ETLA 60 vuotta

Tervehdyssanat

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ETLAn edeltäjä Taloudellinen Tutkimuskeskus aloitti toimintansa 1. elokuuta 1946. Suomi oli silloin kovin erilainen maa kuin nykyään. Maanviljelyksestä sai vielä elantonsa noin puolet väestöstä. Kuluneiden 60 vuoden aikana tapahtunutta elinkeinorakenteen muutosta voi sanoa valtavaksi.

Muutos on luonnollisesti heijastunut myös ETLAn toimintaan. Tutkimuksen painopisteet ovat vuosien mittaan vaihdelleet, mutta johtoaihe on pysynyt aika lailla vakaana: miten luodaan elinkeinoelämälle edellytykset ylläpitää taloudellista kasvua ja turvata elintason nousu Suomessa.

Koulutuksen ja tutkimuksen merkitys taloudelliselle kasvulle tunnistettiin jo Taloudellisen Tutkimuskeskuksen aikana. Niiden vaikutus tuottavuuden nousuun ja teknologiseen kehitykseen on antanut aiheen useille tutkimuksille jo 1950-luvulta alkaen. ETLA on koulutuksen ja innovaatioiden tutkimuksen edelläkävijä Suomessa; molemmilla on laitoksessa pitkät perinteet. Merkittäviä olivat myös viime vuosikymmenen klusteritutkimukset, jotka avasivat uusia uria Suomen elinkeinopolitiikalle.

Taloudelliseen kasvuun vaikuttavia tekijöitä on tutkittu laajasti. Työvoiman kysynnän ja tarjonnan kehitystä ja niiden kohtaamista on analysoitu ja ennakoitu aivan toiminnan alkuvuosista lähtien. Työvoimamarkkinoiden toimivuus on noussut entistä tärkeämmäksi tutkimuskohteeksi sen jälkeen, kun Suomi liittyi Euroopan talous- ja rahaliiton jäseneksi.

Euroopan yhdentymiskehitys oli yksi 1990-luvun keskeisistä tutkimusaiheista. ETLA arvioi sekä Suomen integraatiovaihtoehtojen seurauksia että EU:n laajenemisen vaikutuksia. Sittemmin kansainvälisen talouden tutkimuksen painopiste on siirtynyt globalisaatioon ja sen vaikutuksiin. Venäjän, Kiinan ja Intian kehityksellä on suuri merkitys myös Suomen elinkeinoelämälle.

Verotusta, tulonsiirtoja ja tulonjakoa on tutkittu lähinnä julkisen talouden kestävyyden näkökulmasta. Hyvinvointivaltion perusperiaatteita kyseenalaistamatta on korostettu, että sen ylläpitäminen edellyttää vahvaa taloudellista kasvua. Tämän vuoksi myös riittävien taloudellisten kannusteiden olemassaolo on tärkeää. Tällä hetkellä ajankohtainen tutkimusaihe on väestön ikääntymisen vaikutus eläkejärjestelmään ja julkiseen talouteen; eläke- ja sosiaalimenoihin kohdistuu jo lähivuosina voimakkaita nousupaineita.

ETLAn perustaminen vuonna 1971 Taloudellisen Tutkimuskeskuksen seuraajaksi merkitsi paitsi toiminnan huomattavaa laajenemista, myös riippumattoman ennustetoiminnan aloittamista Suomessa. Siihen asti suhdanneennusteita oli julkaissut vain valtionvarainministeriön kansantalousosasto. ”Virallisten” ennusteiden rinnalle haluttiin myös riippumaton vaihtoehto. Tukea saatiin niin sanotusta Hellerin raportista, jonka OECD julkaisi 1960-luvun lopulla.

Walter W. Heller oli amerikkalaisen ekonomisti, joka aikanaan toimi muun muassa kahden presidentin, Kennedyn ja Johnsonin, neuvonantajana. Hänen johtamansa OECD:n komitea piti tärkeänä, että talouspoliittisten päätösten pohjaksi on olemassa riittävän monipuolista informaatiota.

Ennustelaitosten toiminta on hankalaa, sillä ennusteet toteutuvat harvoin. Silti ne antavat käsityksen kehityksen todennäköisestä suunnasta ja ovat välttämättömiä, jos ylipäänsä halutaan varautua tulevaisuuteen. Tär-

keää on myös kumuloituva tieto, jota kertyy ennusteita laadittaessa sekä taloudellisia malleja ylläpidettäessä ja kehitettäessä. Taloudellisen tilanteen ja talouden rakenteiden perusteellinen tuntemus parantaa valmiuksia analysoida talous- ja rakennepolitiikan vaikutuksia ja vaihtoehtoja. Ilman taloudellisen kehityksen systemaattista seurantaa ja ennakointia ajankohtaiseen keskusteluun osallistuminen olisi paljon vaikeampaa.

Viimeaikaisessa talouspoliittisessa keskustelussa ovat rakennekysymykset nousseet aiempaa voimakkaammin esille. Osaksi tämä johtuu Suomen EU- ja Emu-jäsenyydestä. Osa suhdannepolitiikkaan liittyvistä päätöksistä tehdään nyt koko Euroopan tasolla. Lisäksi yhteinen valuutta ja Emu-jäsenyyteen liittyvät sopimukset rajaavat käytettävissä olevia keinoja ja suhdannepoliittista liikkumavaraa. Siksi on tärkeää, että talouden rakenteet mahdollistavat joustavan sopeutumisen muuttuviin suhdanteisiin. Osaksi kyse on myös siitä, että talouden keskeiset ongelmat ovat pikemminkin rakenteellisia kuin suhdannetilanteeseen liittyviä.

Elinkeinorakenteen muutos on nyt meneillään koko maailmantaloudessa. Pysyäkseen mukana kehityksessä perinteisten teollisuusmaiden on löydettävä uusia kasvupolkuja, jolla voidaan korvata nouseviin talouksiin siirtyvää toimintaa. Globalisaatiokehityksen myötä innovaatioista on tullut Euroopan maille yhä tärkeämpi kilpailukeino. Tämä näkyy muun muassa siinä, että innovaatioiden edistäminen on valittu Suomen puheenjohtajakauden johtavaksi teemaksi.

Historiallisesti Eurooppa on menestynyt innovoinnissa – osaksi monimuotoisuutensa ansiosta. Samalla, kun maat ovat kilpailleet keskenään, ne ovat omaksuneet toisiltaan vaikutteita. Kehityksen painopiste on siirtynyt maasta toiseen. Toivottavasti sama dynamiikka kyetään säilyttämään myös integraation syventyessä ja yhdentyneen Euroopan laajentuessa.

Monimuotoisuuden rinnalla tarvitaan kuitenkin myös yhdenmukaisuutta, jotta 460 miljoonan asukkaan kotimarkkinoiden tarjoamat mahdollisuudet kyetään hyödyntämään. Yhteiset normit ja standardit antavat mahdollisuuden kehittää tuotteita, joilla eurooppalaiset yritykset voivat menestyä myös Euroopan ulkopuolella. Digitaalisen gsm-matkapuhelinjärjestelmän maailmanlaajuinen menestys on hyvä esimerkki potentiaalista, joka yhteisiin eurooppalaisiin standardeihin sisältyy.

Yhteiset normit ja standardit ja yhtenäiset markkinat tarjoavat perustan innovaatioiden kustannustehokkaalle tuotannolle. Keinot, joilla niiden alkutaivalta tasoitetaan, voivat sen sijaan poiketa toisistaan. Ei ole syytä olettaa, että olisi olemassa vain yksi, sellaisenaan kaikille sopiva innovaatiopolitiikan malli. Erilaiset lähestymistavat ovat rikkaus; ne tarjoavat mahdollisuuksia oppia toisten kokemuksista.

Suomalaistenkin on syytä pitää silmänsä auki. Suhteessa kansantalouden kokoon Suomen panostukset ovat Euroopan huippuluokkaa, mutta innovoinnin tehokkuus näyttää olevan vain hyvää keskitasoa. Vuoden 2005 European Innovation Scoreboardin mukaan monet maat saavat omista panostuksistaan irti enemmän kuin Suomi. Voi tietenkin kysyä, kuinka tarkkoja ja kattavia käytetyt indikaattorit ovat. Kyseessä on – kuten raportin

laatijatkin toteavat – vasta ensimmäinen yritys mitata ja vertailla Euroopan innovaatiojärjestelmien tehokkuutta. Vertailun tulokset antavat kuitenkin aiheen jatkaa keskustelua.

Keskustelupohjan laajentamiseksi tarvitaan lisää tiede- ja teknologiapolitiikan tutkimusta. Sen merkitys on tänä päivänä suurempi kuin koskaan. Suomessa – toisin kuin useimmissa meihin verrattavissa maissa – ei ole tiede- ja teknologiapolitiikan tutkimukseen erikoistunutta laitosta. Tutkimusta ei ole syytäkään keskittää, mutta on tärkeää, että siihen varataan tarpeeksi julkista rahoitusta ja että sitä kanavoidaan riittävästi myös riippumattomille tutkimuslaitoksille.

Innovaatiopolitiikassa korostuu luonnollisista syistä soveltava tutkimus. Sitä ei kuitenkaan ole ilman perustutkimusta. Siksi on syytä kantaa huolta myös teoreettisen tutkimuksen riittävästä rahoituksesta, vaikka sen tuottamaa hyötyä onkin melko mahdotonta arvioida ennalta. Myös elinkeinoelämällä on intressi rahoittaa perustutkimusta, vaikka sillä ei useinkaan ole välitöntä kytkentää yritysten liiketoimintaan. Tällaisia pyrkimyksiä ei vain erityisesti rohkaista.

Nykyisin yritys voi lahjoittaa tieteen ja taiteen tukemiseen verovapaasti 25 000 euroa saajaa kohti. Sanomattakin on selvää, ettei lahjoituksen saaja voi niin pienellä summalla toteuttaa minkäänlaisia merkittäviä hankkeita. Kun yritysten tarjoamat lisäresurssit eivät vähentäisi muuta rahoitusta, on vaikea ymmärtää, miksei yritysten lahjoituksia tieteellisen tutkimuksen tukemiseen voitaisi Suomessakin kannustaa paljon nykyistä aktiivisemmin.

Verovapaiden lahjoitusten ylärajan merkittävä nostaminen – se voitaisiin jopa poistaa kokonaan – antaisi yrityksille mahdollisuuden edistää akateemista tutkimusta alueilla, joita ne pitävät tärkeinä. Samalla voitaisiin aiheesta kiinnostuneille tutkijoille tarjota uusia tilaisuuksia syventää osaamistaan kotimaassa. Kun tutkimuksen tasolle asetetaan riittävän kunnianhimoiset tavoitteet, voidaan Suomeen houkutella lahjakkaita tutkijoita myös ulkomailta.

Sama koskee innovaatiopolitiikkaa: myös sen tavoitteiden on oltava korkealla. Tutkimus- ja kehitystoimintaan käytetyt varat saadaan korkoineen takaisin vain, jos syntyvät uudet tuotteet menestyvät maailmanmarkkinoiden alati kovenevassa kilpailussa. Innovaatioiden edistämiseen tarkoitetut toimet on kohdennettava ja mitoitettava niin, että tämä päämäärä on mahdollista saavuttaa.

Korkeatasoinen teknologinen osaaminen on tärkeää, mutta pelkästään sen varaan menestystä ei voi rakentaa. Joukko eurooppalaisia tutkijoita on hiljattain julkaissut tuloksia laajasta kyselystä, johon vastasi yli 9 000 keksijää Alankomaista, Espanjasta, Isosta Britanniasta, Italiasta, Ranskasta ja Saksasta. Kyselyn tekijät pyrkivät muun muassa selvittämään keksijöiden keskeisiä tiedon lähteitä.

