C. Fundamental economic factors affecting international trade

The previous section has shown that the future of trade and economic growth depends on a range of factors. Predictions may change depending on how each of these factors develops. This section discusses how the fundamental economic factors shaping the future of international trade – namely demography, investment, technology, energy and other natural resources, transportation costs and the institutional framework – are likely to evolve in the coming years.

Contents

Some key facts and findings

- Demographic change affects trade through its impact on countries' comparative advantage and on import demand. An ageing population, migration, educational improvements and women's participation in the labour force will all play a role in years to come, as will the continuing emergence of a global middle class.
- Investment in physical infrastructure can facilitate the integration of new players into international supply chains. The accumulation of capital and the build-up of knowledge and technology associated with investment, particularly foreign direct investment, can also enable countries to move up the value chain by altering their comparative advantage.
- New players have emerged among the countries driving technological progress. Countries representing 20 per cent of the world's total population accounted for about 70 per cent of research and development (R&D) expenditure in 1999, but only about 40 per cent in 2010. Technology spillovers are largely regional and stronger among countries connected by production networks. In addition to the traditionally R&D intensive manufacturing sectors, knowledge-intensive business services are emerging as key drivers of knowledge accumulation.
- The shale gas revolution portends dramatic shifts in the future pattern of energy production and trade as North America becomes energy sufficient. Increasing water scarcity in the future in large swathes of the developing world may mean that the long-term decline in the share of food and agricultural products in international trade might be arrested or even reversed.
- Ample opportunities exist for policy actions, at the national and multilateral level, to reduce transportation costs and offset the effect of higher fuel costs in the future – improving the quantity and quality of transportation infrastructure, successfully concluding the Doha Round negotiations on trade facilitation, introducing more competition on transport routes, and supporting innovation.
- Improvements in institutional quality, notably in relation to contract enforcement, can reduce the costs of trade. Institutions are also a source of comparative advantage, and trade and institutions strongly influence each other.

Various economic theories use fundamental economic factors to explain why countries trade and how trade patterns evolve. In David Ricardo's theory, for instance, technological differences between countries determine comparative advantage. In the Heckscher-Ohlin model, relative factor endowments (labour, capital and natural resources) shape trade patterns. The new trade theory predicts that countries with larger economies – as a result of growth in endowments and incomes – will develop an export edge in those goods consumed in relatively greater quantities in the home market. The "new new" trade theory identifies trade costs as a key impediment to entry into trade. Others argue that the quality of a country's political and economic institutions can be a key source of comparative advantage. This section also covers feedback effects from trade which, in turn, have an impact on the fundamental economic factors shaping trade. Trade can lead to technological spillovers, for example, allowing countries with less technological expertise to acquire much-needed know-how. Engaging in trade can also help to strengthen political and economic institutions.

This section shows how developments in demography, investment, technology, energy and other natural resources, transport costs and institutional quality are capable of changing the overall nature of trade: the role that individual countries play in international trade, how they trade and what is traded with whom and why. It explores possible future scenarios for each factor and concludes by describing their potential impact on currently observed trade trends, as discussed in Section B. The discussion foreshadows issues that could become critical for the WTO as well as for international cooperation in the future – a subject that will be taken up in greater detail in Section E of this report.

1. Demographic change

The world's population is expected to reach 8.3 billion by 2030 and 9.3 billion by 2050. Most of this increase will take place in certain developing countries that are in the early stages of their demographic transition and which will see significant increases in the young working-age population of both sexes. In other developing countries and in most developed ones, the demographic transition is already in its most advanced stage. Fertility rates are low, resulting in an ageing population and in a shrinking labour force. In some of these countries, immigration is likely to be the main source of population growth in the future. Furthermore, education and urbanization are advancing everywhere in the world. The objective of this section is to show how these long-term demographic trends are likely to affect international trade patterns through their impact on comparative advantage as well as on the level and composition of import demand.

(a) The demographic transition and ageing

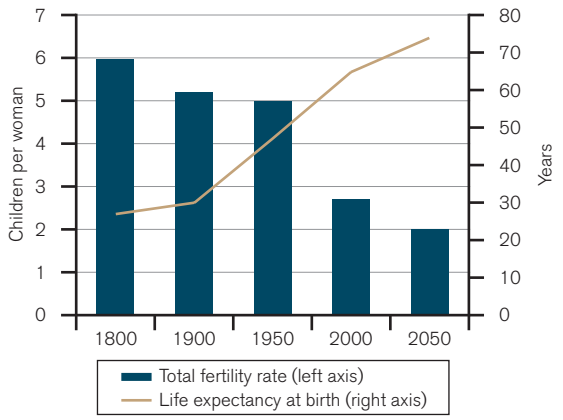
The world is experiencing dramatic changes in the size and composition of its population. These are the result of the so-called "demographic transition" – a process which involves first a decline in mortality rates and then a reduction in fertility. Countries are at different stages of their demographic transition. The data presented in the first part of this section will show that some countries are ageing quickly while others are reaping a "demographic dividend" from a younger population. These trends are likely to have an impact on trade patterns through two main channels: changes in comparative advantage and changes in the level and composition of import demand. The second part of the section discusses these two channels in more detail.

As clarified by Lee (2003), a country's demographic transition occurs in four stages. In the first stage, mortality starts declining while fertility remains high. In this phase, mortality reductions mainly affect the infant population and are mostly related to declines in contagious diseases spread by air or water, and to improvements in nutrition. Since mortality declines, the population increases and becomes relatively younger.

The second stage of the transition is characterized by a decline in fertility and an increase in the working-age population, as the younger people reached adulthood.[1] During this phase, a growing labour force and increased savings can potentially boost economic growth, generating a "demographic dividend". Next, ageing leads to rapid increases in the elderly population, while low fertility reduces the growth of the working age population, thus increasing the young- and old-age dependency ratios.[2] The demographic transition ends when the total dependency ratio is back to the pre-transition level but where the young-age dependency ratio is low while the old-age ratio is high.

The global demographic transition is apparent in Figure C.1, which shows past and projected fertility rates and life expectancy. The decrease in total fertility is clearly noticeable. *The Economist* (2012) reports that almost half the world's population – 3.2 billion – already lives in

Figure C.1: **World fertility rate and life expectancy, 1800-2050**



Source: Lee (2003).

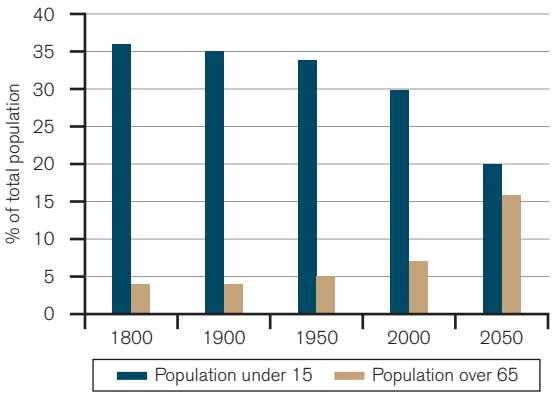
countries with a fertility rate of 2.1 or less. Conversely, life expectancy at birth has followed a clear upward trend. These developments indicate that the world as a whole reaped a demographic dividend in the 40 years to 2010 (*The Economist*, 2012). In 1970, there were 75 dependants for every 100 adults of working age. In 2010, the number of dependants dropped to just 52. Huge improvements were registered not only in China but also in South-East Asia and North Africa, where dependency ratios fell by 40 points. Even Europe and North America ended the period with fewer dependants than at the beginning.

Since 2010, however, the world population has inexorably started to become older (see Figure C.2). Its size will continue to grow but at a rate lower than the historical growth rates of the 19th and early 20th century, as shown in Figure C.3.

Countries are at different stages of their demographic transition (Eberstadt, 2012). Developed economies began the demographic transition in the 19th century. In most developing countries, the transition lagged by almost a century. However, it progressed much more rapidly, thus implying that fertility and population growth rates are converging relatively quickly at the global level (see Figure C.4). Lee (2003) notes that the process of global demographic convergence of the past 50 years is in marked contrast with the growing economic disparities over the same period.

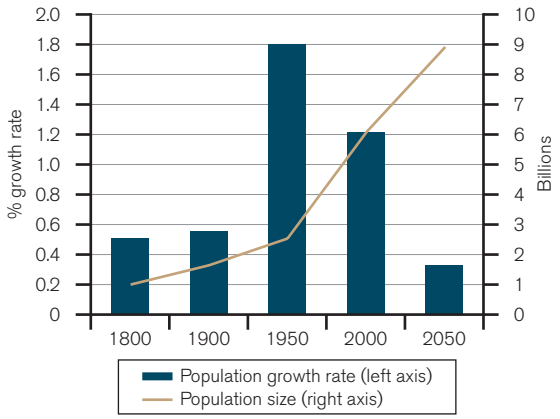
However, these general trends mask noticeable differences within each group of countries, especially in fertility rates. Within developed countries, most European countries have very low fertility rates (for example, Germany at 1.36, Italy at 1.38 and Spain at 1.41 in 2010) but some others have higher rates

Figure C.2: **Age structure of the world population, 1800-2050**
(percentage)



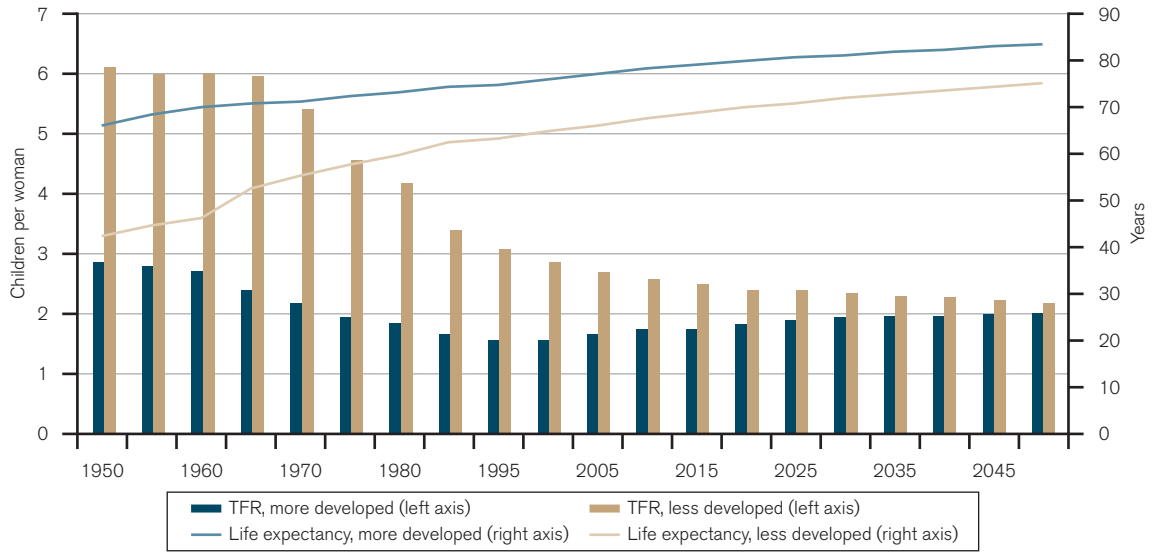
Source: Lee (2003).

Figure C.3: **Size and growth rate of the world population, 1800-2050**



Source: Lee (2003).

Figure C.4: **Total fertility rate (TFR) and life expectancy by country group, 1950-2050**



Source: United Nations Population Division, *World Population Prospects: The 2010 Revision database*.

(for instance, the United Kingdom at 1.83 and France at 1.93). While the fertility rate in Japan is extremely low at 1.32, the rate in the United States is 2.07. Within developing countries, most Sub-Saharan African countries have high fertility rates, with an average of 4.8 in 2010; this is the fastest-growing region of the world in terms of population. The fertility rate in India (2.73) is also relatively high. Other populous developing countries, however, have fertility rates below 2. These include the Republic of Korea (1.29), the Russian Federation (1.44), Thailand (1.63), China (1.64), Iran (1.77) and Brazil (1.90).

One of the implications of different demographic dynamics across countries is that the distribution of world population will continue to shift towards developing and emerging economies. As shown in Figure C.5, the share of world population that lives in such economies will rise from 85 per cent in 2010 to 88 per cent in 2050. China will cease to be the most populous country in the world in 2050; its share of world population dropping from 20 to 14 per cent and being surpassed by India, which will account for 18 per cent of the world population in 2050.[3]

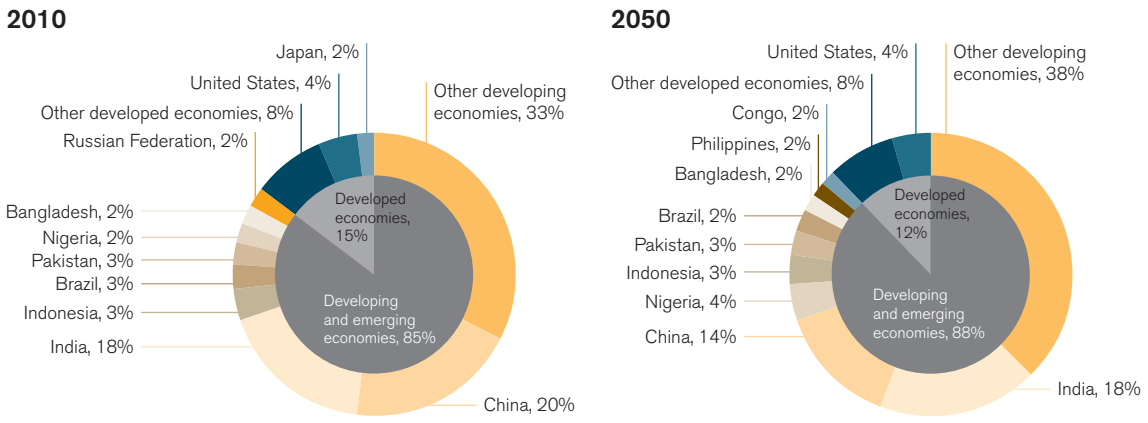
One of the most dramatic consequences of the demographic transition is the shift in age distribution of the population at the later stages of the transition. Two variables that are of particular interest are the dependency ratio and the median age; these are shown for some populous countries (China, India and the United States) and a range of regions (Sub-Saharan Africa, Middle East, Latin America and the European Union) in Figure C.6 in order to highlight certain patterns. Some countries and regions are shown to have a fast-ageing population and increases in the dependency ratio. China, for instance, is ageing fast: the median age was as low as 22 years in 1980 but will reach the level of the United States (around 38 years) in 2020 and the level of Europe (around 46 years) in 2040. Moreover, China's dependency ratio will start to grow from the low level of 37.5 in 2015 to the relatively high level of 64 by 2050 – the sharpest rise in the world (see Figure C.6). According to Li et al. (2012), the decline in labour force as a share of the population will cause labour shortages and thus contribute to rising wages in China (see Section D.1). To put it more bluntly in the words of The Economist, it "will bring an abrupt end to its cheap-labour manufacturing" (*The Economist*, 2012).[4]

In countries with relatively generous welfare systems, rising dependency ratios imply formidable challenges in the provision of pensions and health care that relies on tax revenues from the working population. Countries with intermediate fertility rates, such as the United States, will find it easier to cope with these challenges than countries with low fertility rates and accelerated ageing, such as Japan. There are, conversely, countries where demographic trends represent huge opportunities, especially for India, Sub-Saharan Africa and Middle Eastern countries. Figure C.6 shows that they will have low median ages and will experience decreases in dependency ratios in the coming decades. As argued by *The Economist* (2012), if they can improve their public institutions, keep their economic policies outward-looking and invest more in education, as was the case for East Asia, then Africa, the Middle East and India could become the fastest-growing parts of the world economy within a decade or so.[5]

