensitivity of our results is estimation of both backward- and forward-looking Taylor-type rules. Therefore, we formulate the monetary policy rule in the Eq. (3) in case of backward-looking policy rule such that we set $i = 0$, i.e. we use current inflation rate instead of its forecasted value (which is utilized for the forward-looking policy rule). Another important point has been raised about timeliness of information in the monetary policy conduct (Orphanides, 2001). Output data are typically revised at later stage, but monetary policy is conducted based on information available at the time. Therefore, we collect real-time based CNB output gap estimates (note that inflation is not revised at later stage by the Czech Statistical Office) and re-estimate the monetary policy rule with real-time output gap. Analogously, we use one year ahead CNB's real-time inflation forecast in estimating monetary policy rule.

There are further modeling issues stemming from the fact that policy interest rate is not changed in a continuous fashion. For instance, the CNB Bank Board meets on a monthly basis to discuss the policy interest rate settings. Besides, the policy rate change itself is not continuous. Typically, if the rates are changed, the respective magnitude is 0.25 percentage points (or eventually multiple of 0.25), despite the change maximizing economic stability according to model-based forecast might be of (slightly) different magnitude. In consequence, policy rate is not only discrete, but also censored. Given the inherent censoring of policy interest rates, majority of authors such as Clarida *et al.* (1998, 2000) or Adam *et al.* (2005) rely on using 3 months interbank rate as the approximation of the censored policy rate.

On the other hand, Choi (1999) and Carstensen (2006) put forward modeling censoring in policy rate directly by employing e.g. modified Tobit model and an ordered probit model, respectively. The advantage of this approach is that it models interest rate setting more realistically and does not have to make a rather simplifying assumption by utilizing the short-

term interbank rate. On the other hand, this stream of literature so far models only censoring in the policy rate, but there it has been stressed that there is also censoring in the policy rate change (Podpiera, 2006). In addition, censored models are known to be less efficient and the results based on them do not seem to stand in sharp contrast to those using short-term interbank rate (for example, consider the extent of interest rate smoothing). Additional drawback of this approach in our case is that our main estimation technique is time-varying parameter model with endogenous regressors (Kim, 2006) and to our knowledge; this technique is simply not available with censored dependent variable. Besides, the CNB's QPM also uses 3 months interbank rate instead of 2 weeks policy rate. Having all pros and cons of these two approaches –short-term interbank rate vs. policy interest rate – in mind, we opt for using short-term interbank rate in estimation of the monetary policy rules.

3.2 Data

Our sample contains monthly data over the period 2001:1-2006:09 on yearly CPI inflation ($\pi_t = p_t - p_{t-12}$, where p_t is the log of price level at time t), yearly net inflation (price indexes of regulated goods excluded from the price index; thus $\pi_t^{net} = p_t^{net} - p_{t-12}^{net}$, where p_t^{net} is the log of net price level at time t), output gap (x_t, a difference between actual and potential GDP growth, defined as below), r_t, short-term interbank rate (3M PRIBOR), real effective exchange rate, ($reer_t$), and r_t^+ - foreign interest rate – 1YEURIBOR. We also use the real-time CNB internal forecasts of CPI $\left(\pi_{t+12}^{f}\right)$ and net inflation $\left(\pi_{t+12}^{net,f}\right)$ and output gap. Three different estimates of output gap are employed: a) estimate using HP filter[11], b) ex-post revised output gap from CNB's QPM as of their October 2006 forecast round and c) real-time based output gap collected from CNB's QPM. The source of our data is the CNB public database system ARAD (except inflation forecasts and two aforementioned output gap measures – b) and c), which are not available publicly).

All our variables are available on the monthly basis, except the output gap. Following Adam et al. (2005), we linearly interpolate quarterly estimates of output gap to monthly values.[12] We use the mid-points of CNB inflation target. The choice of 2001-2006 period is motivated to have as long sample period as possible, while not rejecting stationarity of all variables at 5% significance level (using KPSS test). More importantly, real-time output gap and inflation forecast are not available before 2001. As a robustness check, we also estimate the monetary policy rules with net inflation (based on price indexes excluding regulated goods from the consumer basket) instead of CPI inflation.

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11 Standard smoothing parameter of 14440 has been used. Different smoothing parameter, as the one suggested by Ravn and Uhlig (2002), had very little impact on the resulting estimates of policy neutral rate. Output gap derived from HP filter estimates of potential output differs considerably from those used by the CNB – see Chart B.2 in the Appendix. Note that output gap from CNB's QPM is constructed using multivariate Kalman filter. Generally, output gap estimates based on HP filter can be viewed as less reliable, but we keep them in our empirical work, as this gap is replicable based on publicly available data, which is not the case of two other output gap measures derived from CNB's QPM. Note also that HP filter is known to suffer from end-point bias, making it difficult for real-time analysis.

12 We also used quadratic match procedure for interpolation. This yields only little differences on resulting output gap estimates.

4 Results

4.1 Time-varying equilibrium interest rates

Generally, we find that the policy neutral rate decreases over time, as depicted in Chart 1. This is in line with our conjecture laid out in the introduction. We report all specifications, from backward-looking policy rule with the output gap estimated by HP filter to the forward looking rule with the real-time output gap.

The results in Chart 1 unambiguously indicate that policy neutral rate gradually decreased from some 5% to the values around 2% at the end of 2005 and subsequently slightly increased to some 2.5% over the course of 2006.[13] This confirms substantial interest rate convergence to the levels comparable to the euro area countries. For example, Messonier and Renne (2007) estimate euro area real equilibrium interest rate around 1% at the end of their sample (i.e. year 2002) and Wintr et al. (2005) find it a bit below 1% in 2004. If we add to these estimates 2% for the expected inflation – to reflect the European Central Bank definition of price stability –, we receive the estimate of policy neutral rate of about 3% for the euro area. The results actually suggest that the estimated policy neutral rate seem to be a bit below the euro area level. This should not come as surprise, as also actual short-term interest rates were often below those in the euro area (except several months in 2004, Czech rates appear to be below the euro area rates from some mid-2002 onwards).

Detailed parameter estimates of monetary policy rules are presented in the Appendix – Table A.2. It is interesting to note that the degree of interest rate smoothing falls considerably, when allowing for time-varying parameter specification. Compared to the case of constant policy neutral assumption, which is estimated by the GMM[14], the value of interest rate smoothing parameter falls from some 0.9 to 0.4. Time-invariant rules thus overestimate substantially the degree of interest rate smoothing in our case. Other studies in this stream of literature often employ quarterly data; to compare our monthly estimates, taking the cube of 0.4 (this is 0.06) one can get approximately the smoothing term on the quarterly frequency. This complies with the results of Rudebusch (2006), who stresses that once accounting for expectations about future monetary policy the actual policy rate inertia is in fact quite low. The standard errors of the estimates are in some cases large probably reflecting smaller sample size. The coefficient on inflation is around 0.3 in case of backward-looking specifications (interestingly, it is significant only when we introduce bias correction terms, φ_t and ν_t, and insignificant for the forward-looking specifications. The coefficient on output gap ranges from 0.2 to 0.7 according to specification.

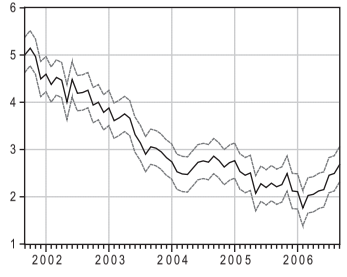
13 *The increase at the end of sample period is likely to reflect higher inflation expectations of economic agents. The CNB conducts regularly a survey on inflation expectations of financial markets, households and non-financial firms (actual numbers are easily available from CNB website within their public database ARAD). Inflation expectations of financial markets for the 1 year horizon have risen from some 2.5% in mid 2005 to 3% over the course of 2006. Similar pattern is visible also for household's and firm's expectations.*

14 *The GMM results are available upon request.*

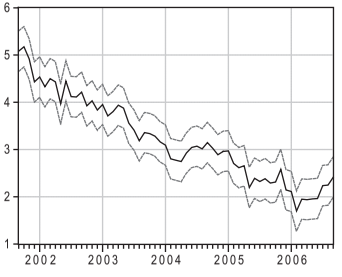
Chart 1 – Policy Neutral Rate Estimates

Time-varying parameter model with endogenous regressors

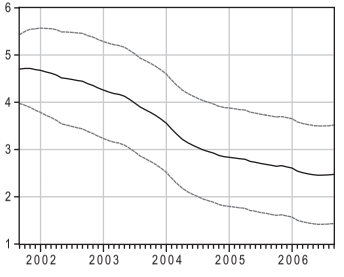
Backward-looking policy rule



Current inflation, output gap – HP filter

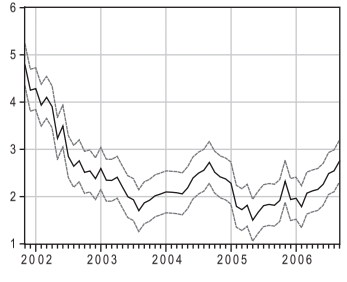


Current inflation, output gap – ex-post

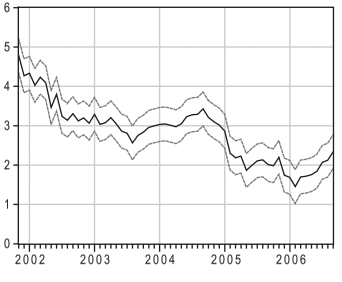


Current inflation, output gap – real-time

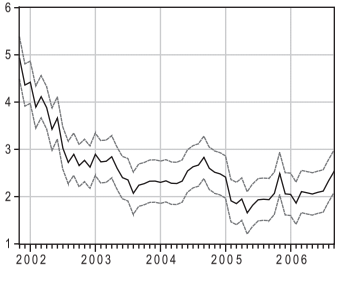
Forward-looking policy rule



Inflation forecast – real-time, output gap – HP filter



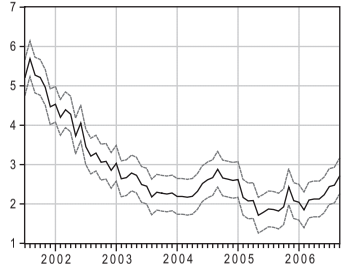
Inflation forecast – real-time, output gap – ex-post



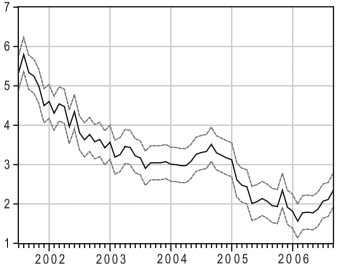
Inflation forecast – real-time, output gap – real-time

Conventional time-varying parameter model

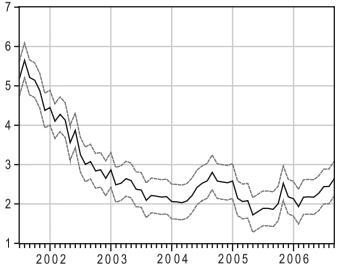
Backward-looking policy rule



Current inflation, output gap – HP filter

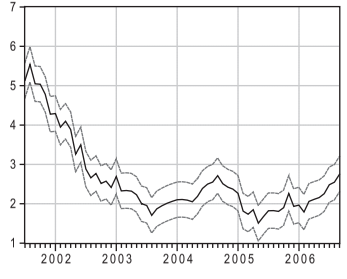


Current inflation, output gap – ex-post

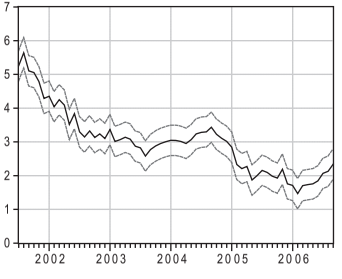


Current inflation, output gap – real-time

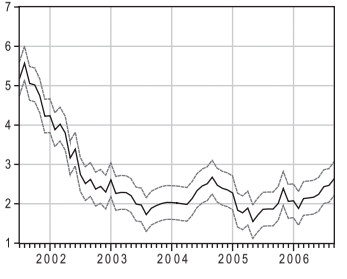
Forward-looking policy rule



Inflation forecast – real-time, output gap – HP filter



Inflation forecast – real-time, output gap – ex-post



Inflation forecast – real-time, output gap – real-time

Note: Policy neutral rate ±2 standard errors reported. The measure of output gap and inflation is used for estimation of policy neutral rate is reported below each chart.