Tärkeimmäksi tiedon lähteeksi vastaajat nimesivät asiakkaat. Tämä ei ole yllättävää siksi, että suurin osa vastaajista oli erikokoisten yritysten palveluksessa. Yrityksille keksinnön omaperäisyys tai uraauurtavuus ei ole it-

seisarvo. Sen pitää myös mahdollisimman hyvin vastata asiakkaiden tarpeita ja mieltymyksiä. Siksi on hyvä jo tuotekehitysvaiheessa selvittää ja ottaa huomioon, mitä asiakkaat haluavat ja tarvitsevat.

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ETLA on aloittanut toimintansa seitsemännen vuosikymmenen. Sille on syytä toivottaa jatkuvaa menestystä. Tärkeitä tutkimusaiheita riittää myös seuraavaksi viideksitoista vuodeksi eli 75-vuotisjuhliin asti, ja senkin jälkeen. Historia ei ole loppumassa eikä maailmantalouden muutos pysähdy. Meidän on yhä uudelleen ymmärrettävä muutoksen luonne ja osattava mukauttaa oma toimintamme muuttuvaan toimintaympäristöön. Mielestäni muutokseen sopeutuminen ja muutoksen hyödyntäminen on jatkuvan hyvinvoinnin ainoa kestävä perusta.

ETLA 60 vuotta

Katsaus tutkimuslaitoksen historiaan

Pentti Vartia

Pentti Vartia
on suorittanut valtiotieteen tohtorin tutkinnon Helsingin yliopistossa ja diplomi-insinöörin tutkinnon Teknillisessä korkeakoulussa. Professorin arvonimi hänelle myönnettiin vuonna 2002.

Pentti Vartia toimi Elinkeinoelämän Tutkimuslaitoksen (ETLA) toimitusjohtajana 1983-2005 sekä Elinkeinoelämän Valtuuskunnan (EVA) toimitusjohtajana 2000-2005, ETLAn tutkimusjohtajana 1977-1983, kansantaloustieteen apulaisprofessorina Helsingin yliopistossa 1973-1977 ja ETLAn tutkijana 1971-1973.

Pentti Vartia on Helsingin yliopiston dosentti vuodesta 1977 ja Helsingin kauppakorkeakoulun dosentti vuodesta 1986. Hän on Teknillisten Tieteiden Akatemian jäsen vuodesta 1993, Yrjö Jahnssonin Säätiön hallituksen varapuheenjohtaja vuodesta 2000 ja ETLAn tutkimusneuvoston puheenjohtaja vuodesta 2005.

Pentti Vartia on kirjoittanut useita kirjoja sekä lukuisia tieteellisiä ja ammatillisia artikkeleita taloustieteen eri aloilta.

Kuusikymmenvuotisjuhlia varten ei haluttu toistaa aiempaa historiankirjoitusta, vaan päätettiin tarkastella ETLAn tutkimuksen pitkää linjaa ja samalla pohtia tulevaisuuden tutkimustarpeita.

Elinkeinoelämän Tutkimuslaitoksen ja sen edeltäjän Taloudellisen Tutkimuskeskuksen toiminta-ajatus on pysynyt oleellisilta osin samana koko toiminnan ajan. Jo alkuvuosina korostettiin pyrkimystä luotettavuuteen ja tieteellisyyteen, mutta heti samalla todettiin, että tutkimuksesta pitää olla myös hyötyä. Laitos on siten perusluonteeltaan aina ollut päätöksentekoa palveleva kansantaloudellista, sosiaalipoliittista ja liiketaloudellista tutkimusta harjoittava yksikkö.

Tämä soveltava ote näkyi alkuvuosina esimerkiksi siinä, että tärkeiksi koetuista tutkimusaiheista ei useinkaan ollut valmiita tilastoja. Laitos onkin ollut synnyttämässä Suomeen mm. teollisuuden tasetilastoja, välillisten työvoimakustannusten seurantaa, jo 1950-luvulla alkanutta tutkimus- ja kehitysmenojen tilastointia, varastotilastoja, kulutuksen kehitystä kuvaavia tilastoja, sekä vielä 1980-luvulla markkinarahaa ja leasing-rahoitusta koskevia tilastoja. Tällaisten tilastojen laatiminen on myöhemmin monesti siirtynyt Tilastokeskukselle.

Tärkeä soveltavaan tutkimukseen liittyvä kysymys on ollut laitoksen osallistuminen yhteiskunnalliseen keskusteluun. Omasta mielestäni tutkimuksen ja keskustelun välinen läheinen yhteys on luonnollista nimenomaan yhteiskuntatieteissä. Yhteiskunnallisen tutkimuksen menetelmälliset perusteet ovat niin epäyhtenäisiä, ettei yhteiskuntapoliittisiin kysymyksiin useinkaan saada lopullista vastausta, mielipiteet voivat olla erilaisia myös huippututkijoiden välillä. Tiede ja tutkimus ovat kuitenkin aivan keskeisiä, jopa välttämättömiä apuneuvoja yhteisiin tavoitteisiin pyrittäessä.

ETLAn tutkimusten läpikäynti on matka Suomen sodanjälkeiseen taloushistoriaan.

Lähtökohdat vaurastumiselle olivat Suomessa olosuhteet huomioon ottaen kohtuulliset. Sotaa edeltäneet sosiaaliset ja poliittiset instituutiot säilyivät; Karjala menetettiin, mutta maata ei missään vaiheessa miehitetty; siviiliväestö ja infrastruktuuri eivät kärsineet sodasta yhtä paljon kuin monissa muissa sotaan osallistuneissa maissa.

Kokonaistuotanto oli jo laitoksen perustamisvuonna 1946 jotakuinkin sotaa edeltäneellä tasolla. Nopea kasvu jatkui sitten aina 1970-luvun puolivälin saakka. Senkin jälkeen kasvu on pysynyt hieman muita teollistuneita maita nopeampana.

Henkeä kohti lasketussa kansantuotteessa Suomi on vähitellen ottanut kiinni useimmat edellään olleet Euroopan maat, muun muassa Ruotsin, joka on usein nostettu vauraan maan esikuvaksi. Vaikka elintaso Venäjä-Neuvostoliitossa oli matalampi kuin meillä, Suomi oli pitkään ahtaassa raossa: molempien naapureiden läheisyys lisäsi paineita suomalaisten hyvinvoinnin lisäämiseen.

Sodanjälkeistä taloutta luonnehti pitkälle jatkunut hyödykemarkkinoiden, hintojen ja palkkojen, raha- ja rahoitusmarkkinoiden, sekä ulkomaan-

kaupan ja pääomaliikkeiden säännöstely. Talouspolitiikkaan kuuluivat myös korkeat investointiasteet, toistuvat devalvaatiot ja idänkauppa. Ja siihen kuuluvat edelleenkin keskitetyt tulosopimukset ja korporativismi.

Kaikki nämä ovat saaneet laitoksessa osakseen paljon tutkimusta.

Sekä Taloudellista Tutkimuskeskusta että ETLAa on aina askarruttanut, kuinka talouden menestys voi jatkua muuttuvissa oloissa.

Perässätulijan kasvumahdollisuuksien hupeneminen oli laitoksessa selvää viimeistään 1980-luvulle tultaessa. Perusteollisuuden luomisen ja yhteiskunnan infrastruktuurin rakentamisen kasvuvaikutus oli pääosin päättynyt ja samanaikaisesti oli menetetty muita teollisuusmaita alhaisempaan palkkatasoon perustuneet kilpailuedut.

Esimerkiksi laitoksen 40-vuotishistoriikissa todettiin että kasvutekijät painottuvat entistäkin enemmän tietoon ja taitoon sekä teknologisen kehityksen antamien mahdollisuuksien oivaltamiseen. Nykyisen globalisaatiopuheen aikana on mielenkiintoista todeta, että samalla korostettiin tarvetta selvittää kansainvälistymisen ”siunauksia ja vaaroja”.

Väestön ja työvoiman tutkimus on ehkä paras esimerkki siitä, kuinka ETLAn tutkimukset ovat liittyneet Suomen yleiseen taloushistoriaan.

Kun laitos perustettiin, jatkosodan päättymisestä oli kulunut vajaat kaksi vuotta. Joukkojen kotiuttamisen vaikutus oli jo selvästi nähtävissä syntyvyydessä. Syntyvyys saavutti huippunsa syksyllä 1945, mutta ensimmäinen suuri vuosittainen ikäluokka, yli 100 000 lasta, syntyi laitoksen perustamisvuonna 1946. ETLA kuuluu siis samaan sukupolveen kuin niin sanotut suuret ikäluokat.

Sotakorvausten maksaminen ja maan jälleenrakennus vaativat runsaasti työvoimaa. Myös Taloudellisessa Tutkimuskeskuksessa oltiin huolissaan työvoimapulasta ja laadittiin mm. selvitys siitä, kuinka työvoimapulaa voitaisiin lievittää naisten työhön osallistumista lisäämällä.

1950 luvulla tilanne kääntyi toisenlaiseksi ja laitos julkaisi mm. selvityksen, jossa tarkasteltiin tilannetta työvoimamarkkinoilla vuoteen 1965 saakka. Ongelmaksi oli tulossa työnsaannin vaikeutuminen suurten ikäluokkien johdosta.

Laitos osuikin arvioissaan oikeaan: työpaikkoja ei syntynyt riittävästi ja 1960-luvulla Ruotsiin muutti 200 000 suomalaista. ETLAn hallitus käynnistikin laajan hankkeen, jossa selviteltiin siirtolaisuuden syitä.

Osin siirtolaisuuden vuoksi Suomea uhkasi kuitenkin jo 70-luvulta lähtien työvoimapula, jonka tuleminen öljykriisien ja 90-luvun laman vuoksi siirtyi eteenpäin. Etlalaisiakin ovat taas pitkään askarruttaneet työvoimapulaan liittyvät kysymykset. Uutena tutkimuskohteena ovat olleet EU:n sisäiset työmarkkinat ja Suomeen tuleva, ei vain täältä lähtevä siirtolaisuus.

Nykyisin väestökehitys näkyy laitoksessa myös tutkimuksina, jotka kohdistuvat eläkejärjestelmiin ja ikääntyvän väestön aiheuttamiin veropaineisiin. Kohtalonyhteys laitoksen ja suurten ikäluokkien välillä jatkuu vielä pitkään, olen varma, että teemaa käsitellään vielä ainakin ETLAn 75-vuotisjuhlissa.

Keskeinen tutkimuskysymys on luonnollisesti ollut myös Suomen asema kansainvälisessä taloudessa. Sodanjälkeinen lähtökohtatilanne kylmän sodan toisen suurvallan naapurina oli vaikea, mutta mitä pitemmälle tullaan sitä suoremmalta länsi-integraation tie näyttää: Suomi liittyi Maailmanpankkiin, Kansainväliseen Valuuttarahastoon ja GATTiin jo 1940-luvulla, EFTAn ulkojäseneksi ja OECDhen 60-luvulla, 1970-luvulla solmittiin vapaakauppasopimus EEC:n kanssa, EFTAn täysjäseniksi tultiin 80-luvulla, ETAn, Euroopan Unionin ja EMUn jäseneksi 90-luvulla ja yhteiset eurosetelit otettiin käyttöön vuoden 2002 alusta.

ETLAssa on usein korostettu sitä, että kansallisvaltiot ovat sidottuja toisiinsa ns. järjestelmäkilpailun kautta. Tätä kilpailua käydään paitsi Euroopan sisämarkkinoilla, myös entistä enemmän globaalilla tasolla.

Kansallisvaltioiden pitäisi kyetä tarjoamaan yrityksille ja kansalaisille kohtuullinen verotus mutta samalla pitäisi rahoittaa korkeatasoiset hyvinvointipalvelut.

Viime vuosina laitoksessa on pohdittu esimerkiksi sitä, kuinka yksi suomalaisen kasvu- ja sivistysprojektin kulmakivistä, suomalainen koulutusjärjestelmä, voisi vähitellen siirtyä ekstensiivisestä intensiiviseen, siis laajenemisvaiheesta järjestelmän tehostamisvaiheeseen.