(i) Ageing and comparative advantage

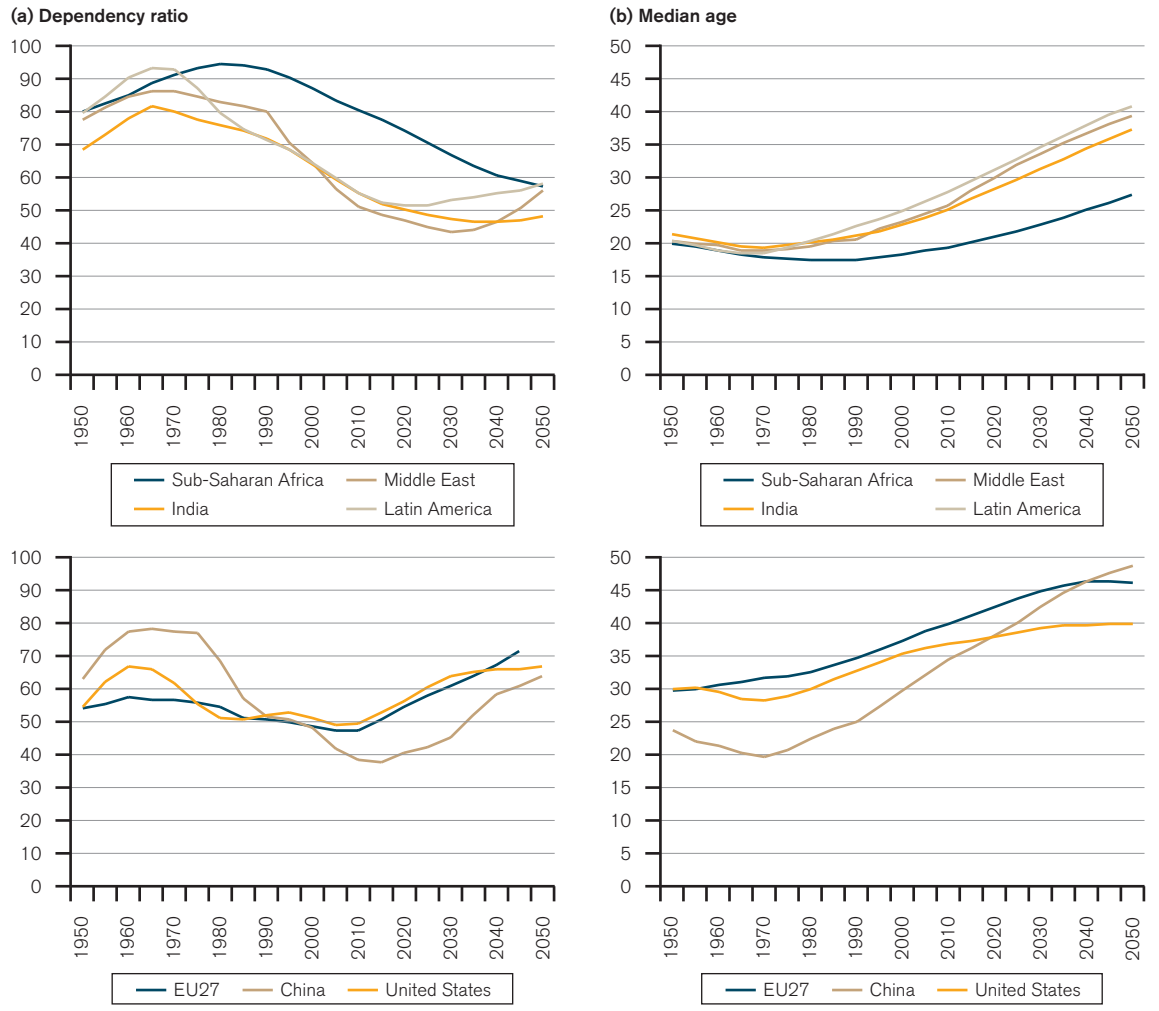
International differences in population dynamics have been identified as a factor determining comparative advantage and the composition of trade. Some theoretical studies show that a country with slower population growth becomes relatively capital-abundant, while a country with faster population growth becomes relatively labour-abundant over time, thus registering lower capital-labour ratios ("capital shallowing"). This gives rise to differences in autarky relative prices,[6]

Figure C.5: **Share of world population, by country group, 2010 and 2050** (percentage)



Source: United Nations Population Division, *World Population Prospects: The 2010 Revision database.*

Figure C.6: **Dependency ratio and median age, selected countries and regions, 1950-2050** (percentage and years)



Source: United Nations Population Division, *World Population Prospects: The 2010 Revision database.*

creating grounds for Heckscher-Ohlin trade in which the former country specializes in capital-intensive goods and the latter country specializes in labour-intensive goods (Sayan, 2005; Naito and Zhao, 2009).[7]

However, Yakita (2012) shows that countries with an ageing population are not necessarily net exporters of capital-intensive goods. A longer retirement prompts individuals to invest more in human capital and to reduce the number of children. Moreover, a longer retirement depresses demand for consumption goods (assumed to be labour-intensive) in the working period, reducing their autarky relative price. If this relative price is below the free trade relative price, the ageing economy ends up exporting labour-intensive goods and importing capital-intensive ones.

Demographic change also has significant effects on capital flows and the trade balance.[8] However, the literature does not provide unambiguous conclusions on the direction of these effects. Some studies underline that countries which are in a relatively more advanced stage of their demographic transition are characterized by net capital outflows and trade surpluses. These studies show that higher life expectancy determines an increase of savings for retirement, exerting pressure on the economy to export capital to "younger" economies. Likewise, a lower fertility rate reduces the size of the working population and investment demand, again inducing capital exports. On the other hand, countries that are in the initial stages of the demographic transition and have relatively higher population growth will have net capital inflows and trade deficit.[9]

However, others have shown that economies with high and rising elderly dependency ratios can register net capital inflows and trade deficits. For instance, Higgins (1998) considers the effect of demographic variables on savings, investment and the current account balance. Large, young dependent populations depress savings supply while augmenting investment demand. Savings and investment, in turn, are negatively affected by ageing. Therefore, the current account

balance is negatively affected both by large young-age and old-age dependency ratios. Lührmann (2003) also finds that a high relative share of those aged 65 or more in the population is associated with capital inflows. This can be explained by declines in savings and the repatriation of capital for consumption in old age.[10]

Overall, little can be said definitively about the prospective effects of ageing on comparative advantage. If associated with a decrease in the labour force as a share of population, ageing can lead to an erosion of comparative advantage in labour-intensive manufactured goods, as is foreseen for China. As a consequence of ageing, countries with a comparative advantage in capital-intensive sectors may see this comparative advantage become stronger, but this is not a general result. Finally, in order to assess the overall impact on trade, it is important to consider demand-side effects, in particular how ageing will affect the level and the composition of demand. This is the subject of the next section.

(ii) Demographic changes and the composition of demand

Demographic changes are affecting both the level and the composition of consumption, with subsequent effects on trade flows. The theoretical and empirical literature on consumption over the life cycle provides a useful framework to understand the likely impact of demography on future consumption and trade patterns.

The life-cycle hypothesis assumes that individuals prefer to smooth consumption over their lifetimes.[11] Hence, they save during their working age, when income is higher, and dis-save in their retirement period, when income is lower. Data on consumption and income, however, contradict the consumption and saving patterns predicted by the basic life-cycle model in several respects. First of all, there is evidence of a hump-shaped relationship between households' total consumption and age. This is mainly explained by household composition effects, according to which households' expenditure increases with the number of children (Attanasio et al., 1999; Browning and Ejrnæs, 2009). Moreover, empirical evidence shows that savings of the elderly do not decrease as much as the life-cycle model (in its simplest formulation) would predict. This mainly depends on bequest motives (Hurd, 1989), or precautionary savings, which are accumulated to accommodate unexpected health or economic shocks (Carroll, 1994; 1997).[12] Liquidity constraints might also generate a pattern of consumption which is similar to that determined by precautionary savings, with individuals accumulating resources in order to smooth consumption when facing economic shocks and impossibility to borrow (Deaton, 1991).[13]

Household composition effects are relevant to assessing the impact of demographic change on demand patterns. In particular, since a higher number of children accounts for higher household consumption expenditure, one may expect, other things being equal, increased consumption in high-fertility, high-population growth countries, such as those in Latin America and Sub-Saharan Africa. However, the ability to finance consumption growth in these countries crucially depends on their economic growth, which, in turn largely hinges on job creation (see Section D). Moreover, domestic demand and import trends also depend on other economic and institutional factors, such as financial integration and social security, which are likely to affect households' expenditure capacity.

For countries at the most advanced stage of the demographic transition, older groups will account for the largest share of consumption.[14] The effects of ageing on aggregate consumption (and, consequently, on import demand) will likely depend on the extent of the decline in consumption following retirement, also known as the "retirement consumption puzzle".[15] However, compositional effects are more relevant than level effects. Expenditures on some categories of goods, such as food, furnishing, clothing and accessories, are noticeably reduced upon retirement, while expenditures on other categories remain constant or increase (Hurst, 2008). Studies that project future consumption patterns in more advanced economies based on current demographic, economic and social trends conclude that services and high-tech sectors will gain most in the coming decades (CBI, 2012; Desvaux et al., 2010; Deutsche Bank, 2007; Lührmann, 2005; Oliveira Martins et al., 2005). In particular, consumption will increase most in communication, transport, health, financial services, tourism services as well as in entertainment and community services that target the senior citizen market. Since not all these sectors are tradeable, the impact on international trade will also depend on the change in demand for tradeable services relative to non-tradeable ones.

The gradual convergence of per capita income levels across countries, documented in Section D, is giving rise to another important phenomenon, namely the expansion of the global middle class. According to the World Bank (2007), in the period 2000-2030, the global middle class is projected to grow from about half a billion to about 1.2 billion, or from 7.6 to 16.1 per cent of the world population. However, its share of world income will remain stable at about 14 per cent, reflecting decreasing inequality across countries.[16] Because of uneven population growth across countries, the geographical distribution of the middle class will change remarkably in the coming decades. Regions with relatively higher projected population growth rates, such as South Asia and Sub-Saharan Africa, will see their share of the global middle class increase while other regions will see a decrease (Kharas and Gertz, 2010; World Bank, 2007).

The expansion of the middle class is likely to result in an increase in demand for goods and services, such as cars, mobile phones, recreational equipment and services, as well as food. Some Western food companies have already modified their products, either to cater to Asian consumers' tastes (*The Economist*, 2013) or to make them more sophisticated. As Asian consumers become richer, they are demanding higher-quality and healthier products (Atsmon et al., 2012). A decrease in the import share of low-value-added products, such as agricultural goods, and an increase in the share of higher-value-added goods, such as cars and office and telecom equipment, is already taking place in the BRIC (Brazil, Russian Federation, India, China) group (Yamakawa et al., 2009).[17]

Trade remains key to sustaining economic growth and thus the expansion of the middle class. This is particularly true of countries such as China where the share of domestic consumption in GDP is still relatively low.[18] Policies that address income inequality can also be important to expanding the middle class and thus economic growth (Kharas and Gertz, 2010).[19]

Another important trend in developing and emerging economies is the rise of education levels. Increasing demand for education, combined with technological advances, is fuelling a rise in education services trade. According to Lim and Saner (2011), education services' exports grew, on average, by 12 per cent between 2002 and 2007. The United States, Australia, the United Kingdom and Canada were among the top exporters; the Republic of Korea, the United States, Germany and India were among the top importers. Education markets are also growing in Latin America and the Middle East (Lim and Saner, 2011). Typically, international students' mobility, which corresponds to mode 2 (consumption abroad) of the General Agreement on Trade in Services (GATS), has been the main channel for educational services trade. However, long-distance education (mode 1 – cross-border supply) and the establishment of foreign branches of educational institutions (mode 3 – foreign commercial presence) are also growing.[20]

In short, demographic changes will affect trade both through their impact on comparative advantage and on patterns of demand. One might expect countries with high and rising old-age dependency ratios to switch from being net exporters to net importers of capital-intensive goods or to experience an erosion of their comparative advantage in labour-intensive manufactured goods. Ageing is also likely to be associated with a relative increase in the demand for goods and services that are disproportionately consumed by older groups of the population. The emergence of a global middle class will also have an impact on the composition of global demand. The growing number of relatively wealthy consumers in emerging and developing economies will open up new business opportunities and expand trade.

(b) Changes in labour force composition

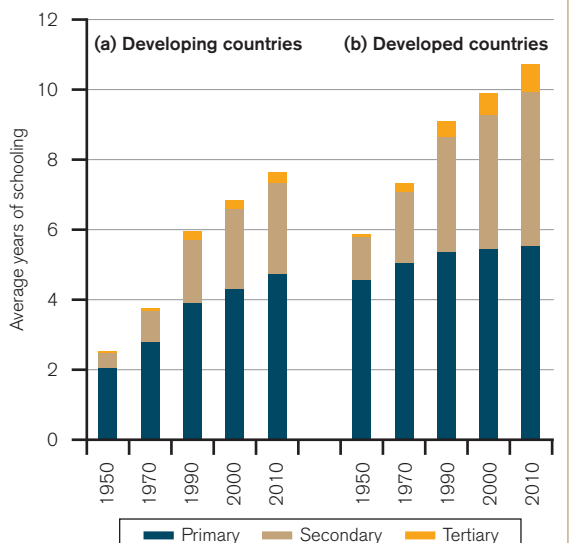
Two other notable labour force developments, both linked to the demographic transition, are likely to affect trade flows: a rising share of educated workers and increased female labour force participation. The following section examines these trends in more detail, and then explores the channels through which they can affect comparative advantage and trade patterns.

(i) Skills

Over the last 60 years, education levels have increased substantially in most countries. Using data from 146 countries, Barro and Lee (2010) show that over the period 1950-2010 the average number of years of schooling among individuals aged 15 or over increased from 2.1 to 7.1 in developing countries and from 6.2 to 11.0 in developed countries (see Figure C.7). The highest growth rates were registered in the Middle East and North Africa, Sub-Saharan Africa and South Asia.[21]

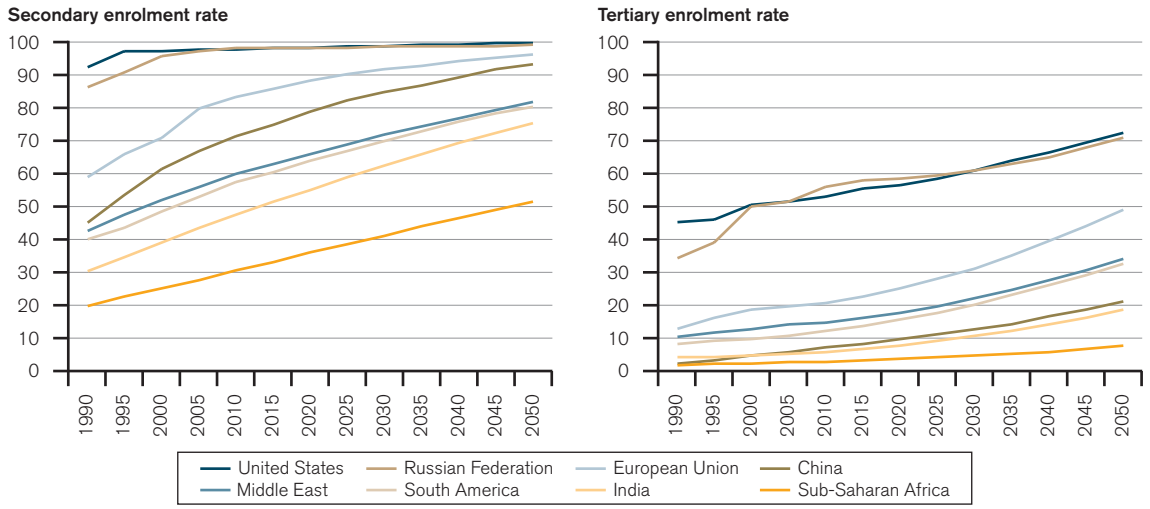
Based on the data provided by Barro and Lee (2010), Fouré et al. (2012) project future secondary and tertiary education enrolment rates for the working age population to 2050. Their projections show that the educational attainment profile of the working population will continue to increase, especially in developing countries, producing a convergence in educational levels between both developing and developed countries (see Figure C.8). The same conclusion is reached by KC et al. (2010), who also explain the underlying causes of this convergence.[22] In countries where the old-age dependency ratio is projected to increase, such as China, progress will be

Figure C.7: **Educational attainment of the total population over age 15 by country group, 1950-2010**
(years)



Source: Barro and Lee (2010).

Figure C.8: **Projections of secondary and tertiary enrolment rates, 1990-2050** (percentage)



Source: Fouré et al. (2012).

defined in terms of the composition of the working-age population. In countries where the old-age dependency ratio is projected to decrease, such as India, progress will mostly be in terms of the growing number of highly qualified people added to the potential labour force.