Additionally, the results support the usefulness of applying time-varying parameter model with endogenous regressors. The bias correction terms, φ_t and ν_t, in Eq. (8), are typically significant and the log likelihood improves after their inclusion. Comparing the estimated policy neutral rate with those implied by conventional time-varying parameter model (not accounting for endogeneity of regressors), we find that the resulting difference between these two varies according to the specification of policy rule as well as over time. While the median difference is only 0.05 p.p. in the absolute terms, the maximum difference, that the inclusion of bias correction terms amounts to, is 1.8 p.p.

Chart 3 in the Appendix presents a comparison of policy neutral rate based on identical specification of policy rule, but estimated either by the time-varying parameter model with endogenous regressors or by the conventional time-varying parameter model (i.e. not accounting for endogenous regressors). Denoting the policy neutral rate estimated by the former method, $\bar{r}_{t,e}$, and, $\bar{r}_{t,c}$, by the latter, the Chart A.3 report a difference between these two. Obviously, if $\bar{r}_{t,e} - \bar{r}_{t,c} = 0$, the bias correction terms do not matter at all.[15] However, we can see from the results that albeit the two methods yield in general rather similar estimates of policy neutral rate path, there are periods, when the bias correction terms matter considerably, i.e. when the policy neutral rate estimates by the conventional time-varying parameter model do not even lie inside the confidence interval of the policy neutral rate estimated by the time-varying parameter model with endogenous regressors.

4.2 Monetary policy stance and inflation developments

There is a discussion in literature to what extent the monetary policy rules provide a useful framework to evaluate the monetary policy tightness and its impact on subsequent inflation. This is typically done by comparing actual interest rate setting with the one implied by the rule and inflation outcomes. For example, Taylor (1999, p. 340) labels the difference as the policy mistakes (i.e. a residual from the policy rule) and shows that they are well associated with high inflation or low capacity utilization with the U.S. data. On the other hand, Reynard (2007) analyzing the U.S. and Swiss data questions the reliability of the so-called policy mistakes, as he observes rather weak link between the so-called policy mistakes and inflation relative to inflation target. Here we propose a little bit different framework to evaluate the policy rule. Instead of focusing on the residual from the policy rule, we analyze the deviation of actual interest rates from policy neutral rate ("equilibrium rate") and its impact on subsequent inflation. We leave examination of the link between policy mistakes and inflation outcomes for further research, as we do not concentrate in this paper, whether the estimated monetary policy rule provides accurate description of CNB policy, but rather on the estimation and evolution of policy neutral rate.

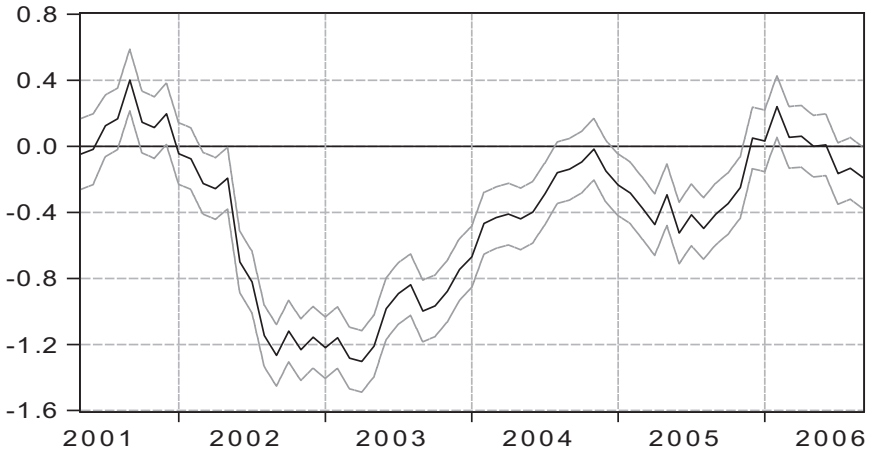
So our simple test here is to examine, whether our estimated policy neutral rate is helpful in predicting future inflation developments. If policy neutral rate is too uncertain measure, then it is likely it does not provide information for subsequent inflation. Our supposition is thus that when actual interest rate is above policy neutral rate, future inflation rate is then likely

15 Obviously, it might be the case that both bias correction terms are statistically significant, but they just „cancel out" their impact on estimated policy neutral rate. The probability of „canceling out" for each month is virtually zero.

to fall, as monetary policy can be considered restrictive and *vice versa*. We label a difference between actual interest rate and policy neutral rate as monetary policy stance hereinafter.

The generic monetary policy stance is plotted in Chart 2.[16] As we also have confidence intervals for the policy neutral rate, it is possible to evaluate if the stance was statistically different from zero. The results indicate that monetary policy during the sample period can be regarded as relatively easy, especially around the years 2002-2003. This should not come as surprise since the inflation was well below the target and even got into the negative numbers for several months in 2003 and the output gap was negative, with the bottom in mid 2003 according to the CNB output gap estimates (see Chart B.1).

Chart 2 – Monetary Policy Stance



Note: Positive values refer to monetary policy tightening, while negative values point to policy easing.

As there are transmission lags between monetary policy action and the response in the economy, we assume that current monetary policy stance affects inflation after from 12 to 24 months. This coincides well with the CNB monetary policy horizon, as the bank acknowledges that *"…interest rate changes have their greatest impact on inflation some 12 to 18 months…"* (CNB). It is also supported by the empirical findings of Borys-Morgese and Horvath (2007). Within their factor augmented VAR framework, they find that the peak response of inflation to interest rate shocks is around year or so (note the maximum reaction of non-tradable inflation is close to two years). Based on this evidence, it seems to be fruitful to analyze the horizon between about one and two years. Here we broadly follow the empirical specification by Moser *et al.* (2007), which is a variant of Stock and Watson (1999). While these two studies examine the role of factor models for inflation forecasting, we analyze

16 *Monetary policy stance presented in Chart 2 is based on monetary policy rule specification with inflation forecast and ex-post GDP gap. Different specification play rather minor role in overall assessment of monetary policy stance. In addition, it is interesting to note that the significance of monetary policy stance has not been affected by the fact, whether we employed backward or forward looking policy rule.*

our monetary policy stance instead. More specifically, we test the significance of monetary policy stance including it in autoregressive-type model for the inflation process.

Our estimation framework begins with the following regression:

$$\pi_{t+i} = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \upsilon_{t+i} \tag{9}$$

where π_{t+i} is yearly inflation *i* months ahead, where *i*=12,….,24.

Next, we control for the lagged inflation terms:

$$\pi_{t+i} = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \sum_{h=1}^{n}\phi_{h+1}\pi_{t-h} + \upsilon_{t+i} \tag{10}$$

where for simplicity we set *n*=4.[17]

Using Eqs. (9) and (10), we investigate the information content of monetary policy stance on the future level of inflation. We also re-specify the above equations to address the future change in the inflation rate as follows:

$$\pi_{t+i} - \pi_t = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \upsilon_{t+i} \tag{11}$$

$$\pi_{t+i} - \pi_t = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \sum_{h=1}^{n}\phi_{h+1}\pi_{t-h} + \upsilon_{t+i} \tag{12}$$

The results from Eq. (9) are given in Table A.3 in the Appendix. Our definition of monetary policy stance seems to be informative for future inflation, explaining typically about 1/3 of its variance. These results are largely confirmed, when controlling for the lagged inflation terms, as suggested the estimation of Eq. (10) presented in Table A.4. The results suggest that when actual interest rate is 10% above the policy neutral rate, inflation is likely to fall by about 1 p.p. at the monetary policy horizon. Similarly, policy neutral rate seems to be relatively good predictor of the future change of inflation rate, as presented in Table A.5. This result is largely robust to inclusion of lagged inflation as well (see Table A.6). All in all, the results suggest usefulness of policy neutral rate in understanding future behavior of inflation.[18]

5 Conclusions

This paper analyzes the policy neutral rate in the Czech Republic. In order to do so, we estimate various specifications of simple Taylor-type monetary policy rules at the monthly

17 We also included higher lags, but with little impact on the results.

18 We also tested the robustness of our results by including other macroeconomic variables to Eqs. (10) and (12) such as real effective exchange rate, credit and monetary aggregates. The results remain largely unchanged and are available upon request.

frequency from 2001:1 to 2006:9. To address the sensitivity of results, the specifications differ based on whether we include real-time or ex-post revised data, employ backward or forward-looking monetary policy rules or vary the measure of output gap.

To estimate time-varying policy neutral rate, we use time-varying parameter model with endogenous regressors (Kim, 2006). This approach is especially appealing, when estimating monetary policy rules, as it addresses the endogeneity of inflation (forecast) and output gap. Indeed, the results support the usefulness of applying time-varying parameter model with endogenous regressors. The bias correction terms, accounting for the endogeneity of regressors, are typically significant, the log likelihood improves after their inclusion and the estimated path of policy neutral rate is for certain periods considerably different.

The results indicate that policy neutral rate decreases gradually over the course of sample period from some 5% in 2001 to about 2.5% in 2006 showing a substantial interest rate convergence to the levels comparable to the euro area. Over the longer time horizon, the decrease may be supported a number of factors such as capital accumulation, the decrease in risk premium, real equilibrium exchange rate appreciation as well as successful disinflation of Czech economy and well-anchored inflation expectations.

One of our primary policy applications, except for measuring policy neutral rate by the novel technique, is also proposing a measure of monetary policy stance based on a deviation of actual interest rate from policy neutral rate. Our results indicate that this measure is quite useful in predicting future inflation developments. More specifically, monetary policy stance affects both the level as well as change of future inflation rate. In terms of future research, it would be interesting to see more evidence on other inflation targeting countries to uncover, whether our proposed monetary policy stance measure remains useful predictor of future inflation developments, as we find in the case of Czech Republic.

Abstract

This paper examines time-varying policy neutral interest rate in real time for the Czech Republic in 2001:1-2006:09 estimating various specifications of simple Taylor-type monetary policy rules. For this reason, we apply a structural time-varying parameter model with endogenous regressors. The results indicate that policy neutral rate gradually decreased over sample period to the levels comparable to those of in the euro area. Next, we propose a measure of monetary policy stance based on a difference between the actual interest rate and estimated policy neutral rate and find it a useful predictor of the level as well as change of future inflation rate.

Keywords

policy neutral rate, Taylor rule, time-varying parameter model with endogenous regressors

JEL classification / JEL klasifikace

E43, E52, E58

Souhrn
Tento článek analyzuje politicky neutrální („rovnovážnou“) úrokovou míru s tzv. daty v reálném čase v České republice od 2001:1 do 2006:09 na základě odhadů různých specifikací Taylorova pravidla. Aplikujeme strukturální model s časově proměnlivými parametry a s endogenními regresory, abychom vyhodnotili fluktuace politicky neutrální sazby v čase. Nalézáme, že politicky neutrální sazba v čase klesá na úroveň srovnatelnou se zeměmi eurozóny. Dále navrhujeme způsob měření nastavení měnové politiky založeném na rozdílu mezi skutečnou úrokovou mírou a námi odhadnutou politicky neutrální sazbou a nalézáme, že tímto způsobem jsme schopni dobře predikovat budoucí inflaci i budoucí změnu inflace.

Klíčová slova
politicky neutrální úroková míra, Taylorovo pravidlo, model s časově proměnlivými parametry a endogenními regresory

Kontaktní adresa / Contact address
Roman Horváth, M.A,
Česká národní banka a Institut ekonomických studií, Karlova univerzita v Praze
(e-mail: roman.horvath@gmail.com)

Roman Horváth, M.A.
Je absolventem Central European University. V současné době pracuje jako starší ekonom odboru ekonomického výzkumu a finanční stability v České národní bance.