Laitoksessa tapahtunutta kehitystä on mahdotonta ymmärtää, ellei sitä tarkastella myös suhteessa tieteen sisäiseen kehitykseen.

Suomalaisessa taloustieteellisessä koulutuksessa ja tutkimuksessa on sotien jälkeen korostunut ns. analyyttinen ote aikaisemman historiallis-institutionaalisen lähestymistavan sijasta. ETLAssa on kuitenkin koko sen 60-vuotisen olemassaoloajan yritetty yhdistää analyyttinen ote suomalaisten instituutioiden ja omien historiallisten kokemusten ymmärtämiseen.

Suuri muutos on ollut myös tietokoneiden laskentakapasiteetin valtava kasvu. Itse kuulun siihen ikäpolveen, joka on tehnyt käsin regressiomalleja.

Vielä 1970-luvulla soveltava ekonometrinen tutkimus liittyi lähinnä makrotaloudellisiin kysymyksiin. Silloin oli vaikea kuvitella, että tutkimuksessa joskus voitaisiin käyttää nykyisenkaltaisia, oleellisesti laajempia aineistoja ja niihin sopivia tilastollisia menetelmiä.

Sittemmin ETLA on ollut yksi mikrotaloudellisen tutkimuksen uranuurtajia Suomessa. Tällaista tutkimusta on tehty esimerkiksi työmarkkinoista, koulutuksesta, tuottavuuden noususta ja siihen läheisesti liittyvästä luovasta tuhosta, tiede- ja teknologiapolitiikasta, yrittäjyydestä ja rahoituksesta.

Laitoksen ennustetoimi on kuitenkin pitänyt huolen siitä, ettei makronäkökulma ole kokonaan päässyt unohtumaan.

Ehkä ratkaisevin muutos, on kuitenkin ollut se, että taloudellisen tutkimuksen rahoitus on viime vuosikymmeninä markkinaehtoistunut, Suomessa ja koko Euroopassa. Ns. ulkopuolisen rahoituksen osuus koko ETLA-yhteisössä (tytäryhtiöt mukaan lukien) on noussut jo kahteen kolmasosaan kokonaisrahoituksesta.

Markkinaehtoisen rahoituksen kasvu on mahdollistanut sen, että laitoksen henkilökunta on hieman kasvanut, vaikka perusrahoitus onkin pienentynyt. Perusrahoituksella on laitokselle kuitenkin edelleen aivan keskei-

nen merkitys ja on erittäin arvokasta, että kannatusyhdistyksen jäsenet ovat tähän sitoutuneet.

Kilpailu rahoituksesta edellyttää korkeaa osaamista ja tieteellisiä näyttöjä; myös tutkimusongelmien teoreettista tuntemusta ja tutkimusmenetelmien hallintaa. Yli puolet laitoksen tutkijoista on jo nyt tohtoreita.

Korkeaa osaamista on aiemmin luotu lähinnä laitoksen sisällä, nykyisin on helpompi hankkia osaajia myös ulkopuolelta. Kotimainen tohtorituotanto on korkealla tasolla. Tosin suomalaiset korkeakoulut eivät vieläkään tarjoa kovin systemaattista opetusta kaikilla taloustieteen erityisaloilla, esimerkiksi kilpailupolitiikan sekä oikeustaloustieteen oppeja on haettava suurelta osin ulkomailta.

Professori Yrjö Neuvon johtama työryhmä pohtii parhaillaan suomalaisen tutkimusrahoituksen organisoimista, muun muassa kysymystä siitä, kuinka julkista rahoitusta pitäisi ohjata valtion sektoritutkimuslaitoksille ja markkinaehtoiseen, kilpailutettuun tutkimukseen.

Kokemukset siitä, kuinka ETLAn kaltainen laitos voi nopeastikin tehdä pioneerityötä kansantalouden kannalta keskeisillä alueilla puoltavat mielestäni voimakkaasti vapaan rahoituksen lisäämistä.

ETLAn tutkimustoiminta on kuluneen 60 vuoden aikana läheisesti liittynyt suomalaisen yhteiskunnan muutokseen ja talouden menestystarinaan. Mielenkiintoisimmat tutkimusaiheet löytynevät jatkossakin samojen perusteemojen uusista variaatioista: millainen on Suomen asema kansainvälisessä taloudessa, miten suomalaisen työn ja tuotteiden kilpailukyky voidaan turvata, miten koulutus, tuottavuus ja osaaminen kehittyvät, miten julkisen sektorin tehtävät organisoidaan, ja miten yhteiskunta pystyy uusiutumaan?

ETLA 60 vuotta

Juhlaesitelmä

"The Market for Ideas and
the Origins of Economic Growth
in Eighteenth Century Europe"

Joel Mokyr

Joel Mokyr
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Joel Mokyr tutkii Euroopan taloushistoriaa ja on erikoistunut ajanjaksoon 1750-1914. Hänen tämänhetkisenä tutkimuskohteenaan ovat teknologisen kehityksen taloudelliset ja sivistykselliset juuret sekä hyödyllisen tiedon (useful knowledge) kasvu Euroopan yhteiskunnissa.

Joel Mokyr on julkaissut kymmeniä tieteellisiä artikkeleita ja kirjoittanut useita kirjoja, muun muassa teokset *The Lever of Riches: Technological Creativity and Economic Progress* (Oxford Univesrity Press 1990) ja *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton University Press 2002). Parhaillaan hän valmistelee kahta kirjaa *Neither Chance nor Necessity: Evolutionary Models in Economics and History* (Princeton University Press) ja *The Enlightened Economy: An Economic History of Britain 1700-1850* (Penguin Press; osa sarjaa *Penguin New Economic History of Britain*).

Joel Mokyr on *Princeton University Press Economic History of the Western World* -sarjan ja *Oxford University Press Encyclopedia of Economic History*n päätoimittaja. Vuonna 2006 hän sai Hollannin kuninkaallisen tiedeakatemian joka toinen vuosi jakaman Heineken Award for History -palkinnon.

Much of the conventional wisdom about the historical experience of growth in the West is summarized by two statements: (1) Modern economic growth was ignited by the Industrial Revolution in the eighteenth century, and (2) the Industrial Revolution was, as everybody had always suspected, primarily about technology. However, both statements must be qualified and nuanced: growth proper did not start until the second third of nineteenth century, and technology (to say nothing of "industry") was not all there was to it. The economic impact of new technology, no matter how ingenious, can be realized only if the institutional environment is conducive and allows for the exploitation of inventions in an effective manner.

This lecture will make two propositions: the Industrial Revolution and the subsequent process of economic growth in Europe were intimately connected to the European Enlightenment and the European political and intellectual structure between 1500 and 1700 determined why Europe had Enlightenment – and no other civilization did.

Economists tend to disagree, whether ideas affect the outcomes of economic history. In a famous paragraph, John Maynard Keynes wrote that "the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas ... soon or late, it is ideas, not vested interests, which are dangerous for good or evil." Most other economists are uncomfortable with the idea, ironically enough agreeing with Marx that ideas were a superstructure determined by deeper economic forces, or as Marx himself famously put it in his Critique of Political Economy, "it is not the consciousness of men that determines their being, but, on the contrary, their social being that determines their consciousness." Modern economists have differed on the matter as well. Ekelund and Tollison have argued that "The absence of any positive theory of idea formation or role for ideology leads us to support economizing activity as the primary explanation for institutional change… Ideology may be usefully thought of as a 'habit of mind' originated and propelled by relative costs and benefits. As an explanation for events or policies, it is a grin without a cat."(Ekelund and Tollison, 1997, pp. 17-18). Paul Samuelson, on the other hand felt more like Keynes in his widely-cited comment that "let those who will write the nation's laws if I can write its textbooks." In the historical experience of European economic development, the two interacted in complicated ways. It is the purpose of this lecture to unpack this interaction by introducing the concept of a market for ideas and analyzing it.

Where did the new ideas that underlay the economic growth of the eighteenth century come from? At the most basic level, of course, the very existence of a market for ideas depends on the economy. Commercial and urban societies that could generate a surplus beyond subsistence, in which a substantial number of people could live by their wits rather than having to toil in the fields, were necessary if any intellectual ideas were to be created. Only societies that had lifted themselves beyond bare agricultural subsistence could afford the leisure to create learning. Learning by itself was insufficient, however. What was needed was for this learning to transform itself into useful knowledge that could be applied to new techniques. Any such feedback

from learning to the economy was historically contingent. Learning could be utterly sterile economically, and in many societies it took the form of exegesis, mystical and occult-like studies, astrology, and the endless poring over and rehashing of theological and abstract philosophical issues.

For economic growth to occur, however, more was needed than an applied and practical research focus. For useful knowledge to have an economic impact through innovation, a certain institutional structure was needed that not only created such knowledge, but also placed it at the disposal of those who could use it best. For knowledge to be technologically productive and to affect material welfare, it had to be engaged in expanding what I have called the epistemic base of technology, that is, the understanding of the natural laws and regularities that make something work (Mokyr, 2002). For sustained growth to occur, it was not sufficient to come up with new tricks and artifacts evolving through trial and error. Although inventions could be and were made without anyone having much of a clue of why and how they worked, these techniques typically crystallized soon and did not generate anything like long-term advances. It was harder to adapt them to new circumstances. Intellectuals had to be concerned with natural phenomena and regularities that underlay the techniques in use, to set up the right kind of questions, and not to rule out any areas of investigation. In other words, growth required an environment that created knowledge of the right kind. This environment can be regarded as part of a "marketplace for ideas" in which new ideas compete with old ones to be somehow "selected." This market is a Schumpeterian construct in which competition is less between identical products than between old and new products and techniques.[1] What is true for new technology is true for all ideas, not just technological ones. Such analogies are, perhaps, a bit stretched. The market for knowledge is in many critical aspects quite different from other markets. It resembles standard markets in that suppliers try to "sell" ideas to others, that is, persuade them that these ideas are worthwhile and believable. Buyers select from a "menu" of new ideas. But there the analogy breaks down. Unlike standard markets, the sellers are rarely compensated by the buyers themselves, because ideas and knowledge are non-rivalrous and often non-excludable. Some other mechanism has to do that. Even when sellers are financially rewarded, there is rarely any proportionality between the social value of their contribution and their remuneration.

Yet in terms of bringing together various elements that explain long-term historical change, the notion of a market is helpful. Much of my talk today will be dedicated to this issue, because it is my hypothesis that a large part of Europe's economic success was the result of the creation of new knowledge (innovation) and its dissemination by means of learning and persuasion.

The point I want to make here is quite simple. The evolution of knowledge and ideology in Europe in the centuries before and during the Industrial Revolution was decisive in explaining Europe's subsequent economic performance. From the late middle ages on, what emerged in Europe was a market for ideas in which intellectual innovators proposed theories, facts, observations,

and interpretations of the world around them. Out of that market emerged victorious a complex but reasonably coherent set of ideas that we term "the Enlightenment." The Enlightenment was the crucial link between the emergence of the market for ideas and the emergence of economic growth in the West. It was not the only link, and the interpretation proposed here does not maintain that such a market was the single mechanism that brought about the economic transformation of Western Europe. But it is one that has hitherto received little attention.

The idea of a Schumpeterian market for ideas immediately implies the concept of an intellectual entrepreneur. Such figures can be discerned with ease in the centuries before 1750. Many of these people were, of course, selling their own ideas. However, the Enlightenment was rich in such entrepreneurs trying to market the ideas of others. After Copernicus's death, some of Europe's most distinguished intellectuals were converted to his views and spent their time and efforts to persuade others. Newton, above all, was followed by a class of "Newtonians" who tried to "sell" his ideas to others. Among those, the Dutch academic Willem s'Gravesande deserves special mention, as does Mme. du Châtelet, one of the first women of note in the European intellectual marketplace. Unlike standard entrepreneurs, intellectual entrepreneurs are not just motivated by profit maximization but have more complex utility functions. The writers, lecturers, publishers, and experimenters of the eighteenth century who jointly made the Enlightenment were for the most persuaded that they were serving values such as Truth and Justice and helping to improve the fate of humanity. Many of them were also driven by ambition, a need to impress their friends, and a desire to prove their ability to themselves. Greed, ambition, curiosity, and altruism all played a role. All the same, their importance in bringing about changes in the intellectual landscape of Europe was indispensable.