In addition to highlighting global educational convergence generally, these studies also reveal specific regional patterns. According to KC et al. (2010), Latin America will register the most relevant improvements in educational attainment, mainly because of the interaction between education and fertility dynamics. In several Latin American countries, increases in school enrolment preceded fertility reductions, with the result that the youngest and most educated segments of the population are also bigger. This expanding population of educated young people is found in several Asian countries, such as Nepal, Pakistan and Cambodia, and in the Middle Eastern countries, such as Jordan and the Kingdom of Saudi Arabia.

In Sub-Saharan Africa, the picture is more complex. Although education rates among 20 to 64-year-olds are expected to improve significantly, some countries, such as Ethiopia, Mali, Niger and Burkina Faso, are starting from such a low base that by 2050 large shares of the working age population (for instance, 40 per cent in the case of Ethiopia and 35 per cent in the case of Burkina Faso) will still have no education despite significant improvements in national averages (KC et al., 2010). The implication is that these countries may fall behind significantly compared with the rest of the world in terms of educational attainment of the working population by 2050.

Improving higher education enrolment rates will require substantial effort and resources, especially in countries starting from a low base and in countries where the size of the young population is projected to increase significantly (KC et al., 2010). Another crucial educational challenge is to make progress in schooling quality, which remains uneven, even among countries with a similar level of educational attainment (Barro and Lee, 2010; Hanushek and Woessmann, 2009). To ensure that there are sufficient jobs created in high population growth countries, it will also be important to match educational supply and demand by, for instance, establishing effective public-private partnerships between business and education institutions.

These educational developments are likely to affect trade patterns because of their impact on comparative advantage. According to the Heckscher-Ohlin model, countries have a comparative advantage in sectors that make more intensive use of their relatively abundant factors (see Section B.2). Several recent studies have shown that the endowment of human capital (relative to labour) is an important determinant of comparative advantage and trade patterns.[23] Building on these observations, Costinot (2009) suggests that comparative advantage is affected by workers' endowment of efficiency units of labour. When workers are more educated, they spend a smaller fraction of their time learning. Since learning costs are relatively more important in more complex sectors, a country with educated workers has a comparative advantage in more complex sectors.[24]

Comparative advantage can also be shaped by the distribution of human capital across workers. In Grossman and Maggi (2000), for instance, there can be trade between countries with similar aggregate factor endowments, provided human capital is more widely dispersed in one country than the other. The country with a relatively similar population in terms of educational levels exports the good with a production technology characterized by complementarities between workers. The country with a diverse population, in turn, exports the good whose technology is characterized by substitutability between

employees.[25] Grossman and Maggi (2000) provide some examples in support of their theory. Countries like Japan and Germany, with a pool of relatively similar workers, have a comparative advantage in industries, such as automobiles, that require care and precision in a long series of production tasks. Conversely, countries such as the United States or Italy, with a more diverse pool of workers, tend to have a comparative advantage in industries where the input of a few very talented individuals (e.g. fashion designers in the case of Italy) matters most.[26]

Demographic changes that increase overall levels of education will affect the relative endowment of productive factors and contribute through the various channels outlined above to shaping the evolution of comparative advantage and trade patterns. Developing countries, such as China, are already exporting sophisticated goods to OECD countries (Rodrik, 2006; Schott, 2008). This generates the increased overlap in the structure and in the skill content of exports from China and the high-income countries documented in Section B. This phenomenon is partly due to processing exports (contracting manufacturing for goods that are designed elsewhere) in sectors that may be labelled as high-tech industries.[27] Wang and Wei (2010), however, report evidence that improvements in human capital (together with government policies in the form of tax-favoured, high-tech zones) appear to contribute most to the growing sophistication of China's exports. Exports of skill-intensive goods to rich countries can be a source of growth for poor countries (Mattoo and Subramanian, 2009a). Integrating a larger number of skilled workers into their labour force (and adopting technologies that most improve the productivity of skilled labour) is therefore a promising option for developing countries.

(ii) Female employment

The demographic transition is also associated with changes in labour force participation rates (LFPRs).[28] These changes depend on country characteristics, such as labour market institutions and social norms, and individual characteristics, such as age and gender. Between 1980 and 2008, the global male LFPRs decreased from 82 to 77.7 per cent, mainly as a result of decreasing participation of young males who are staying longer in education. The global female LFPR grew in the 1980s from a starting point of 50.2 per cent, reached 52.2 per cent in 1990, but then declined between 1990 and 2008 to settle at 51.7 per cent (ILO, 2010). The limited increase in female LFPRs could be explained, among other things, by increased female education, which decreases the participation rate of young females.

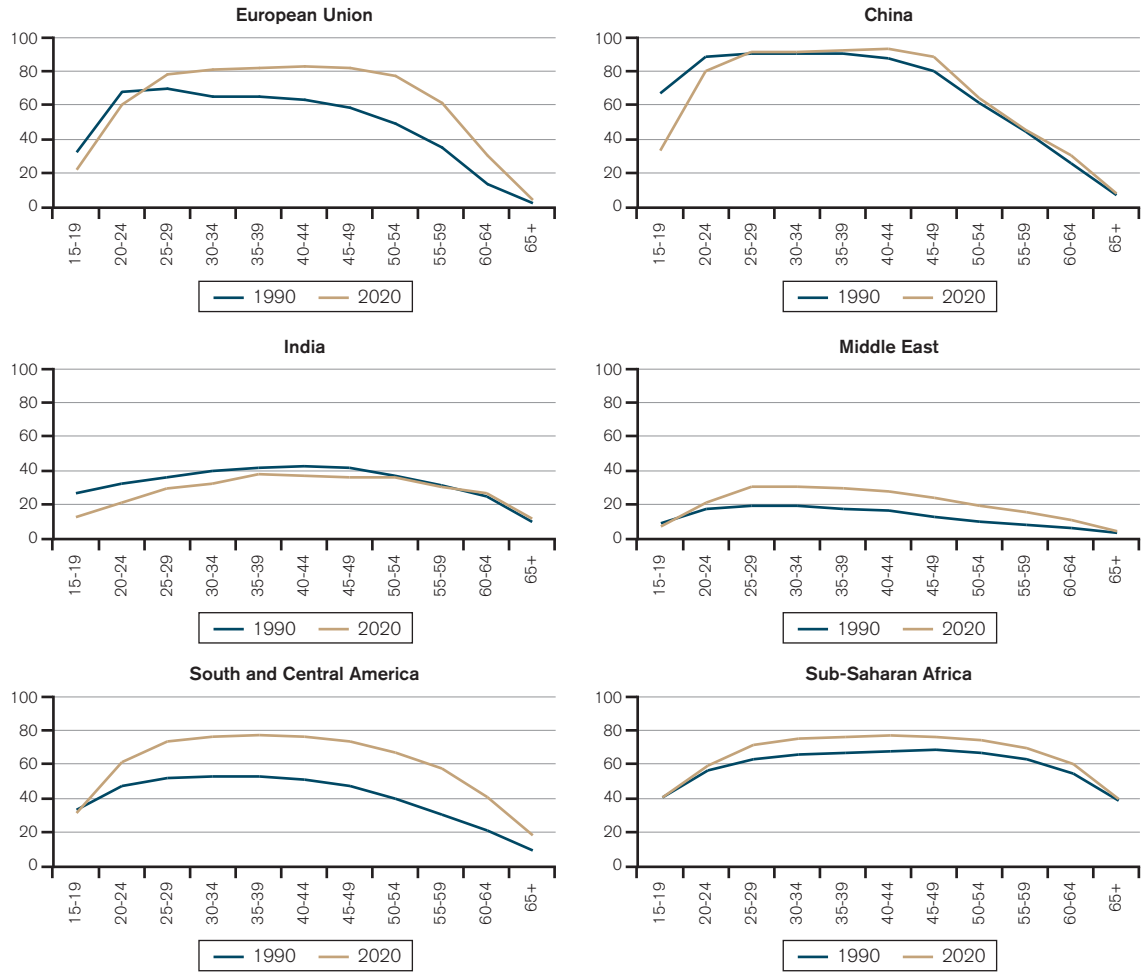
The above data show the relevance of education as a determinant of female LFPRs. Other demographic and economic factors also play a role. For instance, Galor and Weil (1996) show that technological progress and the accumulation of physical capital make labour more productive and increase the opportunity cost of raising children, with negative effects on fertility and positive effects on women's participation in the labour market.[29] Moreover, Soares and Falcão (2008) emphasize the role of increases in adult life expectancy in determining female LFPRs. In particular, reductions in adult mortality increase the returns to education for women and reduce the gains from larger families, thus reducing fertility rates and increasing women's labour market activities.

Female LFPRs are also likely to depend on the country's level of development. The relationship between the two variables seems to be U-shaped (Goldin, 1995; Mammen and Paxson, 2000). Participation rates are higher in subsistence economies. Then, at the initial stage of development, education and wages increase relatively more for men than for women. As household income increases, women reduce their labour market participation (the income effect prevails).[30] At a later development stage, there are educational gains for women as well, raising the opportunity cost of child caring and increasing female labour market participation.[31]

Besides demographic and economic factors, other important determinants of female labour market participation are access to education, religious, cultural and social norms, and the institutional framework (ILO, 2010). The impact of demographic change may be reduced or offset by cultural and social norms. For instance, analysing the determinants of female LFPR in a sample of 160 countries between 1960 and 2008, Tsani et al. (2012) found that, all things being equal, Southern Mediterranean countries have significantly lower female LFPRs than other countries. The authors suggest that these results may reflect region-specific social or institutional factors that act as barriers to women's participation in the labour market.

Figure C.9 shows past and projected data (for 1990 and 2020, respectively) on female LFPRs for selected countries and regions. The data highlight some interesting patterns, which can be explained by the demographic, economic and cultural factors outlined above. In the European Union, China and India, there will be considerable reduction in LFPRs of young women which is mainly the result of increased school attendance.[32] Moreover, in the European Union there will be an increase in LFPR in more mature segments of the female labour force. This is mainly related to increased life expectancy, higher retirement ages and the introduction of age and gender anti-discrimination laws (Jaumotte, 2003). Conversely, LFPRs of the more mature segments of the female population are projected to increase only slightly in the case of China. In India, female LFPRs are expected to decrease for virtually all age groups. Several factors may explain these

Figure C.9: **Women's labour force participation rates in selected economies, 1990 and 2020** (percentage and age group)



Source: ILO, *Economically Active Population, Estimates and Projections* (EAPEP), 2011.

projections. First, continued economic development will lead to lower participation by women in low-income households.[33] Secondly, the specific characteristics of India's process of economic growth in the last decade imply that increases in labour productivity growth are associated with reductions in employment growth (ILO, 2012). Thirdly, according to Kingdon and Unni (2001), specific cultural and social norms, according to which women's labour is less socially acceptable in higher caste, may reduce LFPRs of women with intermediate levels of education.

Cultural and social norms may also explain the low LFPRs currently observed – and projected to continue in the future – in the Middle East (ILO, 2012).[34] Conversely, South and Central American countries will experience significant increases in LFPRs for all age groups. This increase is associated with the favourable demographic trends outlined above, especially lower fertility rates. In Sub-Saharan Africa, participation is also increasing, mainly driven by increases in the working-age population. However, Figure C.9 shows that female LFPRs were already high in 1990, reflecting the fact that several countries in the region were at a very low level of economic development.

Women's increasing labour force participation can be a source of comparative advantage if women are disproportionately employed in particular sectors. In most developing countries, female employment is concentrated in labour-intensive exports. UNCTAD (2004) reports that women's participation in export industries such as textiles, clothing, pharmaceuticals, food processing, electronics and toy production averages between 53 per cent and 90 per cent of the labour force in African, Asian and Latin American developing countries. In South-East Asia, key export industries such as textiles and electronics relied heavily on relatively unskilled, but generally literate, women (Korinek, 2005). Between 1970 and 1995, women's share in the labour force in Indonesia, Malaysia and Singapore grew from between 26-31 per cent to 37-40 per cent. In the Republic of Korea, the share of working women in regular paid work increased from 65 per cent in 1965 to 81 per cent in 1992, and in mining and manufacturing the female to male

employment ratio rose from 0.37 to 0.68 (World Bank, 2001).[35]

Busse and Spielmann (2006) is the only empirical study that analyses the effect of various measures of gender inequality on comparative advantage. Using panel data from 29 countries over six separate years (1975, 1980, 1985, 1990, 1995 and 2000), they show that a reduction in inequality in labour force participation (i.e. higher shares of female to male labour market activity or a higher female participation rate) is associated with an improvement in the comparative advantage of labour-intensive sectors.[36] The relationship, however, loses statistical significance when high-income countries are excluded from the sample. This is surprising since, as noted above, it is especially in most developing countries that women are disproportionately employed in labour-intensive exports.

In many developing countries, women's increased labour force participation is likely to be accompanied by higher education. KC et al. (2010) report that countries such as Chile, China and South Africa often reach near universal secondary school attainment among women aged 20-39 by 2050. In India and Pakistan, secondary school attainment among women aged 20-39 is projected to increase from around 40 per cent in 2010 to more than 80 per cent in 2050. From a theoretical perspective, a reduced gender bias in educational attainment (a measure of decreasing gender inequality) may positively or negatively affect comparative advantage in labour-intensive goods. The empirical results of Busse and Spielmann (2006) indicate that a reduction in inequality in access to education (i.e. higher female literacy rates relative to male or higher female school enrolment) is associated with an improved comparative advantage in labour-intensive sectors.

However, the causal link could run in both directions. As shown by Vijaya (2003), in some developing countries, trade-related employment can lessen women's incentives to invest in higher education compared with men. Therefore, existing gender gaps in education may be reinforced and even widened by greater trade openness. The explanation for this finding is that the demand for female labour remains concentrated in low-skilled jobs, possibly because discrimination closes off other higher-skilled opportunities, thus reducing the incentive to invest in higher education.[37] However, a reduction in discrimination would give women better access to more skill-intensive occupations which would in turn shift comparative advantage from labour-intensive to skill-intensive sectors.

In conclusion, both the rising share of educated workers and increased female labour force participation have an impact on comparative advantage. In particular, a more educated workforce increases the skill content and the sophistication of exports, which has been an important source of growth for a number of developing countries, especially in East Asia. It is hoped that other developing countries, especially in Africa, will also be able to reap the trade-related benefits of increased education in the future. Labour force participation of women is intimately connected with falling fertility rates and rising life expectancy, but also with increased educational opportunities. Inclusive female labour force participation has effects on comparative advantage, can positively affect import demand and can be a source of welfare gains.

(c) Migration

International migration has an important impact on demographic change. It can influence population growth directly by adding to or subtracting from the population (both for the source and host countries) and indirectly by affecting fertility rates (United Nations, 2011a). Moreover, international migrants tend to be a unique population group in terms of age and education. This section suggests that international migration can affect patterns of comparative advantage by shifting the education and age profile of both source and host countries. This section also reviews the theoretical and empirical literature on the relationship of substitutability or complementarity between trade and migration. Finally, it considers the trade effects of urbanization, which is a consequence, among other things, of internal migration.

The global stock of international migrants grew by 38 per cent from 1990 to 2010. However, international migrants still constitute a very small fraction of the world population, just 3.1 per cent (213.9 million) in 2010. Migrants are concentrated in a few receiving countries: in 2010, ten countries hosted more than half of the global international migrants' stock.[38] The majority of international migrants reside in Europe, Asia and Northern America. Oceania and Northern America had the highest percentage of migrants relative to total population in 2010 (see Table C.1).[39]

Migration is overwhelmingly from less developed to more developed countries and regions. From 1990 to 2010, the migrant stock residing in the North (Europe and Northern America plus Australia, New Zealand and Japan) but born in the South (all other countries and regions) increased by 85 per cent, more than twice as fast as the global migrant stock (38 per cent) (United Nations, 2012a).