Je editorem AUCO Czech Economic Review a členem redakční rady Finance a úvěr – Czech Journal of Economics and Finance. Je členem Ekonometrické společnosti a Evropské ekonomické asociace.

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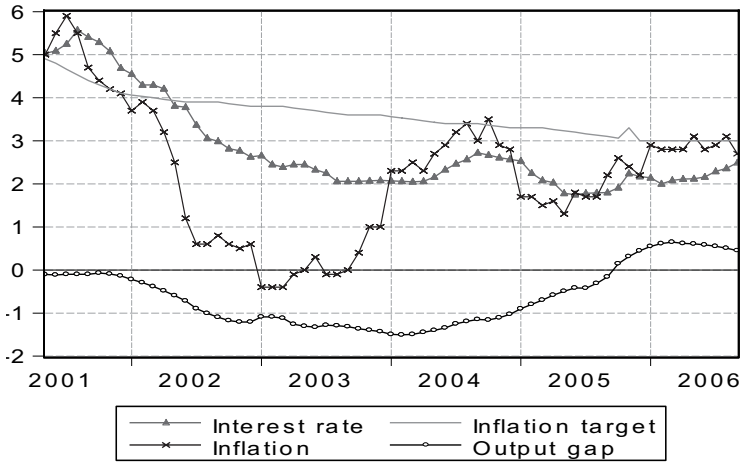
APPENDIX

Table A.1 – KPSS Test

Series	**Test statistic**
PRIBOR 3M	0.355*
CPI Inflation	0.165
CPI Inflation forecast (t+12)	0.163
Net Inflation	0.147
Output gap – HP filtered	0.106
Output gap – Real-time	0.293
Output gap – Ex-post	0.214
M2 growth	0.168
Real effective exchange rate	0.447*

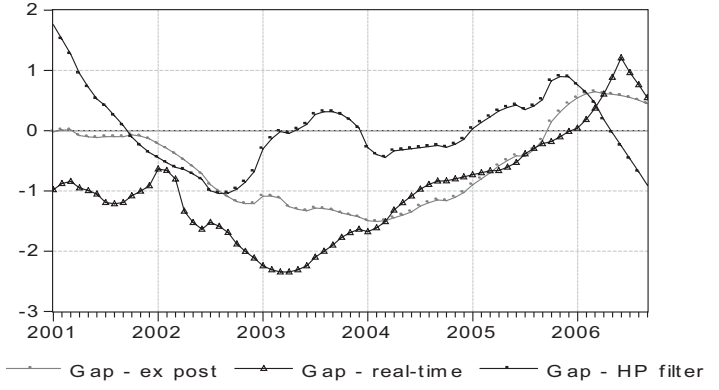
*The null hypothesis is that the series is level stationary. Critical values for the null hypothesis: 10% - 0.347, 5% - 0.463, 1% - 0.739. Sample period: 2001:1-2006:09. *, **, *** denotes significance at the 10, 5 and 1 percent level, respectively.*

Chart A.1 – Interest Rate, Output Gap and Inflation



Note: This chart presents current inflation, short-term interbank interest rate (3M PRIBOR) and CNB output gap as of October 2006 forecast round.

Chart A.2 – Comparison of Output Gap Estimates



Note: This chart presents three measures of output gap used in the paper: Output gap estimated by the CNB as of their October 2006 forecast round (Gap - ex post), Real-time based output gap estimated by the CNB (Gap - real-time) and the output gap calculated using HP filter (Gap – HP filter) as the estimate of potential output.

Table A.2 – Monetary Policy Rules Estimation

$$r_t = (1-\rho)\left[\bar{r}_t + \alpha\left(\pi_{t+i} - \pi^*_{t+i}\right) + \beta x_t\right] + \rho r_{t-1} + \varepsilon_t$$

$$\bar{r}_t = \bar{r}_{t-1} + \vartheta_t,\ \vartheta_t \sim i.i.d.N\left(0, \sigma^2_\vartheta\right)$$

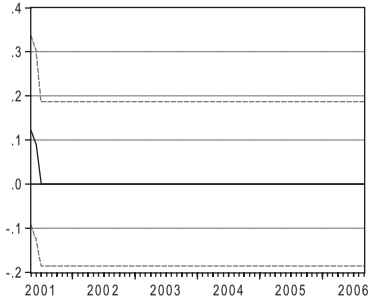
$$\varepsilon_t = \kappa_{\nu,\varepsilon}\sigma_{\varepsilon,t}\nu_t + \kappa_{\varphi,\varepsilon}\sigma_{\varepsilon,t}\varphi_t + \iota_t,\ \ \iota_t \sim N\left(0, (1-\kappa^2_{\nu,\varepsilon} - \kappa^2_{\varphi,\varepsilon})\sigma^2_{\varepsilon,t}\right)$$

	Model											
Parameters	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
ρ	0.40***	0.40***	0.40***	0.41***	0.40***	0.40***	0.42***	0.40***	0.42***	0.42***	0.45***	0.40***
	(0.02)	(0.09)	(0.06)	(0.06)	(0.07)	(0.09)	(0.11)	(0.10)	(0.10)	(0.09)	(0.10)	(0.15)
α	0.27***	0.07	0.28***	0.06	0.28***	0.07	-0.15	-0.15	-0.18	-0.16	-0.17	-0.14
	(0.07)	(0.07)	(0.08)	(0.06)	(0.07)	(0.06)	(0.12)	(0.11)	(0.11)	(0.11)	(0.10)	(0.09)
β	0.21	0.11	-0.06	0.57**	-0.06	-0.06	0.12	0.14	0.66**	0.66**	0.18	-0.02
	(0.24)	(0.24)	(0.28)	(0.29)	(0.22)	(0.23)	(0.27)	(0.25)	(0.28)	(0.31)	(0.23)	(0.19)
$\kappa_{\nu,\varepsilon}$	-0.06***		-0.07***		-0.06***		0.01		0.02		0.02	
	(0.01)		(0.02)		(0.02)		(0.01)		(0.01)		(0.01)	
$\kappa_{\varphi,\varepsilon}$	-0.02*		-0.02*		-0.02*		0.01		-0.01		-0.02***	
	(0.01)		(0.01)		(0.01)		(0.01)		(0.02)		(0.01)	
AIC	-1.10	-1.00	-1.07	-1.00	-0.95	-0.94	-0.91	-0.94	-0.94	-0.96	-0.91	-0.88

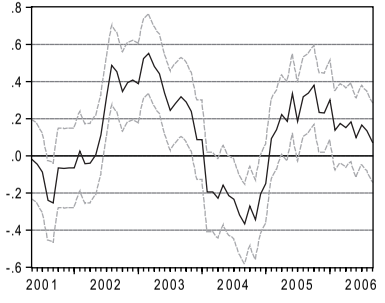
*Note: Robust standard errors in brackets. ***, ** and *indicates the significance at 1,5 and 10%, respectively. Models differ according to whether bias correction terms are included and the specification of π_{t+i} and x_t. π_{t+i} is either CNB inflation forecast one year ahead (abbreviated as IF below) or current inflation rate (IC). x_t is a measure of output gap: 1. as estimated by HP filtering (HP), 2. CNB ex-post output gap measure based on multivariate Kalman filter procedure (EX), 3. CNB real-time output gap measure based on multivariate Kalman filter procedure (REAL). Model 1 and 2 = IC, HP; Model 3 and 4 = IC, EX; Model 5 and 6 = IC, REAL; Model 7 and 8 = IF, HP; Model 9 and 10 = IF, EX and Model 11 and 12 = IF, REAL;*

Chart A.3 – Importance of Bias Correction Terms in Estimating Policy Rules

Backward-looking policy rule



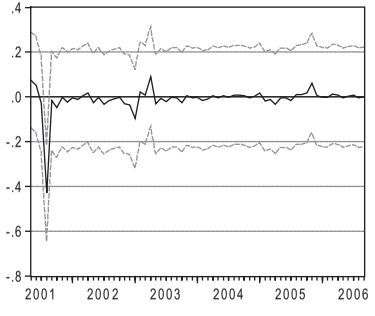
Current inflation, output gap – HP filter



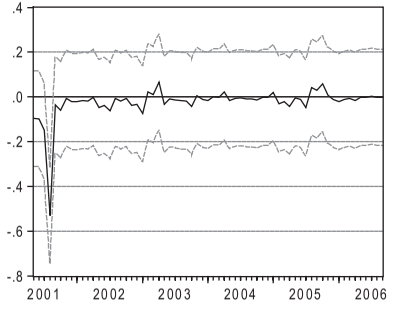
Current inflation, output gap – ex-post

Current inflation, output gap – real-time

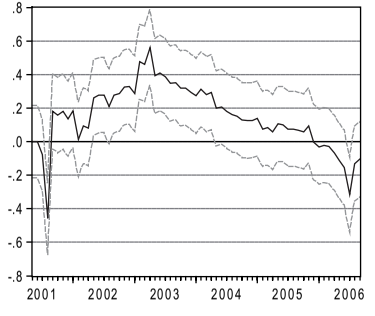
Forward-looking policy rule



Inflation forecast – real-time, output gap – HP filter



Inflation forecast – real-time, output gap – ex-post



Inflation forecast – real-time, output gap – real-time

Note chart A3: The difference between the policy neutral rates estimated from the time-varying parameter model with endogenous regressors, $\bar{r}_{t,e}$ with its confidence intervals, and from the conventional time-varying parameter model, $\bar{r}_{t,c}$. The measure of output gap and inflation is used for estimation of policy neutral rate is reported below each chart. Consequently, if the confidence intervals are different from zero, it means that $\bar{r}_{t,c}$ does not lie within the confidence intervals of $\bar{r}_{t,e}$.

Table A.3 – Monetary Stance and Future Level of Inflation

$$\pi_{t+i} = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \upsilon_{t+i}$$

i	ϕ_0	ϕ_1	Adj. R2
12	1.43***	-6.89	0.07
13	1.31***	-9.91*	0.15
14	1.26***	-11.30**	0.19
15	1.26***	-11.58**	0.20
16	1.22***	-13.23**	0.27
17	1.20***	-14.31***	0.32
18	1.23***	-13.93***	0.31
19	1.14***	-16.02***	0.39
20	1.18***	-15.81***	0.39
21	1.25***	-14.81***	0.36
22	1.31***	-13.82**	0.32
23	1.42***	-12.54**	0.30
24	1.57***	-10.16*	0.21

*Note: Robust standard errors. ***, ** and *indicates the significance at 1,5 and 10%, respectively.*

Table A.4 – Monetary Stance and Future Level of Inflation, Controlling for Lagged Inflation

$$\pi_{t+i} = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \sum_{h=1}^{n}\phi_{h+1}\pi_{t-h} + \upsilon_{t+i}$$

i	ϕ_0	ϕ_1	ϕ_3	ϕ_3	ϕ_4	ϕ_5	Adj. R2
12	2.33***	-0.94	0.03	0.04	0.07	-0.48	0.33
13	1.95**	-2.49	-0.11	0.19	-0.06	-0.33	0.41
14	1.67*	-3.59	-0.14	0.04	0.19	-0.36	0.46
15	1.49	-4.26	-0.25	0.24	-0.07	-0.15	0.48
16	0.66	-6.86**	-0.09	-0.07	-0.22	0.30	0.52
17	0.02	-8.89***	-0.25	-0.16	0.14	0.31	0.57
18	-0.33	-9.98***	-0.55***	0.19	0.14	0.33	0.60
19	-1.05	-12.12***	-0.57***	0.20	0.27	0.36	0.63
20	-1.12	-12.27***	-0.62**	0.36	0.17	0.38	0.60
21	-0.78	-11.09**	-0.46	0.18	0.21	0.34	0.51
22	-0.57	-10.31**	-0.42**	0.25	-0.09	0.52	0.45
23	-0.48	-9.86**	-0.26	-0.06	0.01	0.61*	0.41
24	-0.53	-9.89**	-0.40	0.12	-0.12	0.73*	0.39