The two centuries before the Industrial Revolution witnessed developments in the European intellectual marketplace that were crucial in creating a world in which useful knowledge played an increasing role in expanding the economic opportunities of Western nations, and in the end became the dominant element in productivity growth. This was a slow and drawn-out process, but it was also relentless and cumulative, and by the early nineteenth century it was sufficiently powerful for technological innovation to be turned from being a sporadic exception into a phenomenon that became increasingly routinized and widespread in the economy. Next to the changes in the markets for goods, labor, and capital, which is the standard fare of every undergraduate course in economic history, the Industrial Revolution was preceded by far-reaching developments in the less visible market for ideas and knowledge that affected economic activity through channels that can only be observed indirectly but that in the long run were decisive to the fate of the economy.

The market for ideas is one in which those who have new ideas try to "sell" them, that is convince others. The exact motives why people try to do this are only in part material: the market for ideas is in part a signalling game

in which intellectuals try to establish their "quality", a feature presumably correlated with patronage and sinecures. But ambition and a quest for fame for its own sake obviously played a role as well. So did an idealism in which people who created new knowledge or proposed new ideas hoped that these ideas would make the world better. For this to happen, their ideas had to be accepted by others. In natural philosophy, mathematics, medicine, and engineering certain conventions were established that determined the criteria for acceptance and rejection of new propositions. The market for social and political ideology worked differently, to a degree. Its standards did not have to be nearly as tight, and much depended on rhetoric, religion, and political interests. To be more precise, a market for ideas that generates technologically- or ideologically driven economic growth requires four elements: agenda, capability, selection, and diffusion. The supply side in the market for ideas was determined largely by the first two, and the demand side by the other two.

Agenda

Terms such as "research" or "development" are a bit anachronistic as far as the seventeenth century is concerned, but there is no doubt that in the century before the Industrial Revolution there was considerable progress in what we would call today science and what contemporaries termed "natural philosophy." Whether the advances in physics, chemistry, astronomy, and mathematics between Galileo and Leibniz deserve the term "scientific revolution" or not remains to in dispute. The age became more and more enchanted with the term "useful knowledge," which was increasingly interpreted in a literal sense. This concept became the basis for the "Baconian program," and increasingly served as the key to the agenda of researchers. The idea, in summary, was that knowledge was supposed to be "useful" – morally, socially, and increasingly, materially. Society was improvable through knowledge, and the purpose of study and experiment was to help solve practical problems just as much and eventually more so than to satisfy human curiosity or to demonstrate the wisdom of the creator.[2] Many, if not most of the natural philosophers of the age of enlightenment agreed with Bacon's notions and acknowledged their intellectual debt to his ideas.

Even if the bulk of the knowledge accumulated by natural philosophers in the eighteenth century could only rarely be applied directly to production, these scholars used their rigor and training to attack practical problems. Among them were the greatest minds of the scientific enlightenment.[3] Rather than just gazing at the stars, dabbling in the "occult," or making metaphysical points about the wisdom of the creator, a new, practical, and more down-to-earth natural philosophy emerged in the eighteenth century, produced by people who felt that the world could be improved by their knowledge. This knowledge was to be applied increasingly to the mundane world of crafts and farming, and in the late seventeenth century intellectuals were attracted to technology and its mysteries more than ever before, as embodied in the early

work of the Royal Society.[4] Indeed, the intellectuals of the Enlightenment, often known as philosophes, could be argued to be in favor of abolishing abstract philosophical debates in favor of more practically-oriented work in physics, medicine, chemistry, optics, and mathematics.

It is remarkable that the belief in this mission remained indefatigable in the face of continuous frustration and disappointment (although the Royal Society itself lost its fascination with technology after 1700). And there was plenty of frustration and disappointment. A case in point is William Cullen, a Scottish physician and chemist. His work "exemplifies all the virtues that eighteenth-century chemists believed would flow from the marriage of philosophy and practice" (Donovan, 1975, p. 84). Ironically, however, this marriage remained barren for many decades. Cullen's prediction that chemical theory would yield the principles that would direct innovations in the practical arts remained, in the words of the leading expert on eighteenth-century chemistry, "more in the nature of a promissory note than a cashed-in achievement" (Golinski, 1992, p. 29). Manufacturers needed to know why colors faded, why certain fabrics took dyes more readily than others, and so on, but as late as 1790 best-practice chemistry was incapable of helping them much (Keyser, 1990, p. 222). Before the Lavoisier revolution in chemistry, it just could not be done, no matter how suitable the social climate: the minimum epistemic base simply did not exist. In many other areas, despite the best of efforts and intentions, the new research agenda yielded few tangible results. Although medical science made a few significant advances before 1850, compared with the enormous tasks of combating infectious diseases, these achievements were comparatively modest.[5] Another striking example is electricity. The eighteenth-century natural philosophers were fascinated by this strange force, and believed that once tamed, it held great promise. While advances in electricity such as the Leyden jar (invented in 1746), the discovery of different levels of conductivity, and the finding that electricity could be transmitted over considerable distances all stirred many an imagination, and some entertaining uses were found for this mysterious phenomenon, practical applications had to await the breakthroughs of Oersted, Faraday, and Ampère in the first half of the nineteenth century. The one exception was, of course, Franklin's lightning rod (1749), one of the first useful pragmatic applications of experimental science.

It is important to realize how much effort was spent in this age on unsuccessful research, constrained by the limitations of a world in which engineers, farmers, industrialists, and mine operators knew preciously little about the fundamental physical rules that governed the techniques they used. These techniques had emerged slowly over the ages, the result of the patient accumulation of experience, trial and error, and serendipity. The width of the epistemic base determined the effectiveness of the research program, though the degree to which propositional knowledge was a constraint varied enormously from field to field. When techniques are not based on an understanding of why things work, people trying to improve upon them will not be able to rule out dead ends and blind alleys nearly as efficiently. Alchemy remained

a popular activity until the eighteenth century and the search for perpetuum mobile engines continued until the mid nineteenth century. At the same time, however, some remarkable achievements could be made without the advantage of such a base – such as the successes of British animal breeders in improving the quality of livestock without the benefit of genetics and physiology, but advancing diligently and systematically using rules-of-thumb based on experience rather than theory.

The idea of research was larger than the discovery of underlying general laws. Much of the investigations of the eighteenth century were more in the way of the "three C's": counting, cataloguing, classifying. In that regard, the great figures are the Swedish botanist Carl Linnaeus and his French rival Georges-Louis Buffon, but many contemporaries followed them in an attempt to gather more information about living beings so that farming and husbandry could be improved. In Britain the paradigmatic figures were Erasmus Darwin and Joseph Banks, the authors of voluminous books on plants and animals, and Arthur Young and John Sinclair, who wrote extensively on agriculture. These writings did not have immediate results: agricultural productivity increased only slowly in period of the classical Industrial Revolution, and insofar that it did, it was probably not much due to agricultural writings.[6] And yet, the demand side of the market for ideas was there, and the supply was on the way.

The Baconian program, then, became the dominant force in determining the agenda of intellectual activities of enlightenment *philosophes*. The results, at least in the eighteenth century, were disappointing and much delayed. The debate between those who feel that science played a pivotal role in the Industrial Revolution and those who do not is more than the hackneyed dispute between a glass that is half full or half empty, because the glass started from empty and slowly filled in the century and half after 1750. Scientists and science (not quite the same thing) had a few spectacular successes in developing new production techniques, above all the chlorine bleaching technique, and the inventions made by such natural philosophers as Franklin, Priestley, Davy, and Rumford.[7] The effort put in by Europe's most eminent learned men to improve practical techniques demonstrates that by the second half of the eighteenth century most scientists felt their responsibility to the material world acutely, and made a sincere effort to learn which problems bothered people in the workshops and the fields. These efforts were enforced by commercial interests that created a market in knowledge literally speaking. An increasing number of British natural philosophers and learned persons found it remunerative to hire their services out to manufacturers as consultants.[8]

Capabilities

As noted, progress in science is constrained by the ability of scientists to answer questions, in addition to posing the right ones. One of the great insights of the historian of science Derek Price was to illustrate the extent to which instrumentation, observation, and computational limits constrained the development of science. Experiments and observations needed their own tech-

niques, and without the right instruments and techniques, the most enlightened and well-meaning research programs would fail. A steam engine, for instance, required the notion of a vacuum, and would be unlikely in a world without a vacuum pump. The great advances made by Lavoisier and his pupils in debunking phlogiston chemistry were made possible by the equipment made by his colleague Laplace, who was as skilled an instrument-maker as he was brilliant a mathematician. During the Industrial Enlightenment, scientific advances were made possible by progress in the tools and equipment that scientists had at their disposal. In that sense, the simple causal arrow leading from propositional knowledge to technology was complemented by a positive feedback mechanism leading from technology to science and creating a self-enforcing cumulative process.

An example of the improved capability is Galileo's realization in the seventeenth century that models of machines were not linearly proportional to their full-sized counterparts, but that one had to take into account the disproportional relations between weight and volume and the nonlinear mechanical action of levers and pulleys. While the idea of the lever goes back to classical times, Galileo extended it to the dynamic operation of machines. In his *Discorsi et Dimostrazioni Matematiche* (1638), he laid the foundation for a general theory of mechanics or "kinematics." These ideas were especially influential in France in the eighteenth century leading to more formal theories of engineering, such as Antoine Parent's theory of the strength of beams. Galileo's approach to practical problems was thoroughly pragmatic, emphasizing the economic efficiency of machines rather than their physical capacity. One of the most path-breaking innovations in the capabilities of scientists to establish natural phenomena and regularities was the use of electrolysis in chemical analysis. This became possible in 1800 with the invention of the first battery-like device that produced a steady flow of direct current at a constant voltage, namely Alessandro Volta's pile of 1800. Its ability to separate elements in the newly proposed chemistry filled in the details of the landscape whose rough contours had been outlined by Lavoisier and his students.[9]

Improved instruments and research tools played important roles in a range of "enlightenment projects" that might be seen as technological improvements with some poetic license. One of them was the use of geodesic instruments for the purpose of surveying. Time, too, was measured with increasing accuracy, which was as necessary for precise laboratory experiments as it was for the solution to the stubborn problem of longitude at sea.[10] Experimental engineering also made methodological advances. John Smeaton was one of the first to realize that improvements in technological systems can be tested only by varying components one at a time holding all others constant (Cardwell, 1968, p. 120). In such systems, progress tends to be piecemeal and cumulative rather than revolutionary, yet Smeaton's improvements to the water mill and steam engine increased efficiency substantially even if his inventions were not quite as spectacular as those of James Watt.