In traditional destinations for immigration, such as Australia, Canada, New Zealand and the United States, migrant inflows increased significantly between 1980 and 2008.[40] However, the growth rate was erratic and highly influenced by changes in immigration policies.[41] In the United States, the main host country for the world's migrants, about 1.1 million permanent residence permits were issued between 2005 and 2010 (United Nations, 2011a). Immigrants to the United States mainly originate from Asia and from

Table C.1: **International migrants by region (stocks), 1990-2010**
(millions and percentage)

	Number of international migrants (millions)			International migrants as percentage of the population		
	1990	2000	2010	1990	2000	2010
World	155.5	178.5	213.9	2.9	2.9	3.1
More developed regions	82.4	104.4	127.7	7.2	8.7	10.3
Less developed regions	73.2	74.1	86.2	1.8	1.5	1.5
Africa	16	17.1	19.3	2.5	2.1	1.9
Asia	50.9	51.9	61.3	1.6	1.4	1.5
Europe	49.4	57.6	69.8	6.9	7.9	9.5
Latin America and the Caribbean	7.1	6.5	7.5	1.6	1.2	1.3
Northern America	27.8	40.4	50	9.8	12.7	14.2
Oceania	4.4	5	6	16.2	16.1	16.8

Source: United Nations Population Division, World Migrant Stock database.

Note: For the definition of regions, see http://esa.un.org/MigAge/index.asp?panel=3.

Latin America and the Caribbean (with both regions accounting for 40 per cent of the total immigrant inflows in 2010). Mexico and China account for 13 and 7 per cent of the 2010 inflows, respectively. Asia also represents the main region of origin of migrants to Australia (share of 60 per cent of the total immigrant inflows in 2008) and Canada (share of 58 per cent of the total immigrant inflow in 2009). In Europe, Germany represents the main destination for Central and Eastern European migrants, especially after the enlargement of the European Union in 2004 and 2007.[42] The majority of immigrants to European countries in the period 2000-08 came from other countries in Europe. However, for some European host countries, such as France, the United Kingdom and Spain, immigrants mainly came from developing

Box C.1: **Has migration become more regionalized?**

One of the trends documented in Section B of this report is the increased regionalization of merchandise trade flows. Does a similar pattern emerge for migration? Answering this question is not easy due to severe data limitations. In Figure C.10, historical data on migrants' stocks compiled by the World Bank are used for the years 1990 and 2000.[43] Some interesting facts emerge.

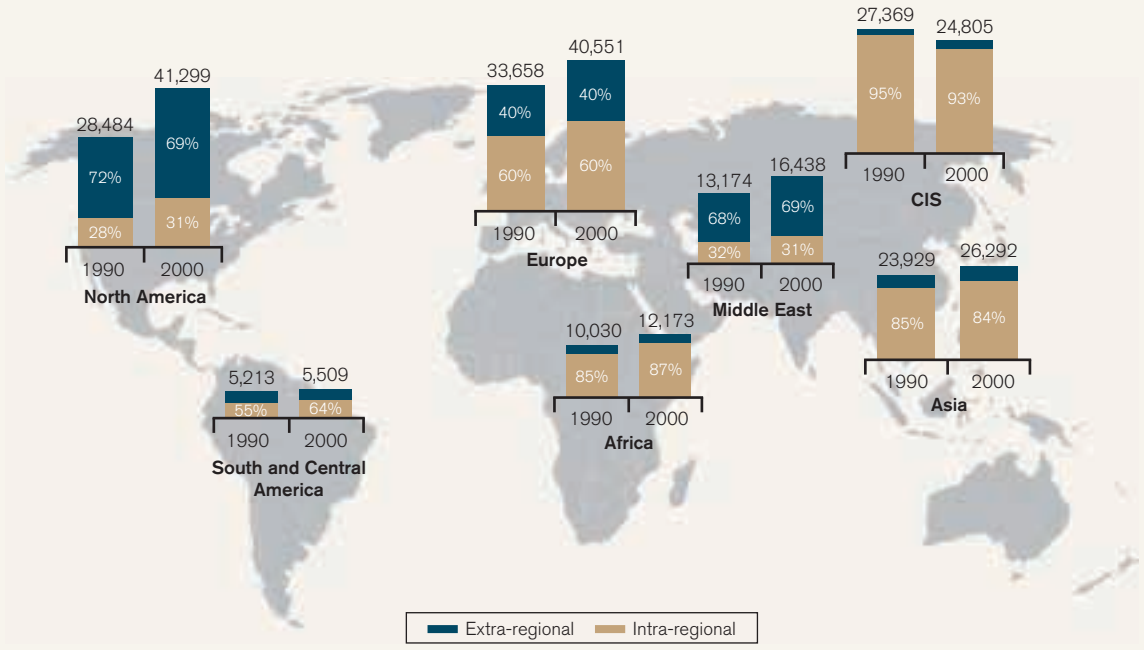
First, migrants from African, Asian and Commonwealth of Independent States (CIS) countries predominantly reside in their respective region of origin. Conversely, the majority of migrants residing in North America and in the Middle East come from countries outside the region. Europe falls between the two, with a share of about 60 per cent of migrants coming from within Europe.

Secondly, between 1990 and 2000, the share of intra-regional migrants increased significantly in South and Central America (from 55 to 64 per cent), and to a minor extent in North America (from 28 to 31 per cent) and Africa (from 85 to 87 per cent). Conversely, this share remained stable in Europe, and it slightly decreased in all other regions (from 32 to 31 per cent in the Middle East; from 95 to 93 per cent in CIS countries; from 85 to 84 per cent in Asia).

The high shares of intra-regional migration in Africa, Asia and the CIS can be explained mainly by movements across the borders of neighbouring states. According to Ratha and Shaw (2007), this geographically limited cross-border migration accounted for 80 per cent of the South-South migrants' stock in 2007. The same study also shows that migrants from Burkina Faso to neighbouring Côte d'Ivoire account for the highest share of South-South migrants in Africa, while migrants from Bangladesh to India represent the highest share of South-South migrants in South Asia. In the CIS region, migrants mainly move between the Russian Federation and Ukraine and between the Russian Federation and Kazakhstan. Other countries with high levels of cross-border migration are South Africa, which is the main destination for migrants from Lesotho, Mozambique and Zimbabwe, and Thailand, which is the main destination for migrants from Cambodia, Lao PDR and Myanmar (IOM, 2008).

The relevance of cross-border migration among developing countries reflects low levels of wealth and education of the population at origin, which limit individuals' and households' ability to afford long-distance migration. Since it is mainly short-distance and temporary, cross-border migration can be equated with internal migration.

Figure C.10: **Intra-regional and extra-regional migrants (stocks), 1990 and 2000** (thousands and percentage)



Source: World Bank *Global Bilateral Migration Database* (GBMD).

Note: Graphs for regions are shown to scale, with the exception of South and Central America and Africa, which share a different scale. Colours and boundaries do not imply any judgment on the part of WTO as to the legal status of any frontier or territory.

However, since it takes place between areas with relatively similar income levels, cross-border migration is likely to be driven more by the desire to reduce risk and diversify income rather than by geographical income differences (Ratha and Shaw, 2007).[44]

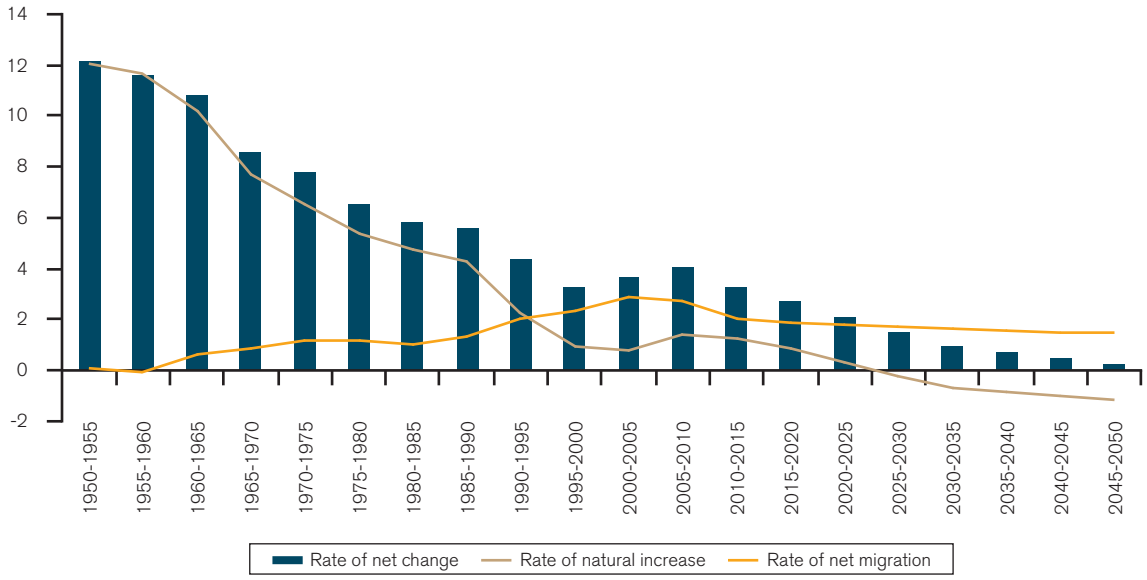
Institutional factors, such as the presence of preferential trade agreements (PTAs) or regional consultative processes (RCPs) on migration, may also help to explain patterns of intra-regional versus extra-regional migration.[45] A recent study by Orefice (2012) shows that PTAs have been a determinant of migration inflows for 29 OECD countries in the period 1998-2008. In particular, visa-and-asylum and labour market related provisions, when included in PTAs, stimulate bilateral migration flows. In this study, however, no distinction is made between intra- and cross-regional PTAs because of data limitations. In the future, more research should be conducted, with the aim of discerning the effects of institutional factors on intra- versus extra-regional migration.

regions.[46] A more detailed analysis of migration patterns within regions (intra-regional) and across regions (extra-regional) is presented in Box C.1.

As argued above, migration can directly influence population growth by adding to or subtracting from the population of the countries concerned. Fifty years ago, the impact of net migration on overall population growth was negligible in virtually all countries and regions. More recently, net migration has become more important to developed countries due to low fertility rates. As shown in Figure C.11, by 1990-2000 net migration was already the main driver of population growth in developed countries.[47] This trend will continue in the future. From 2010 to 2050, the net number of international migrants moving to more developed regions is projected to be 87 million. Since it is projected that deaths will exceed births by 11 million, the overall population growth will be 76 million. From 2050 to 2100, the net number of international migrants moving to more developed regions is projected to be 49 million. Given an excess of deaths over births of 24 million, this will result in an overall growth of 25 million (United Nations, 2011b).

Migration also impacts population change indirectly by influencing fertility rates in the country of origin and in the host country. However, recent evidence suggests that migrants adapt over time to the host country's fertility norms (Kulu, 2005).[48] Thus, any positive impact on host-country fertility that international migration from high- to low-fertility countries might have is likely to be temporary. Migrants' adaptation to the host country's norms affects fertility levels in the country of origin as well because the fertility norms of the host country are, to a certain degree, transferred

Figure C.11: **Contribution of natural increase and net migration to net population change in developed countries, 1950-55 to 2045-50**
(percentage)



Source: United Nations Population Division, *World Population Prospects: The 2010 Revision database.*

back to the country of origin. For instance, Bertoli and Marchetta (2012) show that Egyptian couples have a significantly higher number of children when the husband returns to his home country after having been a migrant in a high-fertility Arab country. Moreover, migration's impact on fertility rates is not limited to migrants and their households but can spill over to the wider population in the country of origin. Using macro-level data for about 150 host countries in 2000, Beine et al. (2012) estimate that a 1 per cent decrease in the fertility level in the host country reduces fertility rates in the country of origin by 0.3 per cent.

Migrants are generally younger than the native population. For instance, the median age of immigrants in EU member states in 2009 ranged from 24.9 years (in Portugal) to 33.7 years (in Latvia), relative to a median age of the EU-27 population of 40.9 years.[49] More importantly, individuals of working age are over-represented among international migrants, as Figure C.12 shows for EU member states.[50]

Accordingly, migration is projected to reduce dependency ratios in a number of economies, as indicated by Table C.2.[51] The impact of migration is very noticeable in oil-exporting Middle Eastern countries, such as the United Arab Emirates, Qatar and the State of Kuwait but it is also noticeable in Hong Kong (China), Switzerland and southern European countries. However, notwithstanding a relatively greater impact in certain economies, the overall impact of migration on the age structure of the world population is likely to be modest, especially in countries where the ageing process is most advanced, such as Japan. The United Nations (2011a) concludes that migration cannot reverse the trend of population ageing.

The impact of migration on the origin and host countries crucially depends on the skills distribution between migrants and the native population. Table C.3 provides a comparison between the education structure of the native population and immigrants in OECD destinations. The last row of the table shows that, between 1990 and 2000, on average, immigrants are more educated than the native population. Thus, immigration is associated with a net "brain gain" in host countries. However, there are significant differences across countries. For instance, immigrants are more skilled than the native population in countries where the nationals' education level is low (such as Mexico and Turkey) or in countries where the immigration policy favours the entry of highly educated individuals (such as Australia, Canada and New Zealand). In contrast, immigrants are less skilled than the native population in countries where the nationals' level of education is high, such as the United States and France.

Table C.3 also shows that during the period 1990-2000 the overall share of high-skill immigrants to OECD countries increased from 30 to 35 per cent. In the same period, the number of high-skill immigrants increased by 64 per cent (from 12.6 to 20.7 million), while the number of low-skill immigrants increased by 22 per cent (from 20.1 to 25.7 million). However, most immigrants to OECD countries are medium- or low-skilled individuals (Docquier et al., 2009). As underlined by Widmaier and Dumont (2011), this is largely explained by labour needs in the so-called "3D job" sector (dirty, dangerous, difficult) and low-wage sectors, such as agriculture, construction and domestic services. Here, too, there is significant heterogeneity across OECD countries. In southern Europe, migrants are mainly low-skilled, while in Canada, Australia and New Zealand, migrants are mostly highly educated.

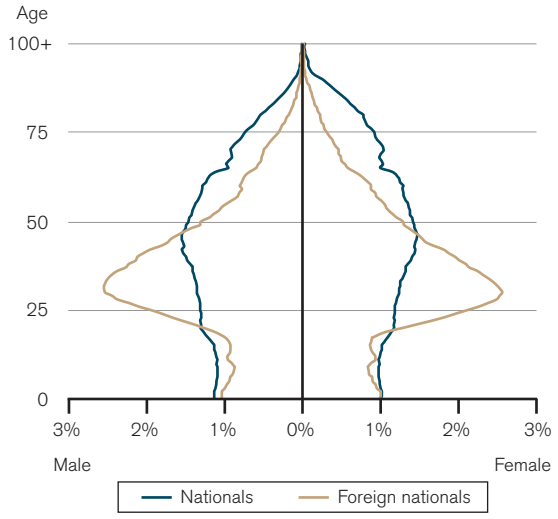
The emigration of skilled individuals ("brain drain") has long been a policy concern in their countries of origin (see the discussion in Docquier and Rapoport, 2012). Table C.4 shows data on the stock on high-skilled emigrants and high-skill emigration rates by region for the years 1990 and 2000. The table shows that, unlike high-skill emigration stocks, high-skill emigration rates remained fairly stable over this period.[52] In both years, there is considerable variation across countries within regions.

For instance, within East Asia and the Pacific, the rate is 3 per cent in Australia but rises to 15 per cent in South-eastern Asia and to about 47 per cent in the Pacific Islands. Within South and Central America, the rate ranges from 18 per cent in South America to 27 per cent in Central America to 65 per cent in the Caribbean (in this sub-region, the countries with the highest skilled emigration rates are Jamaica and Haiti, with rates of 85 and 83 per cent, respectively). Some African countries are also characterized by skilled emigration rates that are significantly higher than the regional average. This is the case for Gambia (68 per cent), Sierra Leone (49 per cent), Ghana (45 per cent) and Kenya (40 per cent) among others.[53] Whether the emigration of skilled individuals is harmful or beneficial for the countries of origin is a question that will be analysed in more detail below.

(i) Migration and trade

Labour migration can have distinct short- and long-run effects in the host country.[54] The short-run effects can best be understood in a specific-factor framework. Consider an economy with two sectors, agriculture

Figure C.12: **Age structure of the national and non-national populations, EU, 2010** (percentage)



Source: Eurostat, Migration and migrant population statistics.

Note: The age distribution is based on the aggregate of all EU member states. All migrants, both from EU and non-EU member states, are considered as foreign nationals.