*Note: Robust standard errors. ***, ** and *indicates the significance at 1,5 and 10%, respectively.*

Table A.5 – Monetary Stance and Future Change of Inflation

$$\pi_{t+i} - \pi_t = \phi_0 + \phi_1 \left(\left(r_t - \bar{r}_t \right) \Big/ \bar{r}_t \right) + \upsilon_{t+i}$$

i	ϕ_0	ϕ_1	Adj. R2
12	-3.04***	-15.39***	0.53
13	-3.29***	-16.55***	0.57
14	-3.48***	-17.47***	0.59
15	-3.54***	-17.77***	0.59
16	-3.58***	-18.01***	0.60
17	-3.60***	-18.09***	0.60
18	-3.56***	-17.93***	0.59
19	-3.60***	-18.05***	0.60
20	-3.54***	-17.81***	0.60
21	-3.42***	-17.24***	0.60
22	-3.28***	-16.62***	0.58
23	-3.10***	-15.88***	0.56
24	-2.89***	-15.11***	0.53

*Note: Robust standard errors. ***, ** and *indicates the significance at 1,5 and 10%, respectively.*

Table A.6 – Monetary Stance and Future Change of Inflation, Controlling for Lagged Inflation

$$\pi_{t+i} - \pi_t = \phi_0 + \phi_1\left(\left(r_t - \bar{r}_t\right)\Big/\bar{r}_t\right) + \sum_{h=1}^{n}\phi_{h+1}\pi_{t-h} + \upsilon_{t+i}$$

i	ϕ_0	ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	Adj. R2
12	2.12***	-1.26	-1.11***	-0.08	0.53*	-0.59	0.82
13	1.62*	-3.18	-1.26***	0.05	0.43	-0.42	0.84
14	1.41	-4.06	-1.28***	-0.11	0.67*	-0.46	0.85
15	1.44	-4.10	-1.41***	0.08	0.46	-0.33	0.86
16	0.56	-6.82*	-1.24***	-0.23	0.33	0.13	0.86
17	-0.08	-8.89**	-1.41***	-0.31	0.69**	0.14	0.89
18	-0.33	-9.70***	-1.72***	0.05	0.68*	0.14	0.89
19	-1.13	-12.05***	-1.74***	0.07	0.80**	0.19	0.88
20	-1.19	-12.20***	-1.79***	0.23	0.70*	0.20	0.87
21	-0.86	-11.03***	-1.63***	0.02	0.77*	0.16	0.86
22	-0.67	-10.31***	-1.61***	0.12	0.45	0.36	0.85
23	-0.49	-9.55***	-1.45***	-0.13	0.42	0.48*	0.85
24	-0.51	-9.49***	-1.57***	0.02	0.32	0.59**	0.86

*Note: Robust standard errors. ***, ** and *indicates the significance at 1,5 and 10%, respectively.*

5th Place – Profesor František Vencovský Award
5. místo – Cena profesora Františka Vencovského

Credit Risk and Stress Testing of the Czech Banking Sector

Kreditní riziko a stresové testování českého bankovního sektoru

PETR JAKUBÍK*

1 Introduction

In the globalization world the financial crises can spread easily between countries. Cross-border contagion can threaten countries with the week banking sector. From this point of view, the stress test exercise should be regularly processed in order to detect financial system fragility. The important part of such exercise is the evaluation of the credit risk under certain macroeconomic scenario. For this reason it is very important to know the link between credit risk and macroeconomic environment. Using these tools for monitoring purpose, reformative measures can be adopted by regulator to prevent the potential financial crises in the country in advance. Due to these facts, macroeconomic credit risk modeling is the new challenge for the economic research.

Our recent experience with the effects of economic downturn on banks' loan portfolios in the Czech economy in the late 1990s provides an opportunity to investigate the link between macroeconomic development and credit portfolio quality. These findings can help to improve the stress test calculation employed by the Czech National Bank for the purpose of financial stability. Despite a very good shape of the Czech economy at this moment, the central bank needs to have reliable tools to detect potential instability within the economy.

From financial stability point of view, credit risk of the banking sector portfolio should be investigated. Rapid credit growth in the Czech Republic creates pressure for the improvement in credit risk management at the present time. Loans to households' growth rate reach 30% on average during last years. After deep recession in the end of the nineties and consequential credit crunch period, credit growth to corporate sector was recover since 2002. Despite of significant growth, level of the private credit in the economy is still far to EU-15 average. The estimation of the sectoral credit risk models together with stress test can be useful tool for the central bank. These models can provide better knowledge about

* *Czech National Bank and the Institute of Economic Studies of Charles University in Prague. The findings, interpretations and conclusions expressed in this paper are entirely those of the author and do not represent the views of any of the above institutions.*

potential instability of the banking sector. Different unfavorable, but plausible scenario can be tested in this manner. Although sectoral models can better explain credit risk in the economy, sectoral data is difficult to obtain. Especially in the case of Central and Eastern European transitional economies, time series are still short with a lot of structural breaks. It makes empirical analyses hard.

This paper follows methodology used by Jakubík (2006a). It extends the study of Jakubik (2007), who estimated macoreconomic credit risk model for the Czech aggregate economy. Besides the credit risk modeling, the paper focuses on difficulties with data of sectoral default rate. It shows how to deal with incomplete data in order to distinguish credit risk for the household and corporate sector. It is structured as follows. Section 2 introduces related studies. Section 3 describe available data, one-factor model as a selected approaches to credit risk modeling and its estimation for the corporate and households sectors. Section 4 presents using of the estimated models for the stress test purpose. The last section concludes and discusses possible further research topics.

2 Related Study

In the context of the New Basel Capital Accord, there are studies investigating cyclical effects in credit risk models on the bank capital requirement. Catarineu-Rabell, Jackson, Tsomocos (2003) investigate the impact of different forms of implementation of the rating system on the bank capital requirement. Verónica Vallés (2006) discuss difficulties with the implementation of Basel II. She focus on the through the cycle rating system and its construction for the emerging economies with financial information affected by macroeconomic crisis. A survey of the literature on cyclical effects on default probability, loss given default and exposure at default can be found in (Allen, Saunders 2003). There are studies investigated which factors drive the corporate credit risk in the economy. Elizalde (2005) studies the importance of credit risk correlation in bond market prices. By decomposing the firms' credit spreads on different credit risk factors is able to compute the importance of each credit risk factor on the evolution of the firms' credit risk, identifying their credit risk correlation. The other studies use the idea of decomposition of the credit risk on the common observable factors for all firms in the economy and firms' specific unobservable factor. This is also assumption of the popular one-factor model belonging to class of latent factor models. The firms' specific factor is unobservable, but the assumption about its distribution is made. This model is employed for example by Rösch (2005), Hamerle, Liebig, Scheule (2004) or Jakubík (2006a).

From the regulators point of view credit risk on the aggregate level is important. The most of the central bank employ some kind of sensitivity analyses or stress test exercise for the financial sector. They try to estimate sectoral credit risk in the economy. Sorge, Virolainen (2006) illustrate the main analytical approaches to macro stress test in the literature and estimate macroeconomic credit risk models for stress test purposes using data for Finland. In order to model corporate credit risk they use bankruptcy data as well as loan loss provisions. Wagner, Marsh (2006) study credit risk transfer in the economy with endogenous financing. They find the transfer of credit risk from banks to non-banks to be more beneficial than credit risk transfer within bank sector. The results of the economic research on the issue credit risk and stress testing is highly demanded by central banks. Boss, Krenn, Puhr,

Summer (2006) gives an overview of the general ideas used by Austrian central bank for the monitoring of systematic risk in the economy. They integrated credit risk into the stress test exercise. They used bankruptcy data as a proxy for default rate for 13 industry sectors. Time series of default frequencies is explained by macroeconomic risk factor changes. The estimated equation enable them translate macroeconomic risk factor changes into probabilities of default for each industry sector. Bario, Furfine, Lowe (2001) covered the relationship between credit risk, financial cycles and financial stability. They found limited number of macroeconomic variables to predict episode of financial turbulence. Danmarks Nationalbank analyzed the financial vulnerability of the Danish household sector (Danmarks Nationalbank (2007)). Macro stress test of Danish households simulates the effect of higher unemployment and interest-rate increases on the households' ability to service their debt. Macroeeconomic credit risk model is also employ in stress test exercise of Bank of England. Pain (2003) found the empirically relationship between banks' provision and macroeconomic indicators as a GDP growth rate, real interest rates, credit growth or concentration of the domestic loan portfolio.

Further related studies to the issues of credit risk and stress testing can be found e.g. in Jakubík (2007).

3 Credit Risk in the Czech Economy

From the central bank point of view it is necessary to assess the change in the credit risk of a loan portfolio in relation to change in the macroeconomic environment within a stress test exercise. To this end, a macroeconomic credit risk model for the Czech aggregate loan portfolio was developed by Jakubík (2006b).

One disadvantage of the aggregate model is that it cannot capture the different sensitivities of corporate and households sectors to change in the macroeconomic environment. The structure of the loan portfolio has changed considerably over the past five years in the Czech economy. The share of loans to households in banks' total loan portfolio increased from 10% in 2001 to almost 40% at the end of 2006. It is thus apparent that the household sector is becoming increasingly significant in the total loan portfolio. For this reason, it would be appropriate to estimate the macroeconomic credit risk model separately for the corporate and household sectors. The main obstacle to the estimation of such models is the non-availability of data on the dependent variable.

The aggregate risk model for the Czech economy was estimated on quarterly data on inflow of non-performing loans (NPLs).[1] However, such data is only available on an aggregate basis and cannot be obtained separately for the household and corporate sectors. The sectoral breakdown shows NPL stocks, not flows. To obtain flows, one has to estimate the decrease in NPLs as a result of write-offs, sales or enforcement of such classified liabilities of banks. The following relationship applies to the stock of NPLs, the default rate and the rate of gross NPLs decrease.

$$NPL_2 = NPL_1 - u\,NPL_1 + df\,(Loans_1 - NPL_1) \tag{1}$$

1 NPLs are loans with a classification of three or higher, i.e. substandard, loss and doubtful.

where *NPL* is the stock of NPLs in the relevant period, *u* the rate of gross NPLs decrease, *df* the default rate and $Loans_1$ volume of outstanding loans at the beginning of the period under review. This enables us to derive the following relationship (2) for the default rate.

$$df = \frac{\Delta NPL + u\,NPL}{Loans_1 - NPL_1} \tag{2}$$

Depending on the frequencies monitored, equation (2) can be used to compute the quarterly or annual default rate.[2] Except for the rate of gross decrease, all the variables in relationship (2) are usually known. Volumes of total loans and NPLs are available for the Czech economy broken down by sector. The rate of decrease was only available for aggregate loans. This figure is highly volatile, mainly due to non-recurring massive write-offs at the end of the 1990s and at the beginning of the new millennium as a result of clean-ups of large banks' balance sheets. It can be assumed that most of the problem loans related to corporations rather than households and that the rate of decrease for the household sector is relatively stable over time. The period of write-off, sale or enforcement of NPLs to households was chosen to be two years as an expert estimate. If we work with the annual default rate, the corresponding rate of decrease is 0.5.[3] Based on this assumption, the default rate of households in the economy can be derived using relationship (2).

The question is how to deal with the corporate sector. Using of the equation (2) is not appropriate for the corporate sector due to unstable behaviour of the rate of gross NPLs decrease. However having an aggregate data on the gross inflow of NPLs and default rate for the households sector we can derive gross inflow of NPLs for the corporate sector. Nevertheless the time series of the sectoral loans are available, we can estimate corporate default rate as a ratio of the gross NPLs inflow and outstanding loans at the given time.[4] For the better figure of the corporate sector credit risk, we can use credit register to compare our estimation and real figure. However the central credit register contains data only since November 2002. We use this data only for the latest values. However we checked that our estimate well fit to credit register data.