Another increased capability came from mathematics. The use of mathematics in scientific research was itself hardly new in the seventeenth and

eighteenth centuries, but advances in mathematics added new tools to the arsenal of the engineers, and theoretical work in engineering advanced consequently and – with a considerable lag – expanded the supply of good ideas. Mathematics became increasingly a problem-solving technology and many great mathematicians lent their skill to computations that had useful applications in ballistics, engineering, astronomy, and navigation. Copernicus's student, Rheticus, prepared complete tables for all six trigonometric functions, and Napier developed logarithmic tables. Computing tools such as Galileo's "compass" and Pascal's early calculating machine were designed, though the inability of mechanics to construct them at low prices limited their use. The input of formal mathematics into technical engineering problems was most remarkable in hydraulics and the design of better waterwheels in the eighteenth century. These attempts reflect the difficulties and slowness of the learning process in applying the newly invented calculus to the dynamic problem of hydraulics.[11] Calculus, developed in the late seventeenth century, found many applications in mechanics as well as in construction, such as the theory of beams, as in Charles Coulomb's celebrated 1773 paper "Statical Problems with Relevance to Architecture." Calculus, indeed, may be regarded a "General Purpose Principle," in the terminology of Lipsey, Bekar, and Carlaw, (2005), a multi-purpose tool that allowed for any function to be maximized and laws of dynamics to be written down and solved. Again, the French led their more pragmatic and less formal British colleagues. The great three French *polytechniciens* of the early nineteenth century, Gustave-Gaspard Coriolis, Jean-Victor Poncelet, and Louis Navier, placed mechanical and civil engineering on a formal base, and while the immediate impact of these advances on productivity is not easy to discern, it is hard to see how sustained progress in the longer run could have been made without it.

Selection

The demand side of a market for knowledge is the foundation of the field of evolutionary epistemology and was popularized by Richard Dawkins and his concept of "memes" that compete for acceptance within human society. A more powerful image of evolutionary selection mechanisms in the market for one set of ideas is presented by Hull (1988). Rather than survey those debates, I accept the notion proposed by Dawkins and Hull (although they differ in the details) that science and technology consist of units that struggle for acceptance in a Schumpeterian world. Techniques (or prescriptive knowledge) compete for acceptance for the simple reason that there are more ways to skin a cat than there are cats. The entire set bound by the isoquant is selected upon by criteria that are largely if not exclusively related to profit maximization. Propositional knowledge, of which science is a part, follows more complex selection criteria (Mokyr, 2006). The fundamental mechanism at work here, as already noted, is not one of cost minimization but one of persuasion. Society constructs certain rhetorical conventions by which logic and evidence are admissible in arguments about ideas, and these conventions set the rules of the game, or the underlying institutions, in the market for ideas. A naive view

of this process would only select among competing alternatives by the criterion of the maximal likelihood that they were "true." By that logic, astrology would have disappeared centuries ago.

Although some scholars such as Ian Inkster (2004) recommend the use of terms such as "reliable" or "tested" knowledge, these terms hardly solve the problem, since what is meant by "reliable" and how the tests are to be carried out are themselves dependent on the specific circumstances. In fact, it is not even true that societies need to choose between inconsistent theories, since consistency itself is a criterion that is contingent and time- and society-specific. The logic of Western thought has normally been that a proposition is either true or false, that two mutually contradictory propositions cannot both hold, and that new paradigms replaced old ones.

For economic history, what matters is not only pure "useful knowledge", that is, ideas about the physical environment but also about the character of the economic game and the functions of economic policy. In this respect the eighteenth century witnessed a wave of new, enlightened ideas that shared a growing aversion to what we would today call "rent-seeking" of any kind, from predatory wars to exclusionary privileges enjoyed by a select few. The debates between enlightenment philosophers and those who defended some aspect of the mercantile system were no less crucial to the long-term economic outcome than were the ones about caloric and phlogiston.

How did the process of selection among competing ideas change in the eighteenth century? Existing knowledge and ideas tend to develop into orthodoxy, and incumbents are defensive and jealous. Many entrenched elites found ingenious ways to perpetuate the status quo, so that intellectual innovation would be only admissible if it were not to contradict the existing orthodoxy. Conservative establishments in science, religion, and political thinking argued that the predominant criterion for the acceptance of novel knowledge was that it be consistent with existing ideas. New ideas that were inconsistent with the intellectual status quo and could thus threaten the human capital of those who were in control of the existing knowledge were to be suppressed, by force if necessary.[12] Intellectual innovation of any kind could only occur in tolerant societies in which possibly outrageous ideas proposed by sometimes highly eccentric men would not incur violent responses against "heresy" and "apostasy." To phrase it differently, the market for ideas can rely on any combination of persuasion and coercion. Coercion can be viewed as nothing more than a special form of persuasion, at times used to spread new ideas (e.g., early Christianity and Islam), but more commonly to protect and defend an existing orthodoxy. At some level, of course, it is impossible to force people to believe in something that they find inherently unacceptable. Coercion, however, can work through control of channels of knowledge transmission such as education, churches, censorship, and propaganda. More insidiously, it can work through the persecution of those who have the potential to propose new ideas, thus raising the expected costs of innovation and discouraging the development of new ideas.[13] How and why did this happen? In the late middle ages, the intellectual innovations of the 12th and 13th centuries

had rigidified into a Ptolemaic-Aristotelian canon that became increasingly intolerant of deviants. Cosmology and theology in the picture of the world that emerged were deeply intertwined and provided an intellectual foundation of the religious establishment. "The resulting system of the Universe was considered impregnable and final. To attack it was considered blasphemy" (White, 1896, p. 120, see also Lipsey, Bekar and Carlaw, 2005, p. 237). Yet from 1500 on, this system came under increasing pressure. The exact timing of the decline of orthodoxy in Europe is not easy to establish. Although it may seem to have become more pronounced in the sixteenth century, when the Reformation overthrew the existing religious order and forced considerable changes on the Church, that kind of simple timing is not wholly satisfactory. The religious reformers themselves could be quite conservative in other areas, while much of the intellectual innovation took place in Catholic lands.[14] The rise of tolerance was far from monotonic, and even the Papacy experienced swings of progressivism and reaction.[15]

Philosophers and theologians may seem to have threatened the entrenched status quo more than experimental scientists. The two most famous executions of intellectual innovators, Giordano Bruno and Miguel Servetus, condemned to death by the Roman inquisition and Calvin's Geneva court respectively were of scientists who were persecuted for their religious doctrines, which at the time were often hard to separate.[16] Geocentric astronomy, of course, straddled astronomy and metaphysics. By the time Galileo was summoned to Rome, this battle was in fact over, and to the extent that Galileo's astronomy was what got him in trouble, it was a rear-guard action. But it is telling that Copernicus delayed publishing De Revolutionibus, and that his editor found it necessary to add a disclaimer that his views were purely speculation. Experimental science could not always be separated from metaphysics either.[17] All the same, seventeenth century scientists were successful in partially separating their science from their religious philosophy. Philosophers and scientists such as Bacon, Descartes, Huygens, and of course Newton were respectful of religion and stayed away from theological controversies. The growing specialization and technical jargon of science made it increasingly difficult for authorities protecting the orthodoxy to intervene directly.

The concept of a market for ideas in which ideas are selected freely by individuals on merits other than acceptability by the ruling orthodoxy was itself an innovation in the seventeenth century. The ideals of tolerance and persuasion by argument and evidence eventually won out. The market for ideas should work in such a way that selection among competing theories or observations be determined by criteria that were unrelated to politics, and that were exclusively determined by the rhetoric of knowledge itself: logic, rigor, experimental evidence, and observation. This idea became closely associated with the concept of the Enlightenment. That such a notion is an ideal that in practice is never achieved, and that all science and knowledge are riven with politics is commonplace, but degree is everything, and the politics of science changed. What was determined in the age of Enlightenment was how scientific disputes were to be resolved when new information or insights

emerged. In that regard, Lavoisier and Adam Smith were subject to the same rules. Consistency with earlier theories and respect for the knowledge of previous generations was to have, at least in theory, little impact on selection.[18]

The market for ideas that emerged in the seventeenth century gradually abandoned coercion and orthodoxy in favor of methods that persuaded by other criteria. This is not to say that coercion was abandoned altogether: as late as the 1760s French philosophes had to worry about the consequences of their publications. Even in progressive Scotland, David Hume was denied a professorial chair because of his atheism.[19] Moreover, authority could not dispensed with altogether; the growth of useful knowledge could not proceed without some notion of authority, nor was such authority altogether independent of social standing (Shapin 1994). All the same, the almost absolute power with which the canons of Aristotle, Avicenna, and similar classics had ruled the intellectual world was broken. In the two centuries before the Industrial Revolution, the selection mechanism of ideas, including both natural and political philosophy, changed and became less committed to the orthodoxy. Coercion was tried over and over again, but ultimately it was becoming increasingly ineffective in the centuries before 1750.

Why did the marketplace for ideas become less coercive and more competitive in Europe in the centuries before the Industrial Revolution? As Elizabeth Eisenstein has stressed, the printing press was surely a major factor in the decline in access cost, but it was not enough in and of itself, because presses could be controlled or even banned by powerful authorities.[20] The main argument I submit is that the power of the authorities in charge of defending the orthodoxy was increasingly constrained by their inability to coordinate their actions over different political entities (Mokyr, 2006b). That is to say, European political fragmentation created the environment in which dissident and heterodox opinions could be put forward with increasing impunity. Had a single, centralized government been in charge of defending the intellectual status quo, many of the new ideas that eventually led to the Enlightenment would have either been suppressed or possibly never even proposed.[21] But Europe almost always offered havens to persecuted dissidents and heretics, and while these havens were not always the same, they could almost always be found. Most "heretics" could survive by finding one protector or another who prevented their suppression, because they were genuinely persuaded or to spite a rival ruler.[22]

European intellectuals learned other methods of playing one political power against another. At times, as Galileo's story makes abundantly clear, this protection was only partial when the response of the threatened orthodoxy was particularly virulent. Yet Galileo spent the time of his trial at the home of the Tuscan ambassador, and afterwards at the home of Ascanio Piccolomini, the archbishop of Siena, one of his admirers. Galileo's plea-bargain was a compromise between fundamentalist reactionaries and his powerful supporters.[23] In one form or another, then, many of the most influential intellectuals post 1500 relied on the fragmentation of power within Europe to thwart attempts of the orthodoxy to suppress them.

Only when the conservative powers were operating in a coordinated fashion (as occurred in the execution of Jan Hus) did the ruling status quo have a chance to succeed in its attempts to suppress intellectual innovation. The division of the main reactionary powers (between the Habsburgs, the Bourbons, and the Papacy) and their internal fights, and the equally serious divisions within the Protestant camp, meant that such coordination was rare.[24] Moreover, fragmentation of power was as prevalent within states as between them. For one thing, power was divided between central authorities and local courts and provincial estates. In Germany and Italy, of course, this had become formalized, but in other "states" such as the Dutch Republic, the central government had little power. Moreover, in many countries there were semi-autonomous corporations that exercised their own justice and sovereignty such as universities, boroughs, and guilds. Overlapping and poorly coordinated jurisdictions created opportunities for adept individuals to maneuver in the seams and cracks of the system and find niches from which they could operate unperturbedly. Even in political units that superficially resembled modern nation states, such as Britain, much of the actual administration was concentrated in the hands of local authorities (such as JP's) who often had their own views.

Victories in this game were piecemeal and never final. The age of Enlightenment, too, experienced a number of cases in which judicious flights to foreign countries were necessary to avoid the consequences of the displeasures of the orthodoxy.[25] By that time, however, suppression was more for face-saving than for any realistic hope that Enlightenment ideas could be suppressed. Rousseau, for instance, could live out his last decade in France despite the storm created by his Émile in 1762, necessitating his flight from France.

The market for ideas can thus be seen as the happy outcome of a classic political coordination failure between the powers of reaction in Europe. There was strong resistance to radical new ideas, and resentment of the often eccentric and erratic behavior of the people who generated them. But the conservative powers did not fight innovation all at the same time, nor did they always pick on the same issues. As a result, the suppression of novel ideas lost steam, and by the mid-eighteenth century they were pursued in a half-hearted way. Even some of the more conservative rulers of Europe found themselves pushed toward a policy of "if you cannot beat them, join them" and co-opted many of the ideas of the Enlightenment, creating the oxymoronic "enlightened despots." As a mechanism of epistemic selection, forcible conformism and coercion in Europe lost power. Their replacement by other tools of rhetoric was not always and everywhere an improvement, and politics remained central to the intellectual evolution of the Continent. However, the incentive structure facing would-be innovators was changed due to the reduction of the likelihood of serious persecution.