Table C.2: **Countries with the greatest increase in dependency ratio under zero-migration scenario, 2050**

Rank	Country	Dependency ratio in 2010	Dependency ratio in 2050	
			Medium variant	Zero-migration scenario
1	United Arab Emirates	25	37	104
2	Qatar	20	38	95
3	Hong Kong, China	32	78	108
4	Kuwait, the State of	34	57	79
5	Switzerland	48	72	88
6	Spain	47	87	98
7	Canada	44	70	80
8	Greece	48	82	92
9	Austria	48	77	86
10	Italy	53	88	96

Source: United Nations (2011a).

and manufacturing, and three factors of production: labour, land and capital. Labour is mobile across sectors, while land and capital are specific to the agricultural and to the manufacturing sector, respectively. At constant relative prices, an increase in the endowment of labour (due to immigration) results in an increase in the output of both sectors because more workers are employed.[55] Since capital and land cannot move between sectors, labour intensity (the amount of labour relative to the amount of the specific factor) in production increases in both sectors, leading to a fall in wage rates (under the assumption that markets are perfectly competitive and workers are paid their marginal productivity). Since the output of both sectors increases symmetrically, there is no change in the overall composition of output and on comparative advantage.

The long-run effects of immigration, however, are different due to the inter-sectoral mobility of production factors. Consider an economy with two sectors, shoes and computers, and two factors of production: labour and capital. Both factors can freely move across sectors, and the shoe sector is relatively more labour intensive than the computer sector. The Rybczynski theorem predicts that, at constant relative prices, an increase in the endowment of labour due to immigration will lead to an increase in the output of shoes and to a decrease in the output of computers. The logic is the following: in the long run, the capital-labour ratio will remain unchanged in both sectors. Therefore, not only will the additional labour be entirely absorbed by the shoe sector, but there will also be some reallocation of labour and capital from the computer to the shoe sector. Therefore, production in the shoe sector will expand while production in the computer sector will contract.[56] If the host country enjoyed a comparative advantage in the shoe sector, this comparative advantage will be strengthened. If,

Table C.3: **Percentage of high-skill immigrants and nationals in OECD countries, 1990-2000**

	1990			2000		
	Percentage of high skill among natives	Percentage of high skill among immigrants	Ratio immigrants/ natives	Percentage of high skill among natives	Percentage of high skill among immigrants	Ratio immigrants/ natives
Australia	31.1%	34.6%	1.11	34.0%	40.3%	1.19
Austria	11.2%	8.4%	0.75	14.4%	12.7%	0.88
Belgium	20.8%	12.7%	0.61	27.5%	19.8%	0.72
Canada	43.8%	50.7%	1.16	51.5%	58.8%	1.14
Czech Republic	8.5%	5.6%	0.66	10.8%	11.5%	1.06
Denmark	19.6%	13.8%	0.71	21.6%	17.3%	0.80
Finland	20.2%	16.0%	0.79	26.3%	23.8%	0.91
France	21.9%	9.9%	0.45	21.9%	16.4%	0.75
Germany	21.8%	16.9%	0.78	25.5%	21.8%	0.85
Greece	10.9%	15.1%	1.39	15.2%	15.0%	0.99
Hungary	10.1%	7.6%	0.75	12.0%	11.6%	0.97
Iceland	11.0%	24.0%	2.17	15.5%	31.4%	2.02
Ireland	14.6%	26.5%	1.82	19.4%	41.1%	2.12
Italy	6.3%	15.4%	2.45	8.7%	15.4%	1.78
Japan	21.2%	22.5%	1.06	24.0%	28.1%	1.17
Korea, Republic of	13.4%	33.1%	2.48	25.8%	38.1%	1.48
Luxembourg	20.8%	17.1%	0.82	27.5%	21.7%	0.79
Mexico	9.1%	33.8%	3.70	11.2%	44.9%	3.99
Netherlands	16.2%	17.3%	1.07	22.0%	22.0%	1.00
New Zealand	23.3%	43.6%	1.87	25.9%	40.9%	1.58
Norway	15.7%	25.2%	1.60	21.8%	28.7%	1.32
Poland	7.9%	12.0%	1.53	11.1%	14.0%	1.26
Portugal	6.5%	20.1%	3.08	8.8%	18.6%	2.10
Slovak Republic	9.5%	7.7%	0.81	11.6%	15.2%	1.31
South Africa	3.8%	16.0%	4.27	10.3%	22.0%	2.13
Spain	9.5%	16.7%	1.76	12.2%	18.5%	1.51
Sweden	20.5%	17.7%	0.86	27.5%	25.7%	0.93
Switzerland	17.2%	15.1%	0.88	17.2%	18.6%	1.08
Turkey	5.0%	11.4%	2.30	8.5%	21.5%	2.54
United Kingdom	13.9%	20.3%	1.46	17.8%	34.9%	1.96
United States	39.2%	41.2%	1.05	51.3%	42.7%	0.83
OECD	21.6%	29.7%	1.37	27.1%	34.8%	1.29

Source: Docquier et al. (2009).

however, its comparative advantage was in the computer sector, this will be weakened and possibly reversed by immigration.

The example can be slightly modified to understand the effects of skill-biased migration. If the composition of migrants is relatively more skilled, in the short run the wage rate of skilled labour will decrease, while in the long run the output of skilled labour-intensive sectors will increase at the expense of unskilled labour-intensive sectors. The same logic holds when immigrants are unskilled. Empirical research on adjustment at the quantity margin is limited but the few existing studies confirm the theoretical predictions. Hanson and Slaughter (2002), for instance, document the rapid growth in apparel, textiles, food products and

Table C.4: **High-skill emigrant stocks and emigration rates by region, 1990 and 2000**

	1990		2000	
	Stock of high-skill emigrants (thousands)	High-skill emigration rate	Stock of high-skill emigrants (thousands)	High-skill emigration rate
Africa	742	11.5%	1,407	10.6%
Asia	3,349	4.9%	6,304	5.7%
Commonwealth of Independent States (CIS)	226	1.0%	681	2.0%
Europe	4,843	9.2%	6,535	9.2%
Middle East	479	12.3%	769	9.8%
North America	1,085	1.4%	1,900	1.7%
South and Central America	1,559	10.0%	2,735	10.1%

Source: Docquier et al. (2009).

Note: For a given region, the high-skill emigration rate is defined as the share of highly educated emigrants from the region in the total of highly educated emigrants and natives of the region.

other labour-intensive industries in California after the arrival of relatively low-skilled Mexican migrants.[57]

A closely related question is whether trade and migration are substitutes or complements. The general presumption is that they are substitutes, as predicted by the standard Heckscher-Ohlin-Samuelson (HOS) trade model. Consider the case of two countries, two goods and two factors. As shown by Mundell (1957), there is a one-to-one relationship between relative commodity prices and relative factor prices. This relationship is identical for both countries due to the assumption of equal technology. If, due to free trade, commodity prices are equalized, then factor prices are also equalized. By the same token, if, due to free factor mobility, factor prices are equalized, then commodity prices are also equalized. These factor prices and commodity prices must be the same as in the case of free trade.[58] Therefore, trade and immigration are substitutes.

As one moves away from the assumptions that define the HOS model, however, the nature of the relationship easily changes, and trade and factor mobility can be complements. Gaston and Nelson (2013) introduce a slight modification of the example discussed above, where the host country has a superior technology in the production of the labour-intensive good. This technological superiority gives rise to a comparative advantage in the labour-intensive good (for a given wage-rental, the autarky price of this good is lower in the host than in the foreign country). If, due to free trade, commodity prices are equalized, the wage-rental in the host country will exceed the wage rental in the foreign country. This will provide an incentive to migrate from the foreign to the host country. If such migration is allowed, labour will flow to the host country, increasing its comparative advantage in the labour-intensive good through Rybczynski effects. Migration is, therefore, complementary to trade. Suppose now that, due to free factor mobility, factor prices are equalized. The relative price of the labour-intensive good will be lower in the host country than abroad. If trade is allowed, production will increase in the comparative advantage good. Migration is, therefore, complementary to trade.[59]

Ultimately, it is an empirical question whether trade and migration are substitutes or complements. Most of the empirical evidence points towards complementarity. Using data for the United States from 1948 to 1983, Wong (1988) finds that trade is a quantity complement to immigration. Using UK data for the period 1975-96, Hijzen and Wright (2010) show that skilled immigrants are quantity complements with trade. Unskilled workers are quantity substitutes but the result is statistically insignificant.[60] The large literature on the effects of migrant networks on trade (see Box C.2), while not providing a rigorous test based on general equilibrium models, also points towards complementarity between migration and trade. The policy implication is that restrictive immigration policies may not only restrict migration flows but also trade flows.

Immigration is not only a labour supply shock; it also affects total factor productivity and consequently international trade. Peri (2012) offers convincing evidence that immigration to the United States has a positive effect on total factor productivity and a negative effect on the skill-bias of production technologies (i.e. it promotes the adoption of unskilled-efficient technologies). These effects can be jointly explained by two mechanisms.

First, Acemoglu's (2002) theory of directed technical change predicts that the availability of a production

Box C.2: **Migrant networks and trade**

The presence of migrant networks can promote trade between their origin and host countries in at least two ways. First, they might help overcome informational barriers to international trade related to language, culture or institutions, facilitate the creation of business relationships and make valuable information on foreign sales and sourcing opportunities more readily available. Secondly, migrants boost trade if they derive higher utility from goods produced in their host countries. Felbermayr and Toubal (2012) refer to the first channel as the trade-cost channel and to the second as the preference channel.[61]

Since the seminal contribution of Gould (1994), several studies have tried to quantify the positive association between immigration and trade.[62] The "business and social network effect" of immigrants received large empirical support (see, for instance, Rauch and Trindade, 2002). In a recent paper, Aleksynska and Peri (2012) examine, as a measure of the trade business network of immigrants, the share of immigrants in managerial/sales jobs. Such immigrants are pivotal to establishing important business connections. The share of migrants in business network occupations has a large and significant effect on exports (but much less on imports), in line with previous studies. Specifically, each business network immigrant generates over ten times the value of trade as a non-business network immigrant does. Aleksynska and Peri (2012) show that business networks are especially trade-enhancing in the case of trade in differentiated goods and for trade between countries with different legal systems, while cultural similarities (linguistic, colonial origin) attenuate the effect of business networks on trade.[63]

The link between immigration and trade through networks is also affected by the composition of the immigrant base, as recently argued by Egger et al. (2012). Highly concentrated skilled or unskilled migrants produce higher trade volumes than a balanced composition of the immigrant base. This can be explained by the fact that immigrants form stronger networks within the same skill group than across skill groups. They also find evidence that a polarization of migrants (regardless of whether they are skilled or unskilled) tends to produce more trade in differentiated goods relative to non-differentiated goods. That is, the knowledge-creation effect of migrant networks is stronger when such networks are polarized.

Migrant networks (in particular, networks of graduate students) can also have a more indirect effect on trade, through the diffusion of similar political ideas. For instance, Spilimbergo (2009) finds a positive correlation between political systems in a country of origin and in the countries in which emigrant students have studied. Since forms of government and trade may be correlated (Yu, 2010; see Section C.6 for more details), migrant networks can also indirectly affect trade through their impact on political systems.

Until recently, evidence regarding the role of the preference channel has been scant. The early literature assumed the importance of such a channel because of the difference between the immigrant elasticity of imports and the immigrant elasticity of exports – given that the trade cost channel affects both imports and exports, while the preference channel only affects the exports. Of late, additional evidence has emerged.

Bronnenberg et al. (2012) show that US internal migrants tend to consume according to the prevalent choices in the state of origin. The same evidence is found for India by Atkin (2010), who shows that inter-state migrants carry their food tastes with them, consuming food less similar to that consumed in their host state and more similar to that consumed in their state of origin. Finally, Mazzolari and Neumark (2012) show that immigration is associated with increased ethnic diversity of restaurants in California, partly because immigrants are consumers with potentially different demand characteristics, and partly because they have a comparative advantage in the production of ethnic food from their country of origin.

factor induces firms to adopt technologies that are more efficient and intensive in the use of that factor.[64] Secondly, Peri and Sparber (2009) show that immigration can drive specialization according to comparative advantage at the task level. They assert that native workers and immigrants are imperfect substitutes in production, even if they have similar (limited) educational attainments. Since immigrants are likely to have imperfect communication skills, but manual skills similar to those of native workers, they have a comparative advantage in occupations requiring manual labour, while less educated native workers have a comparative advantage in occupations demanding communication skills. Immigration, therefore, encourages workers to specialize, with consequent productivity gains. Peri and Sparber (2009) offer empirical support for this hypothesis, using US data. Their main conclusion is that, due to specialization in

different tasks, even less educated native workers may not see adverse wage consequences from low-skill immigration.

Immigration also impacts innovation in host countries. As noted above, the share of highly skilled migrants in the total number of migrants to OECD countries has increased dramatically over the last two decades. In the United States between 1995 and 2006, 67 per cent of the net increased number of scientists and engineers (almost half a million workers) was foreign-born.[65] High-skilled migration can also contribute to technological progress through increased patenting, thus helping to develop or to strengthen comparative advantage in technology-intensive sectors. Empirical evidence based on US and EU data supports this idea.[66] At the same time, however, there is evidence to suggest that immigration appears to disrupt the schooling of the native population in some host countries.[67]

In countries of origin, migration has important effects on the incentives to accumulate human capital, which in turn affects patterns of comparative advantage. As discussed above, well-educated people in certain developing countries are particularly likely to emigrate. This is especially the case in certain middle-income economies where people have both the incentives and the means to emigrate (Docquier and Rapoport, 2012). Traditionally, this type of migration has been viewed as detrimental to the country of origin because of the positive spill-over effects associated with learning.[68] However, in certain circumstances it is also possible that emigration results in a net increase in the supply of human capital in countries of origin, creating a net "brain gain". As first explained by Stark and Wang (2002), this is because the prospect of emigrating increases the returns to schooling, and therefore the incentive to investment in human capital formation. However, if only a fraction of potential migrants manage to emigrate, the result is a net increase in human capital in the country of origin.

Beine et al. (2001) show that accumulation of additional human capital in the country of origin can more than compensate for the loss in skill due to migrant outflows.[69] Recently, others have argued that an increase in the possibility of migration might not only affect the level but also the composition of human capital by encouraging a shift away from rent-seeking activities, which are less conducive to emigration, towards entrepreneurial ones, which are more conducive to emigration (Mariani, 2007). The migration of educated individuals can also imply beneficial transfer of knowledge, because migrants come back to their home countries to visit, to establish dual residence, to start businesses and universities, and, sometimes, to stay (return migration). These people bring back new ideas and skills, which are crucial ingredients to economic growth (Freschi, 2010; Nyarko and Easterly, 2009; *The Economist*, 2011).[70]

As argued above, migration can change fertility decisions in both source and host countries. Mountford and Rapoport (2011) propose a theoretical framework in which skilled migration, investment in education and fertility are analysed together. In the host country, skilled migration will have the static effect of reducing the proportion of individuals who choose to become skilled workers (because the equilibrium wage of skilled workers decreases), which will in turn increase the fertility rate. The dynamic effect is the opposite. Intuitively, the proportion of skilled labour in the economy will increase as a result of skilled immigration, which will in turn raise the growth rate and eventually lead to a reduction in fertility. If the dynamic effect prevails, the host country will accumulate human capital and have a lower fertility rate (and vice versa if the static effect prevails). In the country of origin, there is human capital accumulation due to the brain drain effect (the possibility of emigration increases the incentive to accumulate human capital, which more than compensates for the loss in human capital due to emigration). This accumulation of human capital leads to a decrease in the fertility rate.[71]

(ii) Urbanization and trade

Urbanization is one of the most important global demographic trends. As shown in Table C.5, the rate of urbanization increased by 77 per cent over the last six decades, rising from 29.6 per cent (0.75 billion people) of the global population in 1950 to 52.1 per cent (3.6 billion) in 2011. Urbanization is expected to rise further to 67.1 per cent in 2050. Developed regions are expected to see their level of urbanization increase from 77.4 to 86.3 per cent over the same period. In less developed regions, the urbanization rate is projected to increase from 46.6 per cent in 2011 to 64.1 per cent in 2050. In both groups of countries, urban areas will account for all expected population growth. Consequently, world rural population will decline by about 0.3 million by 2050 (United Nations, 2012b).

Despite the common trend towards urbanization, there are still significant differences across regions. In 2011, Northern America, Latin America and the Caribbean, and Europe had the highest percentage of urban population (82.2, 79.1 and 72.9 per cent, respectively). Conversely, Africa and Asia had the lowest percentage (39.6 and 45.0 per cent, respectively). In the coming decades, urban population growth will be especially concentrated in these two regions. Africa and Asia are expected to reach urbanization rates of 57.7 per cent and 64.4 per cent, respectively, by 2050 (United Nations, 2012b).