3.1 One-factor Model

The one-factor model is the popular version of the latent factor model which belongs to the class of the Merton structural model. This model appear in many papers, for example in (Rösch 2005), (Lucas, Klassen, Spreij, Straetmans 1999) (Cipollini, Missaglia 2005), (Jakubík 2006a), (Jakubík 2006b), (Jakubík 2007). The model is able to good explain credit

2 *An alternative approach to approximating annual default rate is to use bankruptcy data. This approach was used for example by Virolainen (2004) or Bos, Krenn, Puhr, Summer (2006).*

3 *Parameter u in the equation (1) may not in fact be constant over time. Nonetheless, we believe that the level of 0.5 is relatively realistic and consistent with anecdotal evidence.*

4 *Data on the gross inflow on NPLs for the corporate sector were calculated as a difference between this variable for the aggregate economy and households sector. This number was finally adjusted, because there are still others sector in the economy as a government, entrepreneurs and financial sector. We used the share of the corporate sector on the total NPLs for the adjustment.*

risk in the economy due to its nonlinearity. This section briefly describes the model and way how to use this concept for the macroeconomic credit risk modeling.

A random process with a standard normal distribution is assumed for the standardised logarithmic return on assets of a firm. The discrete normal logarithmic return satisfies the following equation for each firm in the economy.

$$R_{it} = \sqrt{\rho} F_t + \sqrt{1-\rho} U_{it} \tag{3}$$

R denotes the logarithmic return on assets for each firm *i* at time *t*. *F* corresponds to the logarithmic return in the economy independent of firm *i* at time *t*, which is assumed to be a random variable with a standard normal distribution. This variable represents the part of the return which is not specific to the firm and can thus satisfy the general conditions for profitability of firms in the economy. *U* denotes the return specific to the firm, which is again assumed to be random with a standard normal distribution. The two random variables are also assumed to be serially independent. Given these assumptions, the logarithmic return on assets of each firm *i* at time *t* also has a standard normal distribution. The model is based on the Merton approach, according to which a default event occurs if the return on a firm's assets falls below a certain threshold. Formally,

$$P(Y_{it} = 1) = P(R_{it} < T), \tag{4}$$

where Y denotes a random variable with the two potential state (1/0 – borrower *i* defaults/non-defaults at time *t*). Different macroeconomic indicators can be considered if the applied variant of the model assumes that the value of this threshold changes depending on changes in the macroeconomic environment. The value can be modelled as a linear combination of macroeconomic variables (x_{jt}). The final version of the model is described by the equation (5) in the case that macroeconomic indicators are included into the model (Ψ denotes the distribution function of the standard normal distribution).

$$p_{it} = P(R_{it} < T) = P(\sqrt{\rho} F_t + \sqrt{1-\rho} U_{it} < \beta_0 + \sum_{j=1}^{K} \beta_j x_{jt}) = \Psi(\beta_0 + \sum_{j=1}^{K} \beta_j x_{jt}) \tag{5}$$

The conditional default probability on realization f_t of random unobservable factor at time *t* corresponding to the default probability (5) is given by formula (6).

$$p_i(f_t) = P(U_{it} < \frac{\beta_0 + \sum_{j=1}^{K} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}}) = \Psi\left(\frac{\beta_0 + \sum_{j=1}^{K} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}} \right) \tag{6}$$

If we furthermore assume a homogenous portfolio of firms in the economy whose returns on assets correspond to process (3), the average default rate in the economy is then – based on the law of large numbers – equivalent to the probability of default of a firm. Given the assumption of homogeneity of firms in the economy, it is more appropriate to estimate the model on the basis of sectoral data.

In order to estimate the model (5), a relationship with a conditional number of defaults of firms depending on the realisation of the random variable *F* representing the latent factor was used. The conditional number of defaults depending on the realisation of the random factor is a random variable which, under the given assumptions, has a binomial distribution, with the parameters of conditional probability $p_i(f_t)$ given by equation (6) and the number of firms N_t.

$$D(f_t) \approx Bi(N_t, p(f_t)) \tag{7}$$

The model can be estimated by maximising a likelihood function containing a random latent factor, which was assumed to have a standard normal distribution. Full description of the one-factor model and way how to estimate it can be found for example in Jakubík (2007). We employed this concept in this paper. [5]

3.2 Macroeconomic Credit Risk model for the Corporate Sector

As was described at the beginning of the chapter Credit Risk in the Czech Economy, the proxy for the credit risk in the corporate sector can be calculated. The credit register, which is operated by the Czech National Bank and contains credit data of the corporate sector, can be used for the more precise calculation of the corporate credit risk in the economy.[6] However this register is operated only since October 2002. We used data from the credit register since 2003 to check our proxy credit risk time series. This data confirmed good construction of the proxy variable.

Key macroeconomic determinants for the development of the corporate sector are interest rates, exchange rates, price of the inputs, and growth rate of the domestic economy and the economy of the key business partners.[7] These indicators also affect default rate in the corporate sector. 90% of the newly granted loans to the Czech corporate sector are with short fixation less then one year. It means that increase of the interest rate cause raise the price of firms´ financial sources at the one year horizon ceteris paribus. More expensive sources decline the ability of the firms to meet their financial obligations. Consequently, corporate default rate increase. Appreciation of the exchange rate can also affect positively default rate of the corporate sector.[8] Stronger exchange rate raises price of the goods in foreign currency. Firms are becoming les competitive. In general the price of goods in foreign currency at the world market is given. Hence the ratio between cost and sales is changed and profit of firms decline. It can lead in the higher default rate in the corporate sector. The increase of the price of firms' inputs can also affects companies in the negative way. On the contrary,

5 *Although this model was originally derived for the bankruptcy data, it can be applied for the loans data as well - see Jakubík (2007).*

6 *The register contains data on legal entities and individual entrepreneurs and can be used to obtain information on the payment discipline of banks' clients.*

7 *Key macroeconomic determinants of the profitability of the non-financial corporations are discussed for example in CNB (2007).*

8 *The relationship between profitability and real effective exchange rate was empirically confirmed e.g. by CNB (2007).*

growth of the market price of firms' outputs can affects firms in the opposite way. From the debtor point of view, the increase of the price level in the economy means decrease of the real value of the obligation. Although permanent inflation leads to the additional cost and harms the economy, in the short run the inflation improves the financial situation of the debtors and decrease probability of the companies' default. The period of the economic boom has positive effect on the corporate sector. Demand for the goods and services produced by the non-financial firms increases. Consequently the profit of companies increases and corporate default rate decreases. The same effect on the corporate credit risk has the growth of the economies of the key business partner. How strongly corporate sector is influenced by foreigner economies depends on the openness of the domestic economy. Vulnerability of the corporate sector also depends on its indebtedness. Higher debt of the company corresponds to the higher financial leverage and higher potential profit or lost. Such a company is more vulnerable to the unexpected macroeconomic shock and its default probability is higher.

In order to estimate credit risk model for the corporate sector we took into account all macroeconomic indicators mentioned above. We were looking for the model which would be able to explain corporate sector credit risk and capture the effect of the key macroeconomic determinant changes. Such a model could be used for the stress test scenario of the Czech banking sector. We used credit data to derive a proxy variable for the credit risk modelling. This variable was derived from the gross inflow of the NPLs for the aggregate economy and households default rate calculated according the equation (2). Such derived time series of the corporate default rate was available from 1997 Q1 to 2007 Q1. However due to the others considered macroeconomic indicators, the final model was estimated for the time period from 1998 3Q.

We employed one-factor model in all analyses. The best performance was obtained for the model where GDP, exchange rate, inflation and indebtedness of the corporate sector were included as macroeconomic indicators. The model was estimated for quarterly time series from 1998 Q3 to 2006 Q4. Resulting estimated model corresponds to equation (8). The estimate of the coefficients is shown in Table 1.

$$df_t = \psi(c + \beta_1 gdp_t + \beta_2 e_{t-2} + \beta_3 \pi_{t-1} + \beta_4 debt_{t-4}) \tag{8}$$

Table 1 – Default rate model for the corporate sector

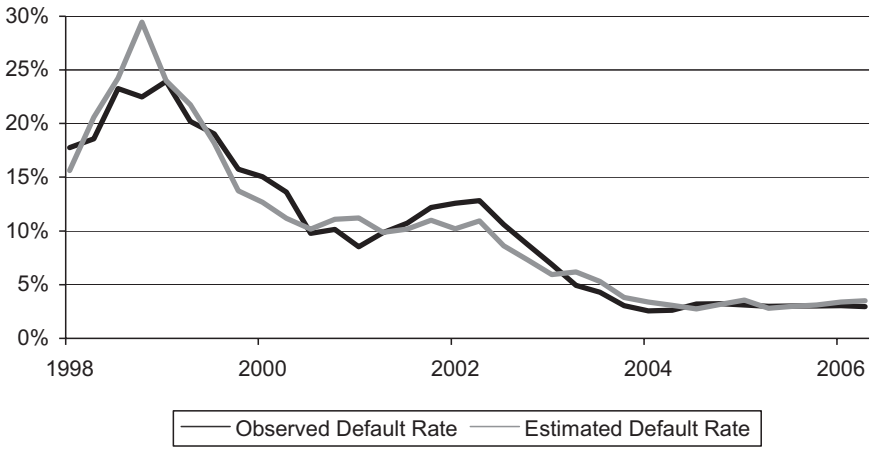
Description of variable corresponding to estimated coefficient	Notation	Estimate	Standard error	Pr>|t|
Constant	c	-2.822	0.484	<.0001
Gross domestic product (β_1)	gdp	-7.765	1.247	<.0001
Real exchange rate (β_2)	e_{t-2}	0.983	0.441	0.0327
Inflation (β_3)	π_{t-1}	-6.389	0.788	<.0001
Loans-to-GDP ratio (β_4)	$debt_{t-4}$	3.497	0.314	<.0001
Latent factor	ρ	0.007	0.002	0.0004

All the estimates were significant at least at the 5% confidence level. According the estimated model, corporate default rate in the Czech economy depends negatively on the non-lagged growth rate of the annual real gross domestic product. The growth rate of the Czech economy improves the situation of the firms and their default probability decrease. Our empirical analysis demonstrates the influence of the exchange rate on the credit risk. We used real effective exchange rate of the Czech koruna deflated by consumer price index lagged by two quarters. Stronger real exchange rate of the domestic currency affects corporate credit risk positively. Impact of the inflation on the firms' default rate was confirmed. In the case of inflation, the annual rate of growth of the average quarterly price consumer index lagged by one quarter was the most significant. A positive effect of the inflation on the situation of debtor was empirically shown. A real value of outstanding debt decreases with the inflation. We consider the debt indicator as a ratio of loans to GDP lagged by four quarters. As the loans we used total outstanding banking loans to the non-financial corporate sector. Latent factor which is the part of the estimation was still significant. However its coefficient is not part of the final model expressed by equation (8). Obtained result implies that corporate default rate in the economy is also affected by other factors then the macroeconomic indicators included.

However only the macroeconomic indicators mentioned above were included into the final model, also the others were considered. We employed for example real and nominal interest rates, real gross domestic product growth rate in the EU-15, EU-25, EA-12 and Germany or unemployment rate. Although some of them had significant prediction power for the corporate defaults rate, due to the correlation with the included indicators they did not contribute to the prediction power of the whole model.

Figure 1 demonstrates the performance of the estimated one-factor model for the Czech corporate sector. It confirms ability of the model to explain corporate default rate in the economy.