The net result of this change was double-barreled. For one thing, the market for ideas increasingly selected those notions that seemed by the criteria of the time to be consistent with the evidence. Needless to say, there is no

presumption that these ideas were in some sense "correct." But the Copernican view of the heliocentric universe, the Newtonian analysis of celestial dynamics, and Torricelli's hypothesis of the existence of an atmosphere (to pick just a few examples) were tested and examined and found to be consistent with the rhetorical conventions and experimental capabilities of the time. So was Georg Stahl's phlogiston theory. Later in the eighteenth century, when phlogiston chemistry was challenged by Lavoisier and his followers, the matter was decided on the experimental evidence despite stubborn resistance.

The market for ideas is in many ways not a real market, but it is a useful metaphor. Much like other markets can be judged by their efficiency if they, for instance, observe the law of one price, we can examine the efficiency of a market for ideas. Three criteria should be emphasized here: consensus, cumulativeness, and contestability. Markets for ideas can be assessed as to whether there is a built-in tendency to converge to a consensus. Knowledge can be characterized as tight when it is held by a wide consensus with high confidence. Much of the knowledge in the areas crucial to modern economic growth in chemistry, biology, and physics, and which is held with a high degree of tightness in modern society, was the subject of debates in the seventeenth and eighteenth centuries, and resolving these was sometimes difficult.[26] It is when knowledge is untight that coercion can play an important role in deciding outcomes in the market for ideas. Part of the platform of the Enlightenment, therefore, was to leave no stone unturned in its efforts to make knowledge tighter by confronting hypotheses with evidence and by allowing more and more evidence as admissible. In this effort, it failed more often than it succeeded, but the effort itself was significant. Another criterion for markets for ideas is whether they were cumulative, that is, whether they retained the information that had been selected. Without some mechanism that preserved knowledge and made it available in the future, each generation would have to re-invent the wheel, and worse, some important knowledge might have been lost. This depends to some extent on the efficacy of the institutions that are in charge of passing knowledge from generation to generation and their technological support in knowledge-storage devices such as books and artefacts.[27] Yet cumulativeness could become an encumbrance, and therefore the third component of efficient knowledge markets, contestability is critical. No social system of knowledge can work without some notion of authority, but there should be no sacred cows and no belief should be beyond challenge. It is precisely for this reason that the weakening of coercion in Europe was so important.

Moreover, the more open-minded selection system affected incentives. The improving efficiency of the market for ideas encouraged new entrants both on the extensive and the intensive margins. As the expected risks of persecution declined, more and more original and talented people chose careers in intellectual pursuits, and those who did may have ventured into more innovative areas. They were still constrained by the moral conventions of the times, but these could be readily circumvented.[28] By the eighteenth century the study of nature had become distinctly less hazardous even for

people who tried to upset the applecart. As the generation of new ideas became more attractive, it brought in more people, who added new ideas. Most of these ideas were rejected, but with the selection system in place, its long term effect on technological development seems certain.

Diffusion

In addition to costs, incentives were affected by the expected benefits of intellectual innovators. These benefits are more complex than they are in the market for commodities, because the market for ideas in many ways resembles an open-source technology. Knowledge is non-rivalrous, and as Dasgupta and David have noted, requires an institutional set-up unlike any other market. Open science, as many scholars have stressed, was the key to the rapid changes in the market for ideas because its very purpose was to disseminate new ideas and offer them to the marketplace. The mechanics of open science, in which important new ideas were exposed to the critical minds of colleagues, was based on the principle that academic contributions were rewarded with priority credit, not profit. New ideas were published and placed in the public realm by their creators to establish priority. Priority is a property right, even if it does not attempt exclusivity.[29] Intellectuals maximized a utility function in which material gains were an argument – but so were fame, respect, and recognition.[30]

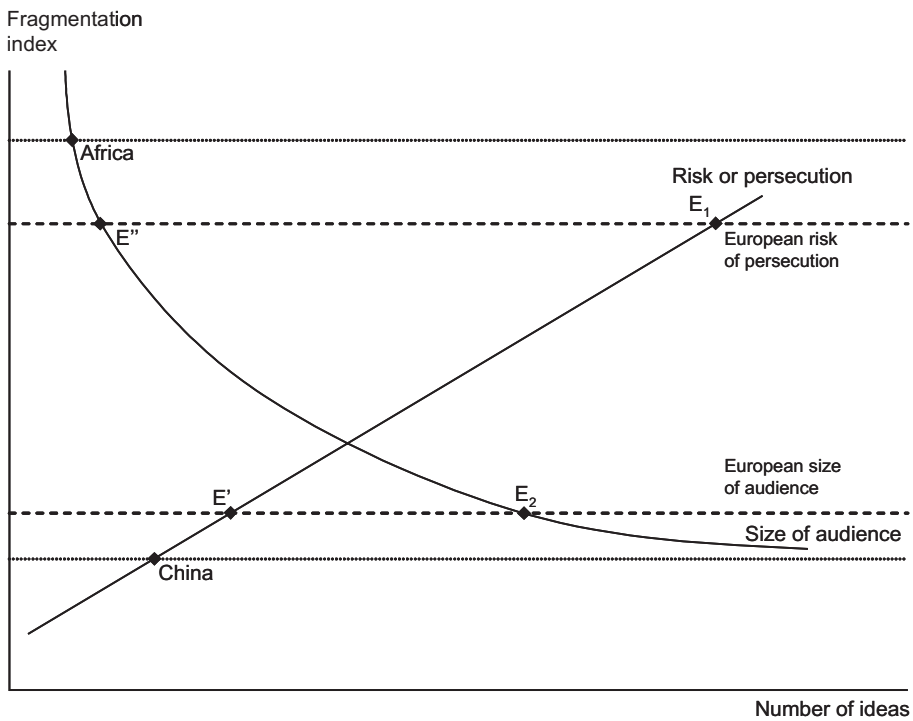
To draw the full benefits from a contribution to knowledge, a maximal audience was optimal, because the cost of making a discovery or proving a theorem is all upfront. The costs were almost entirely fixed, and the marginal costs of dissemination were negligible. Hence, in a highly fragmented world, in which markets for ideas were local , the likely payoff of coming up with a new idea would be, all other things equal, low relative to the cost. Precisely for that reason, a fragmented states system is never a sufficient condition for a sudden flourishing in the market for ideas. Instead, what is needed is a wide market, in which demand for ideas reaches beyond the narrow boundaries of one's country of origin. Such markets could ensure a more intense competition and a greater and more diverse pool of talent from which new ideas could be drawn. Moreover, in an integrated world students were free to pick and choose universities and mentors as well as diversify their intellectual portfolios. In a medieval world of expensive books and personal teaching, fragmentation could be the archenemy of intellectual diffusion. In Europe in the seventeenth and eighteenth centuries the intellectual community was far less fragmented than the political structure, and this peculiar condition holds the key to subsequent intellectual developments.

This situation is described in fig. 1. The upward sloping solid line measures the fact that as fragmentation increases, the effectiveness of persecution declines and thus the number of ideas increases; on the other hand, as fragmentation increases, the audience shrinks and thus the other solid curve is downward-sloping. In a world such as denoted by the lower broken line, the actual level of ideas would be min(E', E2, that is, E'). Hence a high-fragmenta-

tion world ("Africa"– purely in a metaphoric sense), would be at the point so denoted, whereas a single Empire such as "China" would be at an equally low level of ideas. Had Europe not experienced a disconnect between the size of the political unit and the intellectual community, it would have been at something like E'. However, as things turned out to be, they found themselves at a point such as E2 or E1 (whichever of the two is lower), at which the level of ideas will be higher than at either E' or E".

What is striking about early modern Europe, then, is that it was able to combine the best of fragmentation and consolidation. Political fragmentation was combined with a unified market for ideas in which neither language differences nor political boundaries (which often did not coincide) stopped ideas from spreading through the Continent. What emerged in early modern Europe was an transnational entity that served as the extent of the market for ideas. The idea of a"Republic of Letters," or a Respublica Litteraria goes back to the late middle ages, and by the eighteenth century had extended to mechanical and technical knowledge (Daston, 1991; Darnton, 2003). During the Renaissance, Europe witnessed the creation of a community of scholars and engineers in which scholars communicated with one another that transcended political and ethnic boundaries. This community was well established at the start of the Enlightenment movement. It is easy to mistake a sense of belong-

Figure 1 The market for ideas and the level of fragmentation



ing to the "Republic of Letters" as a form of personal loyalty to a transnational entity, but for many if not most scientists' loyalty to King or Republic did not conflict with their need for a large and international audience. The Republic of Letters, in practical terms, was a market, not an identity. On the matter of identity, a great deal of ambiguity remained, an ambiguity that would come to haunt European scientists when national loyalties clashed with the ideal that the "sciences were never at war" as Lavoisier once expressed it, perhaps naively. Its members shared a belief in the principles of "open science," and shared, to a large extent, the rhetorical conventions by which propositions should be accepted or rejected and the rules and forms of the communications of intellectuals. Hence, in the end, on many of the most fiercely debated issues of the day, some measure of consensus was reached, a concept not too far from the notion of market equilibrium.

Market efficiency depended, however, also on the level of transactions costs, and the transactions cost in the market for ideas were primarily what I have called access costs. They are the costs that a person who acquires a piece of knowledge has to pay even though they do not necessarily accrue to the person who created the idea. Access costs consisted of physical costs, affected by such advances as the printing press, cheaper paper, postal services, cheaper personal transportation, and of institutional changes such as the development of schools and universities, and the establishment of academies and scientific societies. Open science was central to the generation as well as the diffusion of new useful knowledge because ideas were made accessible to other intellectuals who could peer-review and criticize them. For non-experts, this set-up increased reliability, so that people in the fields and the workshops might be more likely to make use of them. For many decades, this idea remained more wishful thinking than reality.[31]

Thus, the transnational community of scholars operated with increased effectiveness in the sixteenth and seventeenth centuries. Its norms and rules increasingly favored competitive behavior in the market. New ideas, findings, and theories were placed in the public realm, where they were tested and judged by peers from different nations. Much like our own globalized world, the community of scholars created a winner-take-all tournament, in which a few international superstars emerged, setting a model for hopeful followers. Such superstars in many ways personified the way in which Europe's fragmented-yet-unified intellectual community worked. The two great acdemies founded in the 1660s, the Royal Society and the Académie Royale, were soon propelled to be in a position to pick winners in this tournament. Among those were the Italian Giandomenico Cassini, invited by Colbert to head the royal observatory in 1668 and the Dutchman Christiaan Huygens who became a paid member in 1668. Marcello Malpighi was elected to the Royal Society and published most of his important work in its Transactions.[32] The greatest "winner" in this game was doubtlessly Newton, whose ideas triumphed in the eighteenth century international market and who became a global superstar (David, 2004). But the careers of other leading scholars also indicate this cosmopolitan nature of European intellectuals.[33]

Important works were at first still written in the lingua franca, Latin, but as the vernacular gradually became more and more popular as the form of writing, they were translated. Such translations were one of the most significant signs of the emergence of the international market for ideas. So were the correspondence networks between citizens of different countries. Most importantly, people travelled, notwithstanding the difficult circumstances. Famous scientists were, as a rule, far more mobile that laborers or peasants – as were well-known composers, painters, and performance artists. As a result, scientific reputations were far more valuable and worth investing in. Europe's system, to put it crudely, got the best of two worlds. It had all the advantages of a unified market, without the costs that accompanied the centralization of power.