Besides the shift in the distribution of global population from rural to urban areas, another important trend is the emergence of larger cities. In 2011, the majority of the world's urban population lived in cities with fewer than half a million inhabitants. In the coming decades, however, urban population will be mainly concentrated

Table C.5: **Urban and rural population, 1950-2050**
(billions and per cent)

	1950	1970	2011	2030	2050
World population	2.53	3.70	6.97	8.32	9.31
Urban (%)	29.6	36.5	52.1	59.9	67.1
Rural (%)	70.4	63.5	47.9	40.1	32.9
Population in more developed regions	0.81	1.01	1.24	1.30	1.31
Urban (%)	54.3	66.3	77.4	81.5	86.3
Rural (%)	45.7	33.7	22.6	18.5	13.7
Population in less developed regions	1.72	2.69	5.73	7.03	7.99
Urban (%)	17.4	25.3	46.6	55.8	64.1
Rural (%)	82.6	74.7	53.4	44.2	35.9

Source: United Nations Population Division, *World Urbanization Prospects: The 2011 Revision database.*

in cities with more than half a million inhabitants. The number of mega-cities, defined as cities with more than 10 million inhabitants, will grow from 23 to 37 in the period 2011-25. However, mega-cities will still account for a relatively low percentage of the world's urban population (13.6 per cent in 2025, up from 9.9 per cent in 2011). Population growth rates will vary considerably across mega-cities, with the highest growth rates projected for Lagos in Nigeria, Dhaka in Bangladesh and Shenzhen in China. Tokyo, Osaka-Kobe and Moscow will register the lowest growth rates.

Population growth in urban areas can either be due to natural increase (birth rates in excess of death rates) or to net internal migration. Studies of 19th-century Europe (Williamson, 1988), as well as those on East Asian countries in recent decades, suggest that urbanization occurred at the same time as industrialization and was the result of migration from rural areas. However, in a number of developing countries, especially in Sub-Saharan Africa, urbanization rates have increased prior to, or sometimes in the absence of, industrialization. According to Dyson (2011), this can be explained by the fact that during the demographic transition the main driver of urbanization is not rural-urban migration but rather the natural growth of urban centres.[72]

Urbanization is among the most striking manifestations of "lumpiness" – a situation in which factors of production (land, capital, natural resources and various types of labour) are unequally distributed within a country (World Bank, 2009; Puga, 2010).[73] In a seminal contribution, Courant and Deardorff (1992) show that lumpiness can be a source of comparative advantage and therefore a determinant of trade that is distinct from other more traditional determinants of trade, such as differences in factor endowments and technologies. This is because a country tends to export the good that uses relatively intensively the factor that is more unevenly distributed across its regions. Consider a country composed of two regions. Starting from a situation in which factors are evenly distributed across the two regions, a large enough reallocation of one factor – for example, labour – between regions will bring about complete specialization. At this point, a further reallocation of labour in the same direction can only increase the output of the labour-intensive good in the region producing it, lowering its autarky relative price. This creates comparative advantage in the labour-intensive good.[74]

Various empirical studies have tried to document whether lumpiness affects trade patterns. While the early literature tended to dismiss lumpiness, recent contributions show that it might be a relevant factor. Most of the studies are indirect tests that try to establish whether Deardorff's (1994) "lens condition" is violated. This condition requires factor endowments to vary less across countries than factor input intensities vary across goods. If the set of points (i.e. lens) defined by regional factor abundances passes outside the set of points defined by goods' factor intensities, factor price equalization is impossible and lumpiness may affect trade patterns. The lens condition is found not to be violated for Japan, the United Kingdom and India by Debaere (2004) and for OECD countries by Debaere and Demiroglu (2003).

However, more recent work using city-level (as opposed to region-level) data finds that the lens condition is violated in six European countries (France, Germany, Italy, the Netherlands, Portugal and Sweden), thereby indicating that urban lumpiness might be an important determinant of trade patterns (Brakman and van Marrewijk, 2013).[75] Bernard et al. (2010) argue that factor lumpiness is also significant in the case of Mexico. They show that regional concentration of skilled labour induces skill-abundant regions within the country to offer relatively low wages for skilled labour and thereby specialize in the production of relatively skill-intensive goods. As a result, the country becomes a net importer of labour-intensive products. In this sense, the country's overall labour abundance is undermined by regional heterogeneity.

Urbanization or, more generally, agglomeration can also influence trade patterns indirectly via its impact on productivity.[76] There is ample evidence to suggest that workers and firms are more productive in larger and denser cities (Puga, 2010). Estimated agglomeration gains differ across countries, largely

Box C.3: **Demography and trade: a complex relationship**

The relation between demography and trade is complicated by numerous factors. First, there could be variables that affect both demography and trade. An example is the quality of institutions (as shown in Section C.6).[77] Institutions can also have an indirect effect on demography through their impact on economic development (Rodrik et al., 2004; Bloom and Canning, 2004).

Secondly, causality can run in both directions. Galor and Mountford (2006; 2008) claim that trade helps explain why the timing of the demographic transition differed between technologically advanced and less technologically advanced countries. In the former, trade reinforced specialization in the production of skill-intensive industrial goods, increasing the demand for skilled labour and the incentives to invest in human capital – which, in turn, reduced fertility rates. However, in the latter trade encouraged specialization in the production of unskilled-intensive, non-industrial goods, raising the demand for unskilled labour and reducing the incentives for human capital accumulation – which, in turn, increased fertility rates.

The contrasting demographic experiences of Britain and India during the 19th century provides anecdotal evidence to support this theory (Galor, 2012). During this period, Britain traded manufactured goods for primary products from India. The processes of industrialization in Britain led to a significant increase in the demand for skilled labour in the second phase of the industrial revolution, triggering a demographic transition in the 1870s. In contrast, the lack of demand for skilled labour in India delayed the demographic transition until the second half of the 20th century. Galor and Mountford (2008) provide cross-sectional evidence that trade (measured as the trade share in GDP in 1985) reduced fertility rates (measured as the average between 1985 and 1990) in OECD countries, while it increased fertility rates in non-OECD countries (see Figure C.13).

Figure C.13: **Effect of trade on fertility rates, by group of countries**
(thousands and per cent)

Source: Galor and Mountford (2008).

Moreover, Do et al. (2012) show that comparative advantage has an impact on fertility rates. In particular, countries with a comparative advantage in female labour-intensive goods are characterized by lower fertility rates. This is because female wages, and thus the opportunity costs of child-rearing, are higher in those countries.[78]

Causality may run in both directions in the relationship between trade and migration as well, since immigrants typically move to countries where formal or informal links are already established and where trade with their homeland is already present (Briant et al., 2009).[79] Using instrumental variable techniques, Briant et al. (2009), Peri and Requena-Silvente (2010) and Bratti et al. (2012) show that immigration leads to trade, although their analyses do not preclude the reverse channel co-existing.[80]

In the case of urbanization, the focus has been on the effect of "lumpiness" – the unequal distribution of factors of production within a country – on comparative advantage and trade patterns. A large body of literature, however, considers the reverse causal link, investigating the consequences of trade on urbanization.[81] A major research question is whether trade opening fosters concentration or dispersion of economic activity within a country. In theory, the effect is ambiguous as it depends on the relative importance of agglomeration and dispersion forces.[82] Empirical evidence shows that the distribution of economic activity prior to trade opening crucially affects the results. In general, regions with better access to foreign markets benefit. If, previous to trade opening, these regions were lagging behind, then opening leads to geographical convergence. If, however, these regions were already the most advanced, then trade opening will result in geographical divergence (Brülhart, 2010).

because of cross-country differences in factor mobility (Au and Henderson, 2006; Combes, 2000), and are generally higher for the services sector than for manufacturing. Innovation in knowledge-intensive sectors is especially affected by the geographical concentration of economic activity (Audretsch and Feldman, 2004). The implication is that comparative advantage in these sectors will also depend on agglomeration.

In summary, recent migration patterns have been characterized by significant increases in skilled migration. This has effects on innovation in the host country and on human capital formation in the country of origin that can make skilled migration beneficial for both. Traditional trade models predict that migration (movement of factors) and trade (movement of goods) are substitutes. However, with small modifications that introduce, for instance, differences in technology across countries, the relationship between trade and migration becomes complementary. The pro-trade effect of migrant networks is a good example of such complementarity. Finally, internal migration, and in particular urbanization, can also have effects on trade. Recent theories predict that the geographical concentration of a factor of production within a country can give rise to comparative advantage in the good that uses it relatively intensively. Empirical evidence is scant but recent studies suggest that this might be more than a theoretical possibility. Finally, agglomeration can indirectly affect trade through its impact on productivity.

(d) Conclusions

This section has shown that demographic change is and will continue to be a shaping factor of international trade. Ageing, migration, educational convergence and women's growing participation in the labour force – all linked to the underlying demographic transition – help to shape countries' comparative advantage. Moreover, as the size of the working-age population increases in some countries and decreases in others – and as a global middle class emerges – the size and the composition of import demand is also changing, with further effects on trade flows. For instance, trade in services, such as health care and education, is likely to increase.

The policies that countries adopt to meet the challenges and opportunities created by demographic change will also have effects on trade patterns. Consider, for example, the various policy options facing East Asian countries, such as the Republic of Korea or China, as they grapple with ageing populations (ILO, 2012): developing the appropriate skills policies for a greying population; creating the right incentives for increasing labour force participation among women as well as among older workers; accelerating labour productivity growth in order to counterbalance projected low employment and workforce growth rates; improving the management of labour migration regimes to help address labour shortages; and developing fiscally sustainable social protection systems. Through the various mechanisms discussed in this section, most of these policies are likely to affect the evolution of comparative advantage and therefore trade.

Moreover, improving education enrolment rates and the quality of the educational system will improve countries' integration into global supply chains and increase the sophistication of their exports. Educational policies are particularly important in the African context, where the size of the young population will increase significantly.

While it may be relatively straightforward to predict future demographic trends, the many theoretical and empirical variables discussed in this section indicate that it is more difficult to predict the trade effects of these trends. In short, the relationship between demography and trade is complex. Box C.3 concludes this section by offering some insights into the factors behind this complexity.

2. Investment

The accumulation of physical capital can affect the nature of international trade in a variety of ways. Greater public infrastructure investment can facilitate a country's participation in world markets by, for instance, reducing trade costs and hence increasing supply capacity. Such investment in physical capital can therefore lead to the emergence of "new players" in international trade. Investment in roads, ports and other transport infrastructure can also strengthen regional trade, while investment in information and communications technology (ICT) infrastructure can enable a larger number of countries to participate in the ever-expanding international trade in services. Over time, depending on the rate of growth of capital accumulation relative to the rate of growth of the labour force, it is possible for investments in infrastructure and non-infrastructure physical capital (such as plant, machinery and equipment) to alter the comparative advantage of a country already widely engaged in international trade.

In an economy where factors of production, such as capital, cannot move across countries, investment must be financed by domestic resources. Cross-country resource flows are, however, the current reality. National Income Accounting shows that a country that does not generate savings sufficient to finance its own investment must attract surplus foreign savings in the form of a capital inflow. Such a country is a net borrower from the world. Conversely, a country invests abroad when its domestic savings are more than sufficient to finance domestic investment. It sends its surplus savings abroad in the form of foreign direct investment (FDI) or investment in foreign stocks,

bonds or real estate. This stream of surplus savings is referred to as a capital outflow, making the country a net lender to the rest of the world. Hence, foreign capital flows are the main source of finance to fill the gap between investment and domestic savings. This includes FDI, portfolio investment and bank lending from abroad. Other external resource flows, such as overseas development assistance (ODA) and remittances from migrants also play a part.

Capital flows from abroad can also affect trade in ways other than through their impact on domestic investment. FDI, for example, may lead to trade in intermediate goods by facilitating global supply chains. It may also influence a country's comparative advantage by facilitating the transfer of technology. Portfolio investment and bank lending relationships across countries can strengthen trade flows by reducing information asymmetries between exporters and importers. External resource flows, more generally, may influence a country's exports by affecting its exchange rate.

This section first illustrates how investment can affect the nature of trade, irrespective of how the investment is financed. It then describes other channels through which different sources of investment finance can affect trade directly. Finally, it analyses the financing of investment from an empirical standpoint. In doing so, it examines the relationship between domestic resources and domestic investment across countries and groups of countries. It also assesses the order of magnitude and direction of external resource flows in the world. The aim is to provide a picture of how – and whether – different countries can – or should – enhance their investment rates and use different investment flows to increase their supply capacity, change their comparative advantage and strengthen trade relationships.

(a) Impact of investment on the nature of international trade

Sub-sections (i) and (ii) outline two mechanisms through which investment affects the nature of trade, irrespective of the source of finance used. While domestic resources are naturally important, so too are some external finance flows that are likely to have a quantitatively stronger impact on domestic investment than others. This is highlighted later. Sub-sections (iii), (iv), (v) and (vi) discuss channels through which different external resource flows can directly affect trade (i.e. other than through their impact on domestic investment).

(i) Public investment in infrastructure

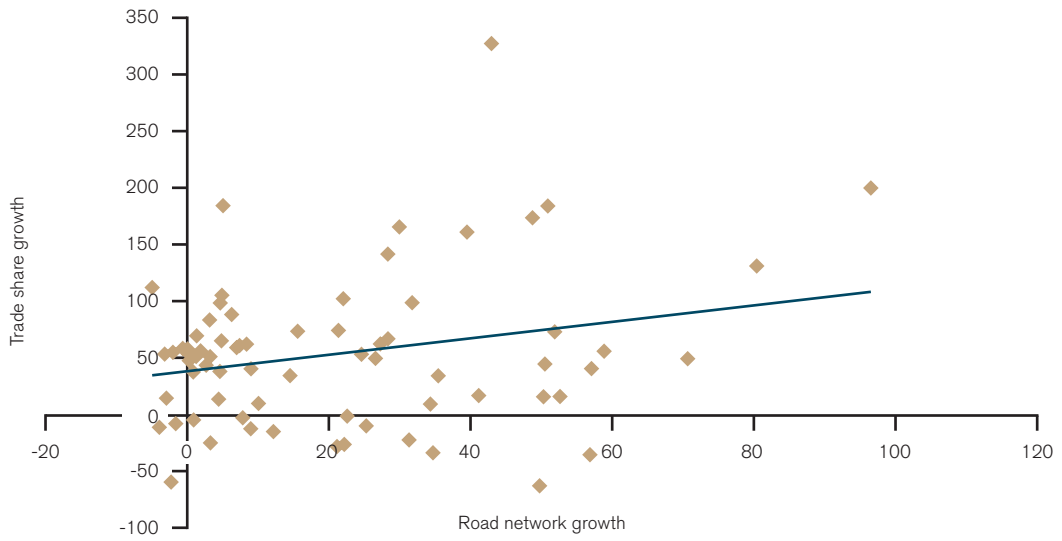
It is worth noting that capital accumulation in the realm of infrastructure creation is likely to be closely linked with public investment, especially in developing economies (Jimenez, 1994). Government resources are therefore crucial to financing this investment. To the extent that overseas development assistance, bank lending from abroad and FDI are directed towards relevant sectors, such as telecommunication, they may also contribute to investment in infrastructure. It is also important to highlight the fact that public investment in both physical and human capital infrastructure is important for the structure of trade. Section C.1 examined how investment in skills and human resources can affect trade. This section is therefore limited to a discussion of physical capital accumulation.

Investment in physical capital, such as roads, ports and ICT infrastructure, is likely to reduce trade costs and hence increase countries' trade participation. In this way, capital accumulation can enable the emergence of "new players" in world trade. This is especially important in the context of global supply chains, where firms headquartered in advanced economies offshore certain tasks involved in the production of a final good to developing countries. Given that the decision to offshore revolves around finding cost-efficient suppliers of that task worldwide, wage costs are not the only relevant variable. A minimum level and quality of infrastructure, created by investment in physical capital, is also likely to play an important role (Baldwin and Lopez-Gonzalez, 2012; Kimura, 2009; Hew et al., 2009). Production networks, for instance, require fluidity, low costs and security in the transmission of information. For this, a high-quality telecommunications system is essential (Grossman and Helpman, 2005).