Figure 1 – Performance of the Estimated Model for the Czech Corporate Sector



Due to nonlinearity of the model, standard methodology for quality measurement of estimate can not be applied. Nevertheless a number of the less common indicator can be used. One of the tests of model quality is a test of the hypothesis that all the coefficients

except the constant term are zero (H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$). This hypothesis can be tested by likelihood ratio $-2ln\lambda = -2ln(L_c/L_u)$, where L_c denotes likelihood function of the constrained model and L_u likelihood function of the unconstrained model. This ratio is an asymptotic chi-squared distributed variable with 4 degrees of freedom due to four macroeconomic indicators included into the estimated one-factor model. The test rejected null hypothesis at the confidence level less then 1%. Instead of the standard coefficient of determination which can not be used due to nonlinearity, the pseudo-coefficients of determination were employed. All these coefficients are based on the likelihood functions of the restricted and unrestricted model. They should be in the interval [0;1]. Our results close to 1 pointed out the good quality of the estimated model.

$$R_E^{\,2} = 1 - \left(\frac{\ln L_U}{\ln L_C} \right)^{-\frac{2}{n}\ln L_C} = 0.97$$

Estrella (1998) (9)

$$R_{CU1}^{\,2} = 1 - \left(\frac{L_C}{L_U} \right)^{\frac{2}{n}} = 0.96$$

Cragg-Uhler (1970) (10)

$$R_{CU2}^{\,2} = \frac{1 - \left(\frac{L_C}{L_U} \right)^{\frac{2}{n}}}{1 - L_C^{\,\frac{2}{n}}} = 0.96$$

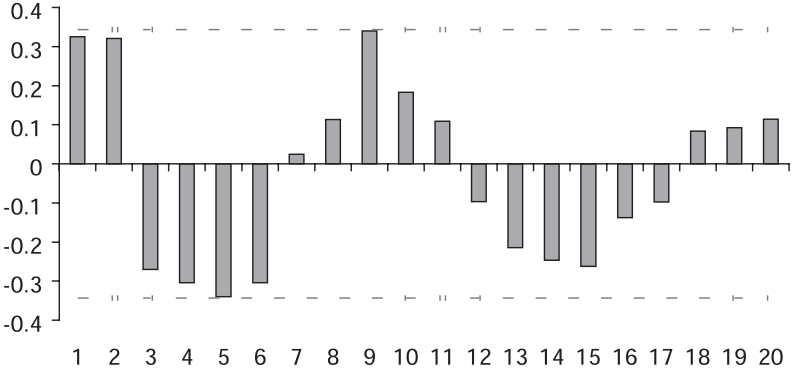
Cragg-Uhler (1970) (11)

$$R_{VZ} = \frac{2(\ln L_U - \ln L_C)}{2(\ln L_U - \ln L_C) + n} \frac{2\ln L_C - n}{2\ln L_C} = 0.81$$

Veall-Zimmermann (1992) (12)

The residuals of the model (8) were tested for autocorrelation using the Q-statistics. These values demonstrate absence of the autocorrelation in the residuals at the 5% confidence level (see figure 2).

Figure 2 – Autocorrelation function of the residuals



Furthermore the heteroskedasticity was investigated by Breusch-Pagan test. We ran the following regression.

$$\varepsilon_t^{\,2} = c + \beta_1 gdp_t + \beta_2 e_{t-2} + \beta_3 \pi_{t-1} + \beta_4 debt_{t-4} + \nu_t \tag{13}$$

We tested following null hypothesis H_0 against alternative hypothesis H_1. H_0 means that square residuals do not vary with any of the original regressors.

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$
$$H_1 : \beta_j \neq 0 \quad j \in \{1,2,3,4\}$$

We were not able to reject the null hypotheses. The present of the heteroskedasticity was not proved. It seems that estimated standard errors of the coefficients are not biased. Overall the estimation of the model (8) is not probably biased due to the properties of the residuals.

3.3 Macroeconomic Credit Risk Model for the Household Sector

In order to estimate credit risk model for the household sector in the Czech economy we follow one-factor model methodology. The same approach as for the corporate sector was applied. The resulting model was estimated for the annual default rate time series from 1997 Q3 to 2006 Q3.[9]

The ability of the households meet their financial obligation depends mainly on the income to instalment ratio. The households usually have a regular income as a salary, pension or some kind of rent. Besides that, they can own financial assets, real or personal estates. If their disposable income decreases under the certain threshold, they have to sell owned assets. If they already have nothing to sell they fall to the default. From the point of banks, it is easier to assess payment ability of the households then firms. One of the key macroeconomic determinants for the households default is unemployment rate which significantly affects the households' income. In the case that the key breadwinner of the heavy indebtedness household is fired from the job the household is usually not able to compensate his income and fall to the default under the condition that all owned assets are already sold. Gross domestic product is usually correlated with the households' income and therefore can be used as a proxy for it. Instalment of the debt depends on the interest rates in the economy. Default probability of the indebted household increases with increase of the interest rate under the consideration that interest rate for the loan is not fixed. Besides the indicators influencing the income to instalment ratio, principal of the debt can be also affected. Increase in the price level declines the real value of the debt. Hence, the inflation decreases the default probability of the households.

9 *The quarterly time series of the annual default rate was generated from the monthly series of the annual default rate calculated using relationship (2) by averaging the three monthly figures corresponding to the relevant quarter. Although the default rate obtained using equation (2) was available from 1994, the time series on which the model was estimated had to be shortened as a result of some lags in the model and due to the shorter series of the other macroeconomic indicators included in the model.*

A whole range of macroeconomic indicators were considered for the estimate. The model chosen as the statistically best model, in line with the economic theory, was one containing the unemployment rate and the real interest rate.[10] The unemployment rate was lagged by four quarters, which corresponds to the lagged impact on payment discipline in the event of loss of employment.[11] The statistically best results were achieved with a lag in the real interest rate of three quarters. This result expresses the lagged impact of an interest rate change on debtors resulting from interest rate fixation. The real interest rate was calculated by deflating the annual PRIBOR by the CPI. Latent factor which is the part of the estimation was still significant as well as in the case of the model for the corporate sector (8). Obtained results imply that default rate of the households sector in the economy is also affected by other factors then the considered macroeconomic indicators. The resulting estimated model corresponds to equation (14). The estimate of the coefficients is shown in Table 3.[12]

$$df_t = \psi(c + \beta_1 u_{t-4} + \beta_2 r_{t-3}) \tag{14}$$

Table 2– Default rate model for the household sector

Description of variable corresponding to estimated coefficient	Notation	Estimate	Standard error	Pr>|t|
Constant	c	-2.224	0.071	<.0001
Unemployment (β_1)	u_{t-4}	3.695	0.846	<.0001
Real interest rate (β_1)	r_{t-3}	1.808	0.596	0.0043
Latent Factor	ρ	0.004	0.001	0.0004

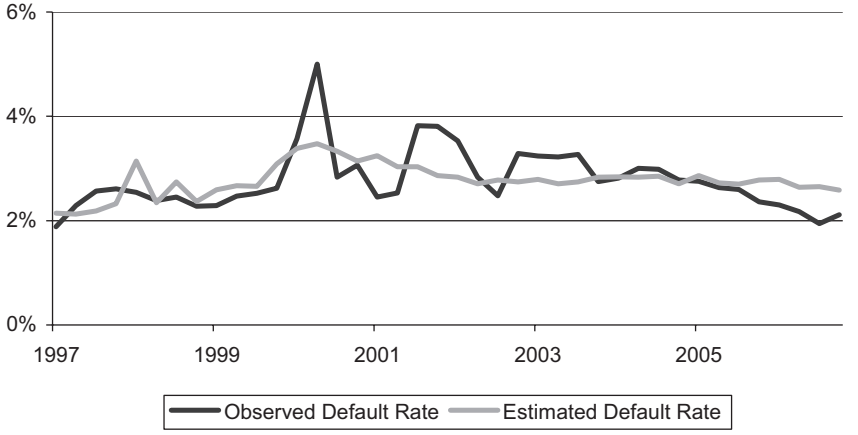
The hypothesis that all the coefficients except the constant term are zero (H_0: $\beta_1 = \beta_2 = 0$) was tested by the likelihood ratio $-2ln\lambda = -2ln(L_c/L_u)$. This ratio is an asymptotic chi-squared distributed variable with 2 degrees of freedom. The test rejected null hypothesis at the confidence level less then 1%. However pseudo coefficients of determination show worse performance of the model compare the corporate sector. It could be caused by the lower prediction power of the macroeconomic indicators to explain households default. Another reason could be instability of the parameter u in the equation (2) which was assumed to be constant.

10 *Also considered for the estimation of the model were nominal interest rates, inflation, the interest rate gap, the real GDP growth rate, the output gap, the ratio of interest paid to income or disposable income, etc. Disposable income was modelled using average wages and household consumption, while interest paid was modelled as the product of the credit volume and the annual PRIBOR increased by a certain interest rate spread.*

11 *The loan is initially repaid from savings or the redundancy payment; payment discipline is affected only after that.*

12 *Danmarks Nationalbank employs unemployment and interest-rate within the macro stress test of Danish households (Danmarks Nationalbank (2007)).*

Figure 3 – Performance of the Estimated Model for the Czech Household Sector



$$R_E^{\,2} = 1 - \left(\frac{\ln L_U}{\ln L_C} \right)^{-\frac{2}{n} \ln L_C} = 0.38$$

Estrella (1998) (15)

$$R_{CU1}^{\,2} = 1 - \left(\frac{L_C}{L_U} \right)^{\frac{2}{n}} = 0.37$$

Cragg-Uhler (1970) (16)

$$R_{CU2}^{\,2} = \frac{1 - \left(\frac{L_C}{L_U} \right)^{\frac{2}{n}}}{1 - L_C^{\,\frac{2}{n}}} = 0.37$$

Cragg-Uhler (1970) (17)

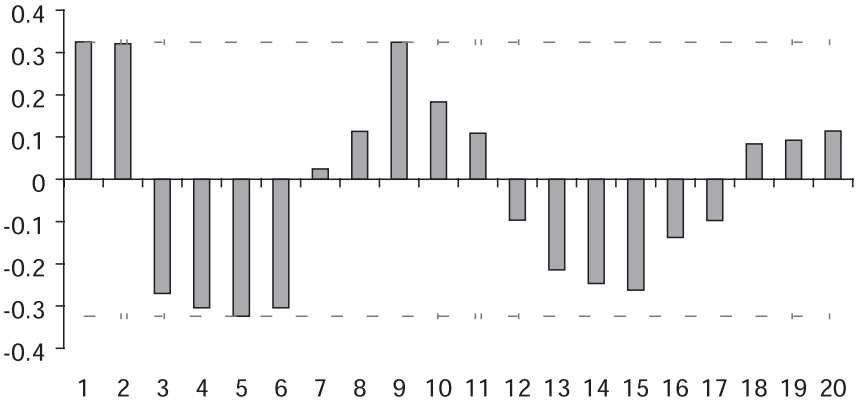
$$R_{VZ} = \frac{2(\ln L_U - \ln L_C)}{2(\ln L_U - \ln L_C) + n} \frac{2 \ln L_C - n}{2 \ln L_C} = 0.34$$

Veall-Zimmermann (1992) (18)

The residuals of the model (14) were tested for autocorrelation using the Q-statistics. These values demonstrate absence of the autocorrelation in the residuals at the 5% significance level (see figure 4).

Furthermore the heteroskedasticity was investigated in the same way as in the case of the corporate credit risk model (8). In contrast to model (8), the estimated model (14) records the heteroskedasticity of the residuals. Due to this result the standard errors of the estimated coefficients can be biased.

Figure 4 – Autocorrelation function of the residuals



4 Use of Models in Stress Testing

The Czech National Bank (CNB) employs the stress test exercise of the Czech banking sector for the purpose of financial stability. This methodology was gradually elaborated since 2004 by Čihák (2004), Čihák Heřmánek (2005), Čihák, Heřmánek a Hlaváček (2007). The basic stress tests based on extreme value from the past were complemented by interbank contagion test. These tests were followed by model scenarios within in-built estimated macroeconomic factors from the CNB's quarterly forecast and estimated growth in non-performing loans from the macroeconomic credit risk model for the aggregate economy developed by Jakubík (2007). This model enables to link development of the non-performing loans and macroeconomic environment. However different sensitivity of the households and corporate sectors was not able to capture. Although the aggregate model records good quality of the estimation, the forecast can be biased due to rapid growth of the loans to household and increasing share on the total banks' portfolio in the present time. The estimated sectoral credit risk models can better capture the real credit risk in the economy. We can test affect of the macroeconomic changes separately for the households and corporate sector. Both of these models can be incorporated into the current stress test methodology of the Czech National Bank. The models can evaluate the effect of the macroeconomic scenario on total non-performing loans to the corporate and households sector.