The significance of the market for ideas

The forces in the market for ideas, like any other market, reflect both supply and demand. The demand for ideas on how economic life should be regarded and controlled reflected, up to a point, the changing interests of a new urban-commercial class that emerged in the sixteenth and seventeenth centuries and was interested in increasing economic openness, monetary stability, more secure property rights, enforceable contracts, a state that solved obvious problems of coordination, and fiscal commitments that were subject to consent. To that list we should add the "demand" for new technology that would replace labor, which was particularly costly in the United Provinces and Britain. It has been argued persuasively by Allen (2006) that the high cost of labor relative to that of energy might have been instrumental in focusing the minds of British inventors on ways in which to substitute fuel for human labor. It may therefore be no accident that steam power was born in Britain. Yet it is hard to see how such growing sentiments by themselves would automatically trigger a process of economic growth based on technological progress without accompanying changes on the supply side. In order for the economic advances of the age of geographical exploration and growing commercial sophistication of the sixteenth century to turn into the Industrial Revolution something had to occur in between.

That event was the Enlightenment. In terms of the market for ideas, one can see the Enlightenment in two ways. It can be regarded, first, as itself a set of ideas that ended up triumphing over competitors. The winners included the Baconians, the Newtonians, Locke, Diderot, Adam Smith, and Antoine Lavoisier. We cannot be fully sure why these ideas triumphed over opposing ideas such as religious fanaticism and mercantilist notions that wealth always and everywhere was based on political power and military muscle. We can establish one important factor in that outcome: Europe had a successful Enlightenment whereas other parts of the world did not because it already had a market for ideas in which these new ideas could compete and win on their own merit. Secondly, it can and should also be seen as a widening of support for the belief in a free market for ideas itself, a market that should be supported by certain institutions and submit to certain rules. The success of

the Enlightenment – in both senses – itself was far from pre-ordained or even probable. In fact, it failed in parts of Europe, and similar phenomena, such as the Kaozheng ("school of evidentiary and pragmatic research") movement in seventeenth century China made little impact on the economy.[34]

Not everything about the Enlightenment mattered to the economy. Moral and political issues, human rights, equality and justice, and the growth of anticlericalism and secularism were perhaps not of immediate significance to economic growth. "Reason" as such was not enough to generate long-term economic growth. But what mattered here were two basic ideas, without which the Industrial Revolution would not have turned into long-run growth.[35]

One was the belief that the discoveries of "natural philosophy" could and would lead to material progress, as Bacon had foreseen. Economic historians and historians of technology have delighted to point out that the Industrial Revolution owed little to science, and that many of the central inventions of the Industrial Revolution did not require more science than what Galileo – some even say Archimedes – knew. But in the years after 1815, the economic sea-change we call the Industrial Revolution would surely have lost steam and eventually fizzled out had it not been for the constant infusion into the technology in use of inputs from scientific methods and discoveries, and the gradual widening of the epistemic base of both existing and new techniques.

The second Enlightenment idea that mattered to economic growth in the long run was a change in the mercantilist world-view that saw the economic process inherently as a zero-sum game. In a mercantilist model, the gains of one side were counterbalanced by the losses of the other. The economic process was regarded purely as a contest, in which individuals, groups, regions, and nations struggled over what they believed was a fixed pie. In that kind of world, redistribution and rent-seeking were more important than efficiency and growth. Enlightenment thought first modified and then abandoned this view. Economics shows that efforts that redistribute wealth rather than create it actually reduce the overall pie because they distort incentives and misallocate resources. While the finer points of this theory were of course not wholly realized, Enlightenment writers intuitively recognized the costs of rent-seeking and launched an all-out campaign against institutions that supported it, from tariffs and bounties that meddled with free international trade and internal barriers to limitations on occupational choice, barriers to entry, and the myriad of *privilèges* and exclusionary rights enjoyed by groups and individuals. In much of post-Napoleonic Europe, in which modern economic growth emerged in earnest, economic institutions and technological progress were conditioned on the triumphs of the Enlightenment. It was an age in which exclusionary privileges and restrictions on economic freedom had been reduced.[36]

The dual ideas of growth through technological progress and institutional reform, then, were the elements of the Enlightenment that brought about modern economic growth. What is remarkable is not that these notions emerged at all, since the supply side of the market for ideas produces all kind

of intellectual innovations, but that they were actually triumphant. European institutions changed in part, because those who wrote the rules of the economic games were persuaded that Enlightened views were correct. How and why this happened remains the key to understanding modern European History. It is surely the case, as John Stuart Mill wrote in an often-quoted line, that a good cause seldom triumphs unless someone's interest is bound up with it. Commercial capitalism, at times, found enlightened ideas congenial to its interests. But it would be unwarranted to write the historical development of ideology as a linear model in which economic interests determined ideology and in which there was no feedback. After all, there were conflicting economic interests bound up with different causes. The *ancien régime* defended itself with vigor. So did many economic interests and entrenched distributional coalitions Why did the Enlightenment ideology win?

One of the supreme ironies in European history is that in the end the triumph of the Enlightenment relied a great deal more on coercion than the philosophes would have been comfortable with. The European continent underwent a radical change in its institutions inspired by the Enlightenment, but these institutions were enforced by the Guillotines of the National Convention and later by the bayonets of Napoleon's battalions. In Britain, the events of the French Revolution triggered a conservative reaction that seriously retarded the process of reform. History is rarely linear in this regard, and it is full of delays and lags that are not always easy to explain. The real triumph of Enlightenment ideas took place only after 1815 – to coincide with the beginning of sustained economic growth through much of the Continent.

The marketplace for ideas thus did not operate purely on persuasion and rhetoric. The institutions and conventions of the ancien régime forcefully resisted the imposition of the new rules and coercion was an important answer. Another reason that the triumph occurred, as Peter Gay has insisted, was that many of its proponents were insiders and were closer to the political establishment than they would be willing to admit. Many of the leading intellectuals of the age of Enlightenment were celebrities in their time, and long before the French Revolution, many rulers, appreciating their intellectual gifts, tried to co-opt them, invited them to their courts, and consulted them. A further reason why the Enlightenment philosophes won out was that they were talented, learned, and articulate and, on balance, more persuasive than their opponents. The writings of Voltaire, Diderot, Hume, and Smith, to name just a few, were effective because they were erudite, logical, and met the rhetorical standards of the time. The impact of the writings of Adam Smith on policy makers in Britain and abroad was amplified through its popularization through his followers such as Dugald Stewart and Jean-Baptiste Say.[37] Following the more famous leaders, there was a considerable chorus of scientists, political economists, and other writers stressing "useful knowledge" and economic liberty. Their cumulative impact on the new institutional and scientific ideology cannot be quantified, but I would submit that without it, economic growth may have been significantly slower and may have ground to a halt, as it had done in the pre-1750 past.

A number of pre-1789 attempted reforms in the eighteenth century were inspired by the insights of the movement, some of them by the enlightened monarchs and others by reform-minded politicians such as Turgot, whose reform-minded rule lasted less than two years.[38] The biggest triumph of the Enlightenment movement was clearly the establishment of a regime in the United States based on its principles. Although the success of these pre-revolutionary Enlightenment reformers in Europe was spotty, since they depended mostly on the cooperation of autocratic rulers and were resisted by powerful authorities, they can be viewed as precursors to the more fundamental reforms introduced by revolutionary authorities after 1790.

All the same, it is important to stress that when historical change depends on the market for ideas, the contingency of the outcome is reinforced by the indeterminacy of the decisions of the market for ideas.[39] Certainly, in the 1780s, the prospects for an age of relatively free market economies and a curtailment of rent-seeking activities on the Continent looked anything but inevitable. Moreover, the clash between the Enlightenment and the ancien régimes produced unintended consequences, such as a strong conservative backlash and a repressive regime in Britain in the 1790s, and a military dictatorship on the Continent. While these effects were eventually reversed, there was nothing inexorable about the outcome. The historical dynamics of the changing ideology were ridden with lags, setbacks, and roundabouts. The late seventeenth century was the age in which many of the components of the Enlightenment were established: the ideas of tolerance and economic liberty were taking root, and the Baconian program crystallized into such institutions as the Royal Society and other scientific and learned societies all over Europe. There was a rather long pause in progress in the first half of the eighteenth century when both population and economic growth were slow, and despite important institutional developments, no major scientific breakthroughs occurred. The Industrial Revolution, when it happened, did not dramatically affect the rate of growth nor did it constitute a major application of the emerging body of propositional knowledge to the economy. Instead, it demonstrated in a number of instances what this knowledge could do, how engineering and ingenuity could solve problems, that at times consultation with natural philosophers could yield good results, and that, with luck, these activities could help one make money. Institutions and an economic environment friendly to innovation could produce the incentives in which existing knowledge could be applied fruitfully. In terms of sustained growth, what was needed were incentives for original and creative minds to propagate new ideas and knowledge, and for these to catch on and be put to work. In this interpretation, the Industrial Revolution was neither the direct consequence of the Scientific Revolution nor itself accompanied by rapid economic growth. Instead, it was another stage in the long chain of changes in the market for ideas that eventually came to significantly affect economic realities.

Endnotes

[1] As he noted (1950, p. 84) in a widely cited passage: "In capitalist reality, as distinguished from its textbook picture it is not [price] competition which counts but the competition from the new commodity, the new technology...which strikes not at the margins of the profits of the existing firms but at their...very lives."

[2] The "business of science," John T. Desaguliers noted in the 1730s, was "to make Art and Nature subservient to the Necessities of Life in joining proper Causes to produce the most useful Effects" (1763, Vol. 1, p. iii). This was spoken by one of the leading Newtonians of the time, a man who made a career out of selling knowledge to others, a professional lecturer, a textbook writer, and a consultant to business.

[3] Leonhard Euler was concerned with ship design, lenses, the buckling of beams, and (with his less famous son Johann) contributed a great deal to theoretical hydraulics. The great Lavoisier worked on assorted applied problems as a young man, including the chemistry of gypsum and the problems of street lighting. Benjamin Franklin, Joseph Priestley, Tobern Bergman, Johann Tobias Mayer, and René Reaumur were among the many first-rate minds who unabashedly devoted some of their efforts to solve mundane problems of technology: how make better and cheaper steel, how to determine longitude at sea, how to light homes and cities safer and better, how to prevent smallpox, and similar questions.

[4] In the words of Thomas Sprat, an early defender of the Society, its mission was to create a natural philosophy that would benefit "mechanicks and artificers.""The business and design of the Royal Society is to improve the knowledge of natural things, and all useful Art, Manufactures, Mechanick practices, Engynes, and inventions by Experiments... The Fellows of the Royal Society have one advantage peculiar to themselves, that very many of their number are men of converse and traffick, which is a good omen that their attempts will bring philosophy from words to action, seeing men of business have had so great a share in their first foundation" wrote Robert Hooke in 1663 (Lyons, 1944, pp. 41-42).

[5] Among those were the discovery by British naval officers that fresh fruits and vegetables could prevent scurvy, the use of cinchona bark (quinine) to fight off the symptoms of malaria, the prescription of foxglove (now known as digitalis) as a treatment for edemas and atrial fibrillation (first recommended by Dr. William Withering, a member of the Lunar Society, in 1785), the consumption of cod liver to prevent rickets, and above all the miraculous vaccination against smallpox discovered by Jenner in 1796.

[6] Voltaire in his famed Philosophical Dictionary (1816, Vol. III, p. 91) caustically remarked that after 1750, many useful books written about agriculture were read by everyone but the farmers.

[7] At times major breakthroughs remained barren for many years. Thus, the most spectacular insight in metallurgical knowledge, the celebrated 1786 paper by three of France's leading scientists, Monge, Berthollet, and Vandermonde that established the chemical properties of steel, had no immediate technological spin-offs. It was "incomprehensible except to those who already knew how to make steel" (Harris, 1998, p. 220). Harris adds that there may have been real penalties for French steelmaking in its heavy reliance on scientists or technologists with scientific pretensions.

[8] Among the best-known ones in the early eighteenth century were the Scottish chemist William Cullen and the itinerant lecturer and Newtonian Jean T. Desaguliers. During the Industrial Revolution the number of these consulting engineers expanded and they were organized in the Smeatonian society after John Smeaton, Britain's leading engineer.