Better transport infrastructure reduces transport costs and hence is associated with higher volumes of trade. Using data on a cross-section of countries, Figure C.14 shows this positive association in the case of changes in road network density and changes in the share of trade in GDP. Using more rigorous statistical methods, Nordas and Piermartini (2004) estimate that doubling the kilometres of paved roads per 100 square kilometres increases trade by 13 per cent. Similarly, they show that doubling the number of paved airports per square kilometres of territory in a country boosts trade by 14 per cent. Investment in better quality and more reliable ICT infrastructure also leads to a reduction in trade costs by reducing the barriers which inhibit economic exchange over long distances (Fink et al., 2005). A more detailed discussion on the relationship between transport and ICT infrastructure, on the one hand, and international trade flows, on the other, is provided in Sections C.5 and C.3, respectively.

The lack of adequate transport infrastructure undoubtedly reduces Africa's ability to participate in the world economy. According to Nkuepo (2012), the continent has fewer kilometres of road now than it did several decades ago, with about 70 per cent of the rural population living more than two kilometres away from an all-season road. Figure C.15 shows that between 1990 and 2005, India's road network almost

Figure C.14: **Total road network and trade openness, 1990-2005**
(percentage change in kilometres and trade to GDP ratio)

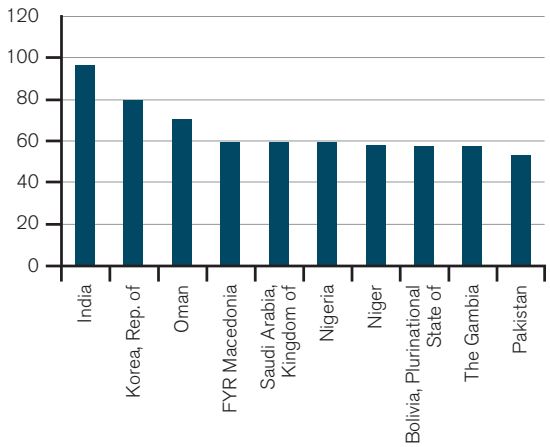


Source: The World Bank, W*orld Development Indicators.*

Note: While more recent data on road networks are available, it is limited to a much smaller sub-set of countries.

doubled, the largest percentage increase in the world. Increases in the road density of certain African countries during this 15-year period were also significant. It can be seen in Figure C.15 that the percentage increase in the road network of Nigeria, Niger and The Gambia was about 60 per cent between 1990 and 2005. It is likely that with increasing rates of economic growth[83] and a range of prospective policy reforms, a larger pool of government resources and more efficiency in public investment will enable many more African countries to increase their road density and hence their supply capacity.

Figure C.15: **Increases in total road network – top ten countries, 1990-2005**
(percentage change in kilometres)



Source: The World Bank, *World Development Indicators.*

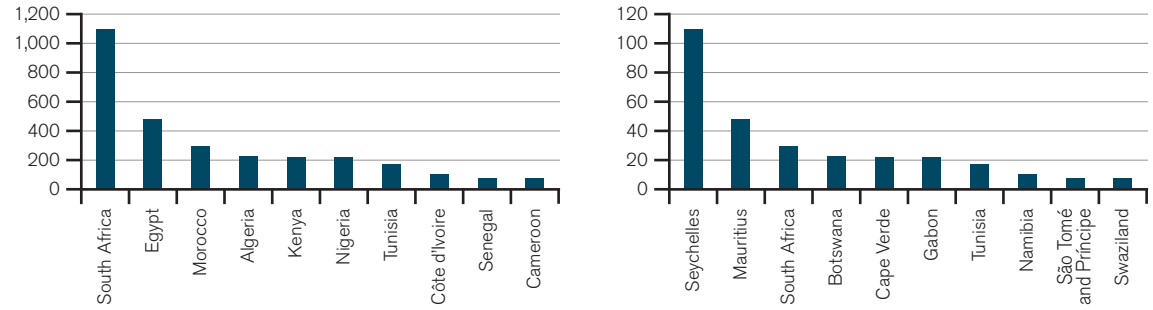
Note: Values for Nigeria and The Gambia have been extrapolated for one year in the period under consideration. More generally, while more recent data on road networks are available, it is limited to a much smaller sub-set of countries. In order to avoid making large-scale extrapolations, we chose 2005 as the cut-off point.

Most African countries also find it hard to compete in the world market owing to inadequate, inefficient and very expensive telecommunication services. This is reflected in Figure C.16, which shows a large gap in telecommunication investments between South Africa and the next ten countries in the continent. Even in per capita terms, it shows that along with four island economies, South Africa and other members of the Southern African Customs Union – Botswana, Namibia and Swaziland – are among the ten countries with the highest telecommunications investment in Africa. Attracting FDI through improved regulatory institutions and policies could play an important future role in this regard. In fact, Djiofack-Zebaze and Keck (2009) show that strong regulatory institutions are a key factor affecting the performance of the telecommunications sector.

Infrastructure investment is also likely to influence the regionalization of trade in the future. Consider, for instance, the case of Africa. Limao and Venables (2001) show that the low level of trade within African in the 1990s is explained to a large extent by their poor infrastructure. Even today, the transportation of goods by roads within the region is more expensive relative to other parts of the world. Flying from one country to another is expensive, and railway infrastructure barely links African countries (Nkuepo, 2012). Poor communications infrastructure continues to be regarded as a major impediment to trade within Africa as well (Mupela and Szirmai, 2012).

Initiating and encouraging more cooperation in infrastructure development projects – for example, in

Figure C.16: **Average annual investment in telecommunications in Africa, 1986-2005**
(US$ million and per capita US$)



Source: World Bank, *African Development Indicators*.

Note: Angola was excluded because of insufficient data availability. While more recent data are available from the International Telecommunication Union (ITU), these include less than one-third of the countries considered above either because of data unavailability or relevant harmonization issues.

telecommunications, transportation, power generation and the provision of water – at the regional level will increase access to these facilities, thereby lowering transactions costs and boosting trade among African countries in the future (Dupasquier and Osakwe, 2006). A future COMESA-SADC-EAC (Common Market for Eastern and Southern Africa – Southern African Development Community – East African Community) tripartite preferential trade agreement (PTA) and even a pan-African PTA could therefore provide a major boost to trade within Africa.

Furthermore, investment in ICT infrastructure may give a further impetus to expansion of trade in services. Cross-border trade in services (mode 1 of the General Agreement on Trade in Services), for instance, largely depends on telecommunications as the channel for transactions. Freund and Weinhold (2004) find that access to the internet for trading partners had a significant impact on US imports of business, professional and technical services. Developing economies hitherto not involved in services trade in a significant way can utilize investments in ICT infrastructure to make initial inroads into this increasingly important world market. English-speaking African countries, for example, could become offshore locations for call-centres and business process outsourcing. South Africa has already started down this path due to the quality of its telecommunications infrastructure even though high costs remain a problem.[84] Mauritius, another recently successful country, has taken direct regulatory action to ensure that costs are not a barrier to developing services offshoring businesses.[85]

(ii) Capital accumulation and changing comparative advantage

If a particular sector is more sensitive than others to the quality of infrastructure, then public infrastructure investment can affect a country's comparative advantage. For example, Yeaple and Golub (2007) find that the provision of road infrastructure consistently appears to be a significant factor in a sector's total factor productivity (TFP) growth and hence in a country's production specialization. The authors show that road infrastructure appears to be particularly important for productivity growth in the transportation equipment sector and for specializing in the production of textiles and apparel. Good telecommunication services may also influence comparative advantage and hence the pattern of international specialization.

ICT infrastructure is particularly important for information-intensive sectors. These are typically sectors that produce goods with short product cycles, experience rapid fluctuations in consumer tastes, enjoy rapid technology development, and where international vertical fragmentation is common. Consumer electronics, for example, is characterized by all these features. Fashion clothing is an example of goods for which tastes change rapidly while the automotive sector is an example of a sector where global production fragmentation is important (World Trade Organization, 2004a).

Investment in non-infrastructure creating physical capital, carried out largely by private players, can also exert an important influence on comparative advantage. According to the Hecksher-Ohlin model of trade, countries should produce and export goods that use intensively relatively abundant factors. So for a country with an abundant supply of unskilled labour, relative to capital, trade based on comparative advantage would imply specializing in the production of unskilled labour-intensive goods.

The Rybczynski theorem, however, shows that at constant relative goods prices, an increase in a country's endowment of one factor leads to a more than proportional expansion of the output of the good which uses that factor intensively and an absolute decline of the output of the other good. Hence, even in a relatively unskilled labour-intensive economy, an

increase in the supply of capital can result in an increase in the production of the relatively capital-intensive good. Over the medium to long run, the accumulation of capital may be large enough, relative to the growth of the labour force, to alter a country's comparative advantage, thereby making countries less specialized (as alluded to in Section B.2(c)). The transformation of Japan from a relatively labour-intensive to a relatively capital-intensive economy is a case in point (see Box C.4).

Figure C.17 shows that, between 1990 and 2009, several unskilled labour-intensive economies saw large increases in their capital-labour ratios. China, Viet Nam and India top the list as their capital-labour ratios increased sixfold, fourfold and threefold, respectively. These and other middle-income countries have relatively high investment rates. In fact, data show that unskilled labour-intensive economies, such as China, Viet Nam and India, were among the ten countries with the highest average investment rates between 2000 and 2010.[86] However, many of them also have high population growth rates. Whether these countries transform themselves into relatively capital-abundant economies in the future depends on how the rate of growth of physical capital compares with that of the labour force. In an emerging economy such as China, where population growth rates have slowed down but where investment in physical capital continues unabated, this may result in a change in comparative advantage in the future.

The trade literature suggests that the evolution of capital accumulation in an economy, and hence comparative advantage, is closely linked to its domestic savings rates – i.e. a country with a high savings rate exports a relatively capital-intensive good (Oniki and Uzawa, 1965; Stiglitz, 1970; Galor and Lin, 1997; Hu and Shimomura, 2007; Chen et al., 2008). The case of Japan validates this theory. While domestic resources are naturally important for domestic investment in physical capital and hence for comparative advantage, it is worth noting that resource flows from abroad can also play a part (see Box C.5 for a discussion on which of these is likely to have a strong effect on domestic investment).

For instance, in the case of Costa Rica, large-scale FDI by a number of multinationals established manufacturing plants in several high-technology electronics sectors, with Intel leading the way in semi-conductor devices (Rodríguez-Clare, 2001). This enabled the country to specialize in technologically more complex activities than apparel exports. Investment to establish a knowledge centre to develop software and contribute to Intel's design processes further strengthened this process of changing comparative advantage. Costa Rica's business-friendly economic and political institutions, together with its well-educated labour force, were instrumental in attracting this FDI (Sanchez-Ancochea, 2006).

(iii) Intertwining of trade and FDI

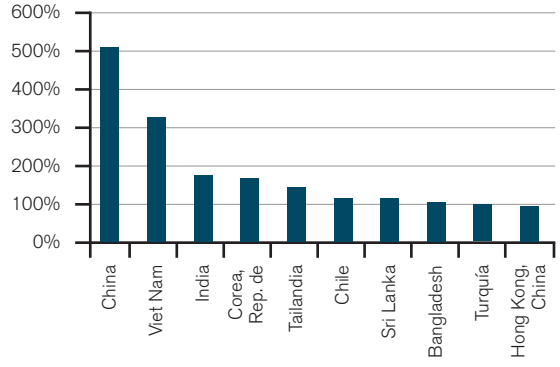
Economic theories of international trade and FDI have tended to develop separately. Hence, the traditional trade model, in which comparative advantage is based on differences in relative factor endowments,[87] assumes factor immobility among countries. In other words, trade and factor mobility are substitutes. For example, in lieu of capital from the capital-abundant country flowing to the capital-scarce country, capital-intensive goods are exported by the former to the latter.

However, this hypothesis is somewhat dissociated from existing economic reality, which is characterized by increasing international factor mobility, mainly in the form of FDI flows that finance investment (the relationship between trade and the mobility of labour across countries is discussed in Section C.1). Multinational firms, with their headquarters in one country, establish operations under their ownership and managerial control in another country.[88] Given that two-thirds of world exports are governed by these multinational firms, deciding where to invest is simultaneously deciding from where to trade (UNCTAD, 2012).

To the extent that local production in the "host" country replaces exports from the "home" country, FDI and trade can be substitutes. This is especially true for "horizontal" FDI, which consists of investment in production facilities abroad to produce the same goods and services as those produced at home to serve the host country market (Markusen, 1984). Increasingly, however, FDI and trade are viewed as being complements (Helpman, 1984). For horizontal FDI, this may be because affiliates or subsidiaries are used as "export platforms" – that is, investment in production capacity results in exports from that country to other third-country markets in its proximity (Grossman et al., 2006).

For example, evidence suggests that high levels of FDI in the automotive industry contributed significantly to

Figure C.17: **Capital-labour ratios, 1990-2009** (percentage change)



Source: Fouré et al. (2012).

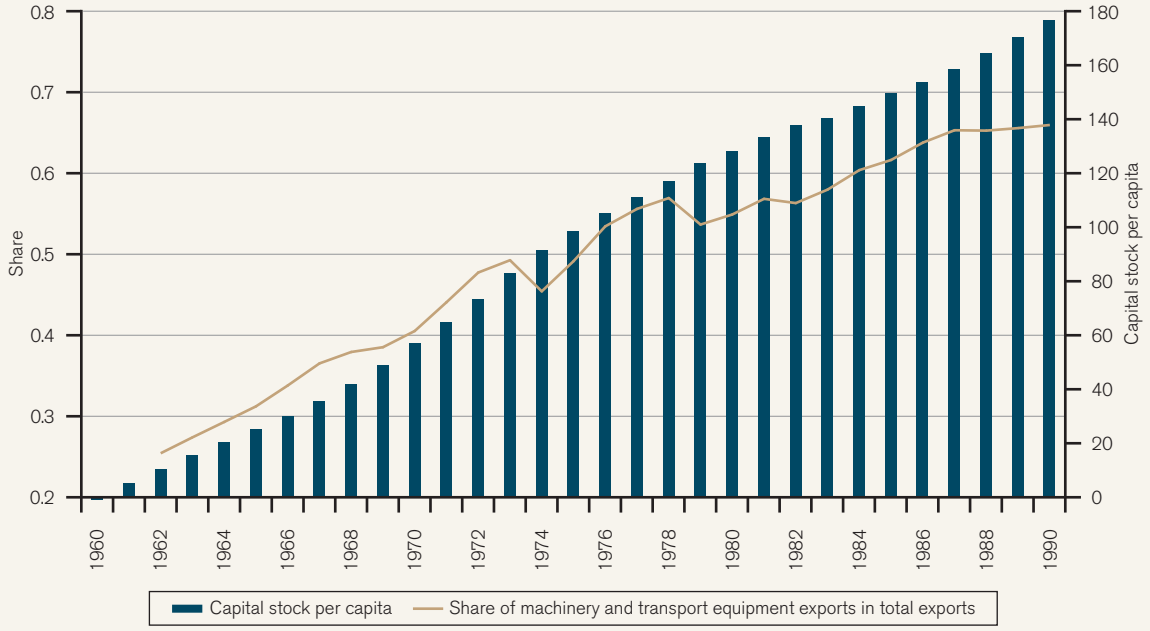
Note: Only economies with GDP above US$ 10 billion are considered.

Box C.4: **Investment and changing comparative advantage – the case of Japan**

Starting as a labour-abundant country, Japan transformed itself into a leading exporter of capital-intensive products in the period after the Second World War. Heller (1976) observes that high investment rates, caused by soaring domestic savings and American aid inflows, pushed Japan into a relatively capital-abundant position between 1956 and 1969. Using data on commodity trade statistics, he finds that Japan's comparative advantage had accordingly changed as its exports were relatively more capital intensive (see Section C.1). In a later study, Balassa and Noland (1988) find that the Japanese investment rate continued to be substantially higher than those of other industrial countries, such as the United States, between 1973 and 1985. In their examination of changing trade patterns, the authors find that relative to the period between 1967 and 1983, Japan's revealed comparative advantage (RCA) in unskilled labour-intensive industries, such as apparel and leather, had diminished. In contrast, the country developed a comparative advantage in skilled labour and high-technology intensive industries. Similar results are also found in Balassa and Noland (1989) and Lee (1986).

Figure C.18 shows that the changing share of machinery and transport equipment – regarded as one of the most capital-intensive sectors – in Japan's total exports and the evolving capital-labour ratio in Japan between 1960 and 1990 are highly correlated. This evidence suggests that Japan is a good example of an investment-driven change in a country's relative factor endowments and comparative advantage.

Figure C.18: **Japan's capital-labour ratio and the share of machinery and transport equipment exports in its total exports, 1960-90**



Sources: UN Comtrade and Fouré et al. (2012).

the Czech Republic's supply capacity and hence its exports to third-country markets until 2008 (Economist Intelligence Unit, 2010). Similarly, Tunea (2006) finds that NAFTA (North American Free Trade Agreement)-led foreign investment in Mexico's manufacturing sector was driven by its potential as an export platform for neighbouring countries. In the absence of FDI, these markets might have remained untapped because exporting to them directly from the home country would have entailed significant transport costs.

At the same time, home country operations of the parent firm can be linked with host country operations via "vertical" FDI, which involves the fragmentation of the production process along global supply chains. In this set-up (see Section B.2(e)), there are increased export possibilities for intermediate products, such as capital goods, design services and research and development, from the home country. At the same time, the home country imports varieties of a final good from the host country as a result of the supply capacity created by the FDI. For instance, Arnold and Javorcik (2009) find that receiving FDI enhanced the integration of Indonesian plants into the global economy through increased export intensity and greater reliance on imports of intermediate inputs. What is more, third-country markets may also begin to import from the host country.

Consider the electronics industry where FDI inflows, especially from firms in developed and "newly industrialized" countries, have established Malaysia as a global production hub. Intermediate inputs are imported from the country of the parent firm into Malaysia. At the

Box C.5: **Contribution of external resource flows to domestic investment**

Capital inflows

FDI can affect domestic investment by contributing directly to new plant and equipment ("greenfield" investment) or by acquiring (or merging with) an existing local firm. FDI may also produce investment spillovers beyond the direct increase in capital stock. For example, it could "crowd-in" the host country's domestic investment through linkages among firms – multinational corporations may purchase specialized inputs from domestic suppliers, thereby encouraging new investment by local firms (Mileva, 2008). According to Borenzstein et al. (1998), FDI could also spur domestic investment by lowering the costs of adopting new technologies. For a sample of ten CIS countries and Albania, Mileva (2008) shows that FDI flows crowd-in domestic investment. At the same time, it is possible for FDI to "crowd-out" domestic investment by raising productivity and hence wages.

Inflows of portfolio investment and bank lending from abroad can complement domestic savings in promoting domestic investment by lowering the cost of capital (Levine and Zervos, 1998; Manova, 2008a).[89] In a study of 11 developing countries, for instance, Henry (2000) finds that – on average – domestic private investment grows by 22 percentage points faster in the period after stock market liberalization. In a study which analyses a larger number of countries, Henry (2003) reaffirms his earlier findings by estimating that the domestic investment rate increases by approximately one percentage point every year following capital account liberalization.

In contrast, Pal (2006) and Mileva (2008) find a weak relationship between portfolio investment flows from abroad and the real economy in the case of India and economies in transition. This may be explained, in part, by the fact that portfolio investment flows are relatively more short-term in nature. Moreover, if foreign capital is limited to stock purchases on the secondary market, equity investment increases the price of the shares but not the flow of funds to the companies that wish to increase investment (Kraay and Ventura, 1999). According to Mody and Murshid (2005), multinationals have increasingly focused on acquiring existing assets rather than purchasing newly issued equity. Such capital inflows may still contribute to capital accumulation if the new foreign owners modernize or expand their acquisitions by investing in new technology (Mileva, 2008).

Analysing a sample of 58 developing countries between 1978 and 1995, Bosworth and Collins (1999) show that while FDI appears to bring about close to a one-for-one increase in domestic investment, there is virtually no discernible relationship between portfolio inflows and investment, and the impact of bank lending is only minor. According to Mody et al. (2003), this may be attributable to an informational advantage (based on their specialized technical knowledge and market experience), which allows FDI investors to "outbid" other investor-types for the most productive opportunities. In countries with missing or inefficient markets, foreign investors will prefer to operate directly instead of relying on local financial markets.

The importance of capital inflows to domestic investment also depends on the subsequent decisions of domestic investors. If residual domestic investment opportunities offer low returns, especially since new capital inflows could indirectly reduce the risk-free rate, domestic savings may actually be channelled out of the country in search of higher returns or lower risk (Mody and Murshid, 2005). Such capital outflow may actually reduce the resources available for domestic investment. It is also likely that countries with better policies and institutions (as described in Section C.6) are likely to have greater success in absorbing foreign capital inflows for domestic investment by creating an environment conducive for the diffusion of new technologies and reducing the risk of holding domestic assets.

Other external resource flows

In the empirical literature on the subject, opinions are divided concerning the effect of overseas development assistance (ODA) on investment, with results often being a function of the choice of data sample and estimation technique. For instance, while Boone (1996) and Hansen and Tarp (2001) find a statistically significant positive impact of ODA on investment, Dollar and Easterly (1999) and Collier and Dollar (2001) do not. It is argued that aid money meant for investment is often used for disaster relief (Dollar and Easterly, 1999), financing tax cuts (Devarajan et al., 1999) or supporting consumption (Boone, 1994).

Many studies find that remittances from migrants are positively correlated with entrepreneurship and small business investment in developing economies (Woodruff and Zenteno, 2007; Mesnard, 2004). For instance, comparing expenditures in Mexican households with and without international migrants, Taylor and

Mora (2006) find that the former spent more on investment and less on consumption than other households at the same income level. Adams (2005) presents similar findings for Guatemala. There are, however, studies which show that remittances mainly contribute to higher consumption (Brown and Ahlburg, 1999). A central methodological concern in this regard is that any observed relationship between remittances and household investment may simply reflect the influence of unobserved third factors. In a recent study, Yang (2008) finds that exogenous shocks to the income of Philippine migrant households, manifested in part via changes in remittances, have large effects on relatively capital-intensive entrepreneurial activity, such as manufacturing and transport services. The author argues that remittance receipts enable investment that was previously inhibited by credit constraints.

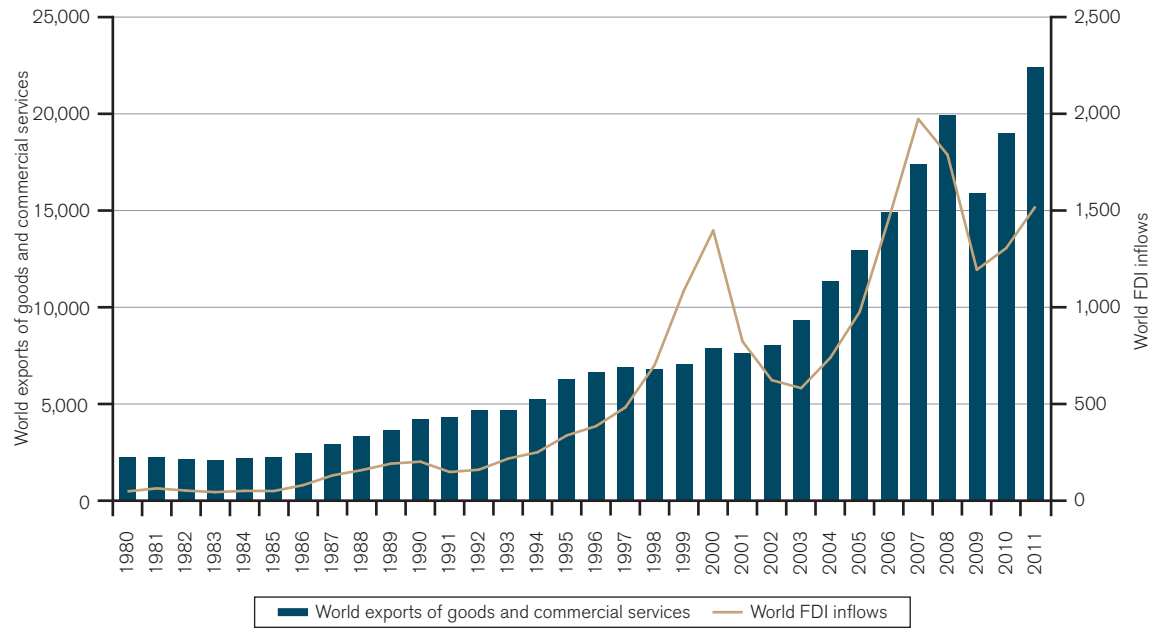
same time, the country ranks among of the world's largest exporters of semi-conductor devices and audio-visual equipment to the FDI-source countries or other markets (Malaysian Industrial Development Authority, 2006). The same is true for the automobiles industry where FDI has resulted in increased exports of automobiles from Thailand to developed economies as well neighbours in the region (Nag et al., 2007).

What if a firm produces not one but several final goods? It results in other channels of complementarity between FDI and exports through its effect on demand. First, the establishment of a productive unit for one of its products in a foreign market creates a reputation for its brand. This can increase the demand and, consequently, the exports of other final goods for that market (Lipsey and Weiss, 1984). Secondly, the marketing, distribution and delivery capabilities created by FDI in one product might enable the home country to export all its final products that would not reach customers in the foreign market in the absence of FDI (Blonigen, 2001). Thirdly, foreign demand for a firm's other final goods can be stimulated through the supply of valuable after-sale services resulting from FDI, which represents a permanent commitment to customers in the host country market (Head and Ries, 2001). Finally, exports from the home to the host country may also increase for the reason that FDI stimulates the host country's purchasing power for importing both intermediate and final goods from the home country.

In sum, the theory suggests that greater FDI can lead to more trade. However, can trade also boost FDI flows? Analysis suggests that it can. Exports can be a source of information on the host country and hence enhance capital flows (Portes and Rey, 2005). FDI may also follow exports in order to preserve markets that were previously established by exports (Obstfeld and Taylor, 2004). Trade associated with cross-border vertical integration, in particular, may boost FDI as it assures ownership advantages and a market.

The data show a systematic positive association between trade and FDI, thereby highlighting their complementarity (see Figure C.19). Evidence from particular sectors and countries reinforces this finding. The trade orientation of FDI is well-represented in the development experience of China

Figure C.19: **World trade and foreign direct investment, 1980-2011**
(US$ billion)



Sources: WTO Secretariat, UNCTAD.

where foreign investment enterprises accounted for 58 per cent of total exports in 2005 (WTO, 2010). It is equally well-illustrated in other cases. In the textiles industry, for example, FDI from Hong Kong (China) and Chinese Taipei dominates export production in Lesotho, Madagascar and Mauritius, while FDI from the United States does so in the Dominican Republic (McNamara, 2008). Furthermore, several empirical studies find that more FDI establishing affiliates abroad is associated with more, rather than less, exports from the parent firm in the home country (Bergsten et al., 1978; Lipsey and Weiss, 1981; Blomstrom et al., 1988; Buiges and Jacquemin, 1994). Such complementarity has been found to be especially true for intra-firm exports, highlighting the importance of vertical relationships among various international affiliates (Pearce, 1990).

(iv) FDI, technology diffusion and changing comparative advantage

A country's position in a global supply chain is generally correlated with its comparative advantage. Developing countries complete low value-added unskilled labour-intensive tasks because they have a relatively abundant supply of unskilled labour. It is advanced economies where the skill and capital-intensive tasks are completed. In modern economies, however, much comparative advantage is man-made. So is it possible for a country that has a comparative advantage in unskilled labour-intensive tasks today to have a comparative advantage in high-technology-intensive tasks tomorrow?

In Asia, several firms in Japan offshored unskilled labour-intensive manufacturing tasks to the Republic of Korea, Chinese Taipei, Hong Kong (China) and Singapore, starting in the 1970s (Baldwin, 2012a). Hence, these countries entered global supply chains by specializing in component manufacturing and product assembly. As they industrialized, they began to manufacture sophisticated intermediate inputs, which they earlier imported from advanced economies. These newly industrialized countries also expanded into the design and distribution of goods and hence captured more of the total value added (Wood, 2001).

While investment in higher education is likely to have played an important role, the diffusion of technology and knowledge associated with FDI played a crucial role in upgrading. In a study of 105 countries between 1984 and 2000, for instance, Harding and Javorcik (2012) find a positive relationship between FDI and the quality of exports in developing countries. Global supply chains have made technology internationally more mobile by offshoring firm-specific technical know-how, especially via investment by multinational companies in the establishment of subsidiaries overseas. This helped to enable developing countries, such as Hong Kong (China), the Republic of Korea, Singapore and Chinese Taipei to move up the product ladder in terms of capital intensity, technological content, design and quality. Signs of technology upgrading and changing export orientation, facilitated by FDI, are already visible in China – it has begun to produce sophisticated intermediate goods and services that previously would have been imported – and are likely to only get stronger in the future (Rodrik, 2006).

A discussion on the mechanisms through which FDI, both "horizontal" and "vertical", can lead to technology diffusion is provided in Section C.3. The following are a few examples. Evidence for direct technology transfer from multinational affiliates to local suppliers or technology upgrading due to higher quality requirements on intermediate inputs from domestic suppliers is documented in the case of vertical FDI flows into Lithuania and Indonesia (Javorcik, 2004; Blalock and Gertler, 2008).

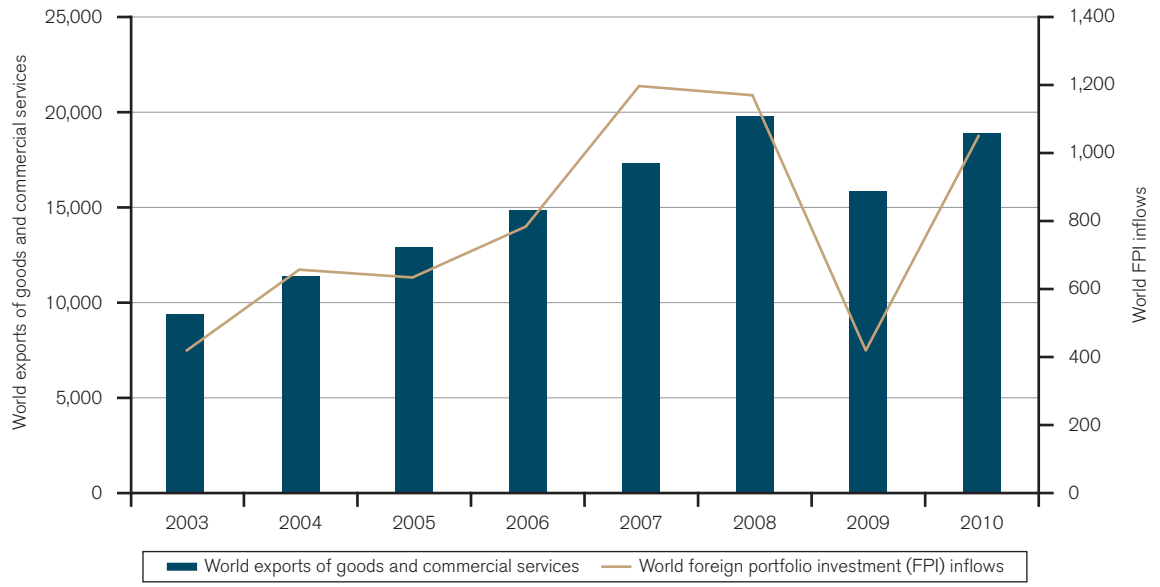
Iacovone et al. (2011) find that following the entry of Walmex (the Mexican affiliate of Walmart), local Mexican retailers started to adopt advanced technologies, such as cold chain (a temperature-controlled supply chain), in order to catch up. This is indicative of indirect technology transfer. Knowledge spillovers are also documented in the case of Intel's FDI in Costa Rica. Intel invested heavily in the training of its employees, leading to learning-by-doing and even the creation of several "spin-off" firms. Intel also collaborated with public universities in order to improve their curriculum and teacher training in technical fields (Rodríguez-Clare, 2001).

(v) Information, capital flows from abroad and international trade

It is argued that portfolio investment and bank lending relationships between countries can generate information that leads to an increase in bilateral trade (Lane and Milesi-Ferretti, 2008; Jeanneau and Micu, 2002; Portes and Rey, 2005). The relationship between lenders abroad and borrowers at home – or vice versa – can improve the exchange of information between exporters and importers, thereby encouraging international trade. At the same time, existing trade relationships may