In order to forecast credit risk for the corporate sector, we have to set the inputs of the model (8). These include the non-lagged real GDP growth rate, real effective exchange rate lagged by two quarters, annual inflation lagged by one quarter and aggregate corporate loans to GDP ratio lagged by four quarters. These values can be set either expertly or as a percentage deviation from the CNB's quarterly macroeconomic forecast (see CNB (2003)). All these indicators are the part of the CNB's forecast except loans to the corporate sector. In the case that stress test exercise assume one-year horizon, we do not need to predict this variable due to four lags in the model. For longer horizon some kind of the credit growth model could be applied. The models based on the panel regression are used most frequently for the loan portfolio growth rate. This sort of models was also applied to the countries of Central and Eastern Europe, for example by Cottarelli, Dell'Ariccia, Vladkova – Hollar (2003) or Duenwald, Gueorguiev, Schaechter

(2005). The vector error correction model (VEC) is generally used for estimates for individual country as well as for aggregate data for several countries – e.g. Hofman (2001) or Schadler, Murgasova, Elkan (2005). In many studies the volume of loans in the economy is expressed as a ratio of loans to the private sector to GDP and is often estimated on the basis of a set of macroeconomic variables. Other studies try to model directly the rate of growth of the absolute volume of loans in the economy as for instance Fabrizio, Igan, Mody, Tamirisa (2006) who modeling credit growth for the countries of Central and Eastern Europe.

Table 3 – Sensitivity Analysis of the Credit Risk Model for the Corporate Sector (annual default rate in response to the value of exogenous variables)*

			GDP Growth Rate (in %)					
Inflation (in %)	*Real Effective ER*	*Loans to GDP (in %)*	1	2	3	4	5	6
1	0.9	15	6.01	5.14	4.37	3.70	3.11	2.61
		35	19.64	17.56	15.63	13.84	12.20	10.70
		50	37.07	34.18	31.37	28.68	26.09	23.63
	1.0	15	7.28	6.26	5.36	4.57	3.87	3.26
		35	22.48	20.22	18.10	16.13	14.30	12.62
		50	40.84	37.85	34.94	32.11	29.38	26.77
	1.1	15	8.73	7.57	6.52	5.59	4.77	4.04
		35	25.53	23.10	20.81	18.65	16.64	14.77
		50	44.70	41.64	38.64	35.71	32.85	30.10
3	0.9	15	4.63	3.93	3.31	2.78	2.32	1.92
		35	16.30	14.46	12.76	11.21	9.80	8.53
		50	32.36	29.62	26.99	24.49	22.11	19.88
	1.0	15	5.67	4.84	4.10	3.47	2.91	2.43
		35	18.84	16.81	14.93	13.20	11.61	10.16
		50	35.96	33.10	30.34	27.68	25.14	22.73
	1.1	15	6.88	5.91	5.05	4.29	3.63	3.05
		35	21.60	19.40	17.34	15.42	13.65	12.02
		50	39.70	36.74	33.86	31.06	28.38	25.80
5	0.9	15	3.52	2.96	2.47	2.06	1.70	1.40
		35	13.35	11.75	10.29	8.96	7.77	6.70
		50	27.91	25.36	22.94	20.65	18.51	16.51
	1.0	15	4.35	3.68	3.10	2.59	2.16	1.79
		35	15.58	13.80	12.16	10.66	9.30	8.08
		50	31.31	28.61	26.03	23.57	21.25	19.07
	1.1	15	5.34	4.55	3.85	3.25	2.72	2.27
		35	18.05	16.08	14.26	12.58	11.05	9.65
		50	34.87	32.04	29.32	26.70	24.21	21.85

Note: The sensitivity analysis uses non-lagged real GDP growth, CPI inflation lagged by one quarter, real effective exchange rate lagged by two quarters and corporate loan-to-GDP ratio lagged by four quarters.*

Table 3 shows the sensitivity of the corporate credit risk to the change in real GDP growth rate, real effective exchange rate, inflation and corporate loans to GDP ratio. The coefficients of the equation (8) cannot be interpreted as the commonly used elasticities of impacts of the relevant macroeconomic factors on credit risk, due to recalculation by the cumulative distribution function of a normal distribution. For this reason the effect of the change in one macroeconomic indicator depends on the value of the others indicators. This fact points out

the table 3. For example the effect of slow down in GDP growth from 5% to 3% depends on the actual corporate loans to GDP ratio, real effective exchange rate and inflation.

The CNB's quarterly macroeconomic forecast for unemployment rate, 12-month PRIBOR and CPI can be used to predict credit risk in the household sector according to the equation (14). However the model (14) does not record so good statistical performance as the model (8) for the corporate sector.

Table 4 shows the sensitivity of households' credit risk to the change in the unemployment rate and real interest rate in the economy. We observe low sensitivity of the model to the exogenous macroeconomic shocks. It can be caused by lower sensitivity of the households sector to the macroeconomic environment as well as inaccurate estimation of the proxy variable for the households' credit risk in the economy according to equation (2).

Table 4 – Sensitivity Analysis of the Credit Risk Model for the Households Sector (annual default rate in response to the value of exogenous variables)*

	Unemployment Rate (in %)			
Real IR (in %)	5	7	10	15
0	2.07	2.47	3.18	4.75
1	2.16	2.57	3.31	4.93
2	2.26	2.68	3.45	5.11
4	2.46	2.92	3.73	5.50
6	2.67	3.16	4.04	5.92
8	2.91	3.43	4.36	6.36

*Note: * The sensitivity analysis uses unemployment rate lagged by four quarters and real interest rate lagged by tree quarters.*

5 Conclusions

Credit risk modelling is an important part of the stress test exercise. We investigated different sensitivity of the corporate and households sector credit risk to the change of macroeconomic environment in the Czech economy. In order to improve banking sector stress test, sectoral macroeconomic credit risk models can be incorporated into the exercise. While the performance of the estimated model for the corporate sector records very good quality, the performance of the model for the households sector was worse. Further work in this area could be done. Data from the credit register for individuals would be possible to use in the future for the credit risk modelling for the households sector. Nevertheless this research study is important step to capture different impact of the macroeconomic change on the sectoral credit risk. One-factor model was employed in all analyses. This methodology enables to capture nonlinearities of the credit risk determinants. All these results can contribute to detect potential fragility of the banking sector and prevent the financial crises.

Abstract

This paper deals with sectoral credit risk in the Czech economy. It follows structural Merton's approach. Latent factor models are employed within this framework. The credit risk

models for the corporate and household sectors in the Czech Republic were estimated in this manner. They are able to capture the effects of macroeconomic changes on the sectoral credit risk in the economy. The results of this study can be used for the improvement of the Czech banking sector stress test. The models enable the stress tests to be linked to the Czech National Bank's official quarterly macroeconomic forecast.

JEL Classification / JEL klasifikace
G21, G28, G33

Souhrn
Tato práce se zabývá sektorovým kreditním rizikem v české ekonomice a vychází z mertonovského strukturálního přístupu. Pro modelování kreditního rizika jsou použity latentní faktorové modely. Na datech české ekonomiky byly odhadnuty makroekonomické modely kreditního rizika pro sektor podniků a domácností. Tyto modely jsou schopny zachytit dopad změn makroekonomického prostředí na sektorální kreditní riziko v ekonomice. Výsledky této studie mohou být použity k zpřesnění stresového testování českého bankovního sektoru. Modely umožňují navázání stresového testování na oficiální čtvrtletní prognózu České národní banky.

Kontaktní adresa / Contact address
PhDr. Ing. Petr Jakubík, Ph.D.
Česká národní banka a Institut ekonomických studií Fakulty sociálních věd Univerzity Karlovy v Praze
(e-mail: Petr.Jakubik@cnb.cz)

PhDr. Ing. Petr Jakubík, Ph.D.
Vystudoval ekonomii na Fakultě sociálních věd Univerzity Karlovy v Praze, statisticko-pojistné inženýrství na Fakultě informatiky a statistiky VŠE v Praze, inženýrskou informatiku na Fakultě jaderné a fyzikálně inženýrské ČVUT v Praze. Ph.D. v oboru finance obhájil na Fakultě financí a účetnictví v Praze. V průběhu své odborné praxe vystřídal několik bankovních institucí, v současné době působí jako vrchní ekonom ČNB v Praze. Je členem představenstva a výkonného výboru České společnosti ekonomické, Centra základního výzkumu pro dynamickou ekonomii a ekonometrii a členem Evropské ekonomické společnosti."

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Nash Equilibrium in Redistribution Systems (Calculation, Weight, Application)

Nashova rovnováha v redistribučních systémech (výpočet, význam, využití)

PETR BUDINSKÝ, RADIM VALENČÍK

The more the company is able to appreciate performance of its employees the higher its output. This applies in general to other social systems as well - public administrative institutions, organizations, political competitors, public associations, regional self-governing bodies on different levels, the private and the public sector etc. The above principle also works in the opposite direction: The bigger the collision between cash distribution inside the social system and appreciation of performance of those creating the system, the lower the overall performance of the system as a whole. A typical case of redistribution inside such systems is formation of a certain coalition using its dominant influence for redistribution of the means acquired by the company for the benefit of the members of the coalition. This also applies to administered organizations where the person deciding about distribution of gains is appointed for the position and enjoys unlimited or at least significant powers. Here also various informal coalitions are formed with the abovementioned goal.

The theory of redistribution systems may be applied to resolution of this issue as one of the cases of the general theory of game. The theory represents an original approach developed by a team of the College of Finance and Administration and applicable in many different areas. For the purpose of analysis of standard situations occurring in the redistribution systems there is a formalized model of elementary redistribution system with three players (A, B, C) whose performance is distributed in the ratio of 6:4:2. Each of the players possesses the same power to affect the result (influence equal to 1).[1] One of the first steps of the redistribution system analyses was definition of the redistribution equation describing all options of payment distribution in the elementary redistribution system. For the purpose of the elementary redistribution system the equation can be defined as follows:

$$x + y + z = 12 - \eta.R(x - 6, y - 4, z - 2)$$

where:

x + y + z is the sum of real pay-offs of individual players,

12 is maximum pay-off which could be divided, if output of the redistribution system was maximal, which means that no distribution would be taking place and dividing of pay-offs would be according to performance, η is coefficient of lowering performance,

1 *For details see Wawrosz (2007).*

R(x - 6, y - 4, z - 2)

is function of length of division of real pay-offs according to performance.

The redistribution equation may be interpreted as follows: the amount to be distributed among the players equals the maximum amount that the players might distribute among themselves reduced by the value of their deviation from performance-based distribution. The function of distance **R** can be defined in various ways. The best way seems to be the definition based on the usual metrics defining the distance as square root of the sum of squares of the difference between the optimum payment and the actual payment (only positive values being taken into account):

$$\sqrt{(x - 6)^2 + (y - 4)^2 (z - 4)^2}$$

A professional mathematical analysis of the elementary redistribution system is extremely important for two reasons. One is its relevance for analyses of various types of the elementary redistribution system applications and the other its relevance for analyses of how the simple elementary systems are chained into more complex ones. Every equilibrium within a simple redistribution system is unstable and that leads to chaining of simple systems into hierarchical and network structures.

This analysis shows that what might appear to be an external influence (such as personal sympathies etc.) often is determined by the very parameters of the system.[2] Further to this issue there is a very interesting recently developed apparatus based on a computer model, used for simulation of a number of situations opening the way to analyses of the more hidden layers of the issue. The model allows for descriptions of various types of negotiations and their results, which display as negotiation trajectories in the redistribution area.

Diagram 1 shows an example of computer plotted redistribution area for the value of the coefficient of performance decrease η equal to 0.5 and R defined as square root of the squares of the difference between redistribution and performance-based remuneration. The bottom cross sign marks a point with coordinates (6; 4; 2), i.e. the point of payment distribution based on performance, and the top cross sign marks the point of equal payments to all players, which in the given case is about 3.51, i.e. a point with coordinates (3.51; 3.51; 3.51). Every redistribution plane must intersect both points. In the point with coordinates (6; 4; 2) the sum of payments to all players is the highest. The farther from this point the lower the sum of the payments.[3]

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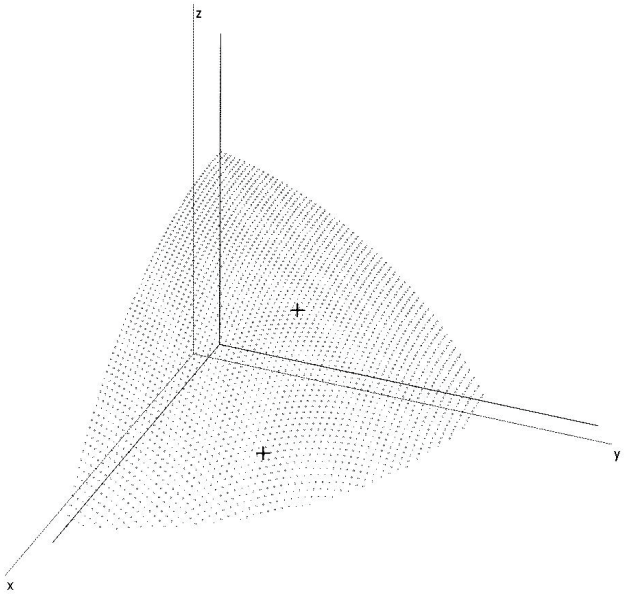
2 *M. Maňas, in the context of solution of a similar task (collusive oligopoly consisting of five players) after presenting all equilibrium situations states: "Contract negotiation is usually long and if in general fatigue resulting form the protracted negotiations a contract is signed in the end, it is mostly under the effect of personal sympathies rather than on the basis of a logical consideration. " (Maňas 2002, p. 61) In the area of redistribution systems, however, we can go even further and look at the hidden causes of what appears to be personal sympathy etc.*

3 *The model works with the step equal to 0, 1. Compiled by computer science student Mr. Vávra (from IFA)*

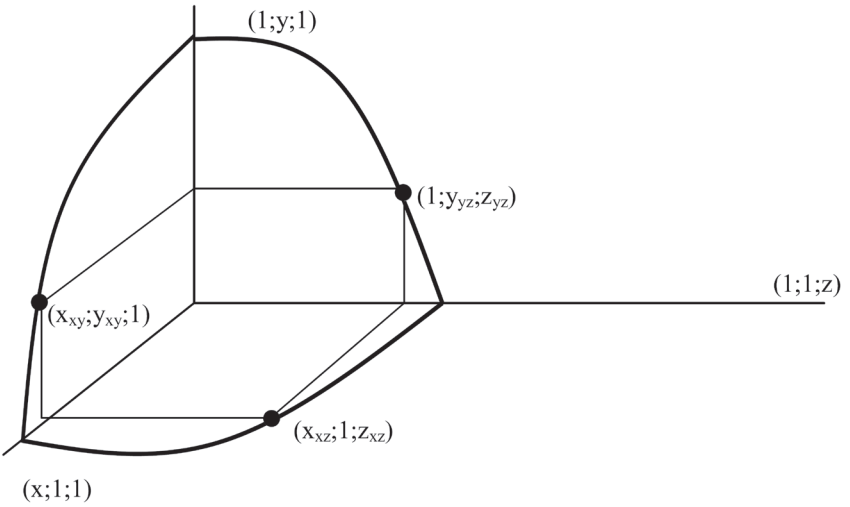
Diagram 1 Computer-based simulation of redistribution surface



Let us look at one particular and very practical conclusion that can be drawn on the basis of the analysis of what happens in the redistribution area. With regard to coalition forming the redistribution area looks very symmetrical at first sight. The player with the top performance (A) can form a coalition with the average player (B) and both of them can improve their earnings at the cost of the weakest player (C). Similarly player B can form a coalition with player C and improve its earnings at the expense of player A. And then there is the third option of a coalition between players A and C against player B. In the case of a coalition between players B and C and improvement of their earnings at the cost of the top performance player will be the highest (for they can get most of the player with the top performance). At the same time this will result in the largest decrease of the overall performance of the system. The conclusion drawn from the above is very important. Under very general assumptions actual systems will tend to "drop" to a situation when the mediocre ally with the weakest and control the system (institution, organization etc.) including distribution of earnings within the system.

The strongest player, however, is not completely helpless and can do something against this development of the situation. He can offer more to the weakest player than what the weakest player would achieve by alliance with the mediocre. Or instead of the promises to the weakest player the strongest player may ally with the mediocre player and they can improve their situations in comparison to the situation under agreement with the weakest player. In the logic of the case the agreement of a player with the player other than the member of the original coalition and the resulting redistribution of payments represents sacrificed opportunity. In he case of the offers described above a equilibrium can be calculated.

Diagram 2: Equilibrium in negotiations by using pandering method:



The key to finding a equilibrium in the case of negotiation with offer is represented by the following consideration:

- If an agreement has been made between the weakest and the mediocre player and the parameters of the agreement are **$(1;y_{yz};z_{yz})$**, then with regard to payment to the weakest player there is a equilibrium between this agreement and the agreement between the strongest and the weakest payer with the parameters **$(x_{xz};1;z_{xz})$**.

- In this case the following must be true: **$z_{yz} = z_{xz} =$ def: z_p** (the value must be the same whether resulting from negotiation between the weakest and the mediocre player or from negotiation between the weakest and the strongest player and therefore may be **z_p** in both cases, with the p index derived from the word promise (offer).

- The same obviously applies in the case of the other agreements, i.e.:

$x_{xy} = x_{xz} =$ def: x_p
$y_{xy} = y_{yz} =$ def: y_p

This relation implies following equation system:

$1 + y + z = 12 - \eta.R(5; y - 4; z - 2)$
$x + 1 + z = 12 - \eta.R(x - 6; 3; z - 2)$
$x + y + 1 = 12 - \eta.R(x - 6; y - 4; 1)$

There are three independent equations with three variables whose solutions represent the sought for values. What is the purpose of this solution? The solution points out three equilibrium points with coordinates:

$(1; y_p; z_p)$ – with player A outside the coalition and discriminated
$(x_p; 1; z_p)$ – with player B outside the coalition and discriminated
$(x_p; y_p; 1)$ – with player C outside the coalition and discriminated

Let us call equilibriums of this type discrimination equilibriums. They can already be used for calculation of the Nash equilibrium. The ratio of mean payments to the players (the sum of value 1 and the two values corresponding to the victorious coalition, all divided by three) is to be entered in the redistribution equation. The solution to this equation is the Nash equilibrium.

The definition of Nash equilibrium is not simple and some monographs of textbook type even include certain inaccuracies. A detailed account is presented by Carmichael (2005)4. Her detailed definition reads: "In Nash equilibrium the players in the game select strategies to each other that are the best for themselves. But not every Nash strategy applied by the individual player is the best answer to every other strategy applied by the other players. Nevertheless, if al players in the game play Nash strategies, none of them is inclined to do anything else."

If any player wants to improve its pay – whether by requirement for a higher pay or by a promise to and a coalition with another player with discrimination of the third player

- he will achieve the very opposite, his situation will get worse.[5]

It is clear that if players B and C manage to exclude player A from the possibility to negotiate, their reward will be higher than in the case of the above calculated Nash equilibrium. This leads to a conclusion important for the practice, which is that in real systems you can come across cases when the top performance player is in advance deprived form the possibility to negotiate who will assert himself in the given system.

The principles of calculation of Nash equilibrium can be transferred to situations representing an extension of ERS, for example if:

- There is some pressure from competitors exerted on the system.
- The system develops (grows) in time and compares to other systems.
- There is a back effect of the income on the negotiation positions of the players (their ability to affect the redistribution).
- There is inter-organisation migration.
- Etc.

In all these cases it is possible to express the effect of the extended assumptions on the negotiation positions of the players and in which directions the discrimination equilibriums and the Nash equilibrium will be shifted. Discrimination equilibriums of a similar type and Nash equilibrium even exist in more complex systems with relationships between areas with effective competition pressures, and areas with limited competition pressures and

4 Carmichael. (2005, p. 36).

5 For details see Valenčík et al. (2007).

with the option of inter-organisation migration. Generally speaking the proof of existence and demonstration of the possibility of calculation of Nash equilibrium in an elementary redistribution system in the key to identification, description and possibly calculation (if you quantify the system parameters) of Nash equilibrium for more complex redistribution systems. It is possible to provide a general methodology of analysis of effects of various factors on the shifts of the individual types of the equilibrium.

Identification, description and possible calculation of Nash equilibrium in redistribution systems are crucial. As the discrimination equilibriums and the Nash equilibrium are statuses with very close probability, but significantly different positions of the individual players, important rules can be derived for combinations or mergers of simpler redistribution systems to more complex wholes and rules of development of social networks acting between various redistribution systems. Research into this is quite intense. The results of the research are continuously published on www.vsfs.cz/vyzkum-a-projekty/seminar/.

The theory of redistribution systems offers broad possibilities for international cooperation, among other things in areas such as doctoral study. The solutions of the individual issues may focus on achievement of original results with regard to development and application of a mathematical apparatus specific for the given area (including one not yet applicable in economic disciplines) as well as with regard to a number of important and socially relevant practical applications.

Abstract

A redistribution system is any social system as organization, company or institution is where the redistribution of payments of players in comparison with their performance happens. The very important role is played by constitutions of alliances created in this system. Modeling of essential three players redistribution system as well as identifying and calculating the forms of equilibrium (discriminatory or Nash) provide the key for analysis of a real individual or group behavior including problems of its stability and chaining of other social systems. The theory of redistribution systems, as an original extension, comes out of the "game theory" and it has numerous practical applications.

Keywords

Game Theory, Theory of Redistribution Systems, Redistribution Equation, Coalition, Bargaining, Pareto Optionality, Nash Equilibrium

JEL classification / JEL klasifikace

D01, D33, D74.

Kontaktní adresa / Contact address

h. doc. RNDr. Petr Budinský, CSc.
Vysoká škola finanční a správní, o.p.s., prorektor pro obchod a vnější vztahy
(e-mail: petr.budinsky@vsfs.cz)

doc. Radim Valenčík, CSc.
Vysoká škola finanční a správní, o.p.s., Centrum pro ekonomické studie a analýzy
(e-mail: radim.valencik@vsfs.cz)

Souhrn

Redistribuční systém je jakýkoli sociální systém typu organizace, firmy či instituce, ve kterém dochází k přerozdělení výplat hráčů oproti jejich výkonnosti. Podstatnou roli přitom hrají koalice, které se v takovém systému vytvářejí. Modelování elementárního redistribučního systému, který se sestává ze tří hráčů, identifikování a výpočet rovnováhy diskriminačního typu a Nashovy rovnováhy poskytuje klíč k analýze reálného chování jednotlivců i jejich skupin včetně problematiky stability a spojování různých sociálních systémů. Teorie redistribučních systémů jako původní rozšíření a aplikace teorie her má četné praktické aplikace.

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PŘIPRAVUJEME /PREVIEW:

Příští číslo: ACTA VŠFS 2/2008

Stať doc. Ing. Mojmíra Helíska, CSc. k problematice zavedení eura v ČR
Stať bude věnována problematice zavedení eura v ČR, a to potenciálnímu konfliktu mezi inflačním a Kurzovým konvergenčním kritériem. Teoretickým východiskem je koncepce imposible trinity (neslučitelnost tří cílů hospodářské politiky), empirickým východiskem pak zkušenosti zemí, které již euro zavedly nebo které v současnosti setrvávají v mechanismu ERM II.

PŘÍLOHA /INSERT