[9] Humphry Davy, perhaps the most accomplished practitioner of the new electrochemistry put it, Volta 's pile acted as an "alarm bell to experimenters in every part of Europe" (cited by Brock, 1992, p. 147).

[10] Jesse Ramsden designed a famous theodolite that was employed in the Ordnance Survey of Britain, commenced in 1791. A comparable tool, the repeating circle, was designed by the great French instrument maker Jean-Charles Borda in 1775, and was used in the famed project in which the French tried to establish with precision the length of the meridian.

[11] The French mathematician Antoine Parent calculated that the maximum useful effect of a waterwheel was only 4/27th the natural force of the stream and that the optimal speed of the waterwheel was 1/3 that of the stream. These calculations were widely accepted, although they were incorrect and did not square with empirical observations. They were subsequently revised and corrected. Experimental work remained central and at times had to set the theorists straight (Reynolds, 1983).

[12] The explanations of how such intellectual conservatism can be a rational response can vary (Kuran, 1988). It was often felt that a free marketplace for ideas might lead to subversion that threatened political stability (that is, the power base of the status quo), or that they might cause economic disruption such as unemployment. In other cases, still not entirely absent in our own age, disrespect toward the wisdom of elders or the presumption of appropriating powers that belong to a higher being ("playing God") are also resented. Symbols like the sorcerer's apprentice and Prometheus embody the notion that innovation could be dangerous and should be contained and controlled.

[13] The Chinese institution of examination for the Civil Service, ostensibly the most meritocratic institution of the world, tested the students on their knowledge of Confucian philosophy, and did not tolerate major deviations, much less knowledge that came from other societies. Because Judaism before the nineteenth century, despite its intellectual character, was backward looking and based on the assumption that all wisdom had been revealed to earlier generations, exegesis rather than research was the key to scholarship. A famous dictum from the Jewish Chazal (earlier sages) has it that "if those who were before us were like angels, we are but men; and if those who were before us were like men, we are but asses."

[14] Consider Philipp Melanchton's denunciation of Copernicus: "some think it a distinguished achievement to construct such a crazy thing as that Prussian astronomer who moves the earth and fixes the sun. Verily, wise rulers should tame the unrestraint of men's minds." (cited by Kesten, 1945, p. 309, emphasis added). In 1896 Andrew D. White (1896, vol. 1, p. 128) added that "strange as it may seem, nowhere were the facts confirming the Copernican theory more carefully kept out of sight than at Wittenberg – the university of Luther and Melanchton. On the other hand, in Catholic France, the philosopher Petrus Ramus could be promoted on a lecture entitled "On the errors of Aristotle" (1536) in which he proposed nothing short of a complete alternative to Aristotle's philosophical system. The Sienese Monk Bernardino Ochino (1487-1564) advocated a host of unorthodox ideas such as divorce and bigamy. Much of the most innovative scientific work between 1500 and 1700 took place in Catholic nations.

[15] Despite the increasingly repressive regime of the counter-reformation in Italy in the second half of the seventeenth century, some of the most innovative scientists of the scientific revolution were Italians: Marcello Malpighi, Giovanni Alfonso Borelli, and Giandomenico Cassini.

[16] A few others could be added to this list, such as Lucilio Vanini, executed in Toulouse in 1617 for atheism and Ferrente Pallavicino, executed in Avignon in 1642 for disrespect to the Pope.

[17] The Brabant chemist Jan-Baptist Van Helmont had his book De magnetica vulnerum impounded and in 1624 the inquisition in the Spanish Netherlands began formal proceedings against him for "heresy and impudent arrogance." In Naples, the philosopher Giambattista della Porta who had experimented with incubators for chicken hatching was accused in 1588 by the Inquisition of being "a sorcerer" and had to abandon his work. The great Paracelsus, admittedly an extraordinarily pugnacious person, strongly provoked the received medical wisdom of his time and had to repeatedly escape towns where he had worn out his welcome with the local authorities.

[18] John Taylor, a teacher at one of Britain's dissenting academies, Warrington Academy, told his pupils in 1757 that "if at any time hereafter any principle or sentiment by me taught or advanced, or by you admitted and embraced, shall upon impartial and faithful examination appear to you to be dubious or false, you either suspect or totally reject that principle or sentiment" (cited by Reid, 2006, pp. 8-9).

[19] Voltaire famously purchased his property in Ferney in the 1750s close enough to the Swiss border to make an escape if push came to shove, but within France's borders to escape repressive Geneva regulations on having a private theater on his estate.

[20] In the Islamic world, printing was prohibited until the eighteenth century, and no books in Arabic script were printed in the Ottoman Empire before 1729.

[21] This argument complements the one made by Elizabeth Eisenstein (1979, p. 398) who points out the role the printing press played in the decline of the influence of the only supranational body with the capability of coordinating the suppression of intellectual innovation, namely the Catholic Church.

[22] The career of Martin Luther was, of course, a classic example of this phenomenon, but many of the most influential and innovative intellectuals took advantage of what Jones has called the competitive "States system." In different ways, Paracelsus, Comenius, Descartes, Hobbes, and Bayle, to name but a few, survived through

strategic moves across national boundaries. They were able to flee persecutors, and while this imposed no-doubt considerable hardship, they survived and prospered. For details, see Mokyr (2006b).

[23] Less well-known but equally telling is the tale of Tommasso Campanella, (1568-1639), an Italian monk who studied astronomy, astrology, and occult philosophy, and soon became a severe critic of the Aristotelian orthodoxy. Accused from an early age of heresy by the Inquisition, his ability to play one power against another in fragmented Italy ran out when he was sentenced to life imprisonment in 1599 (for anti-Spanish activity rather than for heresy) and spent twenty seven years in a Neapolitan jail. His conditions there, however, were sufficiently benign that he could write seven books as well as a pamphlet defending Galileo during his first trial in 1616. He could accomplish this in part because the Emperor Rudolf, Duke Maximilian of Bavaria, and other Catholic notables were exerting influence to protect him. In the end, he was released from jail thanks to the intervention of Pope Urban VIII.

[24] Cardinal Reginald Pole, the leader of the Catholic reaction in England was denounced as a heretic by the equally reactionary Pope Paul IV.

[25] While suppression of new ideas had become decidedly less virulent, it flared up in France in the late 1750s after the publication of Claude-Adrien Helvétius's De l'Esprit in 1758. It was condemned by the Sorbonne and burned in public; Helvétius found himself in England and later on in Potsdam. A few years later, Rousseau's Émile created a scandal, and he, too, had to flee.

[26] Thus, for instance, scientists could not decide on the nature of heat, and while they were getting better at measuring and controlling it, they were unsure of what its real essence was.

[27] This point is well-made by Lipsey, Carlaw, and Bekar (2005), p. 260, when they discuss the importance of what they call institutional memory.

[28] Thus Anthonie van Leeuwenhoeck used his microscope to identify spermatozoa in 1677, but prudently added that the specimen he chose was the result of the excess bestowed upon him by Nature in his conjugal relations with his wife Cornelia and not obtained by any "sinful contrivance" (Cobb, 2006, pp. 202-203).

[29] The first major priority fights between scientists date to the seventeenth century, the most famous of which are the arguments between Newton and Leibniz (about calculus) and Newton and Hooke (about the inverse-square force law). No less fierce was the battle between two Dutchmen, Jan Swammerdam and Reinier de Graaf. on certain aspects of female reproduction.

[30] To be sure, as the modern economics of open source technology has emphasized, many of these arguments were themselves correlated with income. In the seventeenth and eighteenth centuries, fame and reputation were conditions for university professorships or patronage jobs in a variety of courts, from Galileo's comfortable appointment at the court of the Medicis to Newton's sinecure at the British mint.

[31] As late as 1799, one of the archetypical Enlightenment scientists, Count Rumford, sighed that that "there are no two classes of men in society that are more distinct, or that are more separated from each other by a more marked line, than philosophers and those who are engaged in arts and manufactures" and that this prevented "all connection and intercourse between them." By that time, surely, his statement was no longer wholly valid, and indeed was becoming increasingly less so. Priestley (1768, p. 22) felt that "the politeness of the times has brought the learned and the unlearned into more familiar intercourse that they had before."

[32] The Society chose to prefer Malpighi's work over that of his Dutch competitor, Jan Swammerdam. See Wilson, 1995, pp. 94-98, 189.

[33] The great Moravian intellectual Jan Comenius, fleeing war and persecution, found himself in London, Stockholm, and Amsterdam among other places and was offered the presidency of the newly-founded Harvard College. Descartes, Huygens, Leibniz, Euler, and many others established international reputations and were offered cushy patronage jobs by various academies, courts, and universities.

[34] An instructive example is the career of Chu Shun-shui, one of the Chinese intellectuals who can be compared with his European counterparts. His pragmatic approach to wisdom, which he felt should be judged on whether it was of use to society. While not quite Baconian in his approach (his interest were rituals and public virtues), he was an unusually independent thinker. His knowledge was quite broad and extended to fields of practical knowledge such as architecture and crafts. Fleeing from China (he had remained a supporter of the

Ming dynasty, overthrown in 1644) first to Annam (Vietnam) and then to Japan he encountered many hardships in both places as the East was clearly not accustomed to itinerant intellectuals. He was twice denied permission to remain in Japan and imprisoned in Annam. In the end, he was allowed to stay in Japan, where he had quite a following and eventually became advisor and mentor to the daimyo Mitsukuni. Chu Shun-shui, in Julia Ching's words, was hardly a purely abstract philosopher, but "the investigation of things referred to less to the metaphysical understanding of principle of material force s, and more to coping with concrete situations. At the same time, the extension of knowledge applied not only to knowledge of the Confucian classics, but also to all that is useful in life" (Ching, 1978, p. 217). Yet Chu's work remained unknown in China and his work was rediscovered by a much later generation of Chinese refugees who fled to Japan after the Hundred Days Reform in 1898.

[35] For more details, see Mokyr (2006b).

[36] Guilds and monopolies had been weakened, internal tariffs had been eliminated, and price control of wheat was abolished. Anachronistic legislation such as Navigation Acts, Bubble Acts, and laws limiting labor mobility and occupational choice were disappearing in the West. Free trade was slow in fully establishing itself, but from the 1820s on it was clearly on the rise.

[37] Two years after Smith's death, Pitt referred in the House of Commons to "the writings of an author of our own times, now unfortunately no more, (I mean the author of a celebrated treatise on the Wealth of Nations,) whose extensive knowledge of detail, and depth of philosophical research, will, I believe, furnish the best solution to every question connected with the history of commerce, or with the systems of political economy" (Pitt, 1817, vol. 1, pp. 357-9). The chief clerk of the committee of Trade, George Shelburne, and his colleague Charles Jenkinson (later Lord Liverpool and father of the PM) were also deeply influenced by Smith's nuanced but clear-cut liberal ideas, though they tried to combine them with the British national interests (Crowley, 1990).

[38] Other examples can readily be found: the Austrians Joseph von Sonnenfels (1732-1817), the first professor of Political Economy at the University of Vienna, who influenced public policy under Maria Theresa (curtailing the power of the guilds and reforming the judiciary), and Karl von Zinzendorf, who had come under the influence of radicals in Milan and physiocrats in Paris. In Milan, the Supreme Economic Council set up in 1765 to reform economic and social policy counted such Enlightenment heavyweights as Cesare Beccaria, the brothers Alessandro and Pietro Verri. In Denmark, the German physician Johann Friedrich Struensee was an "enlightened reformer" who lasted for only a few years before his enemies got the better of him, though in 1784 another enlightened German named Andreas Peter Bernstorff was able to introduce many important reforms. In Spain, the Campomanes reforms under Carlos III attempted a similar set of policies.

[39] In 1784, Kant famously reflected that the "age of Enlightenment" in which he lived was not yet "an enlightened age." Peter Gay assesses that this distinction was penetrating and important, because even late in the eighteenth century the philosophes had ample reason for uncertainty and occasional gloom (1966, p. 20).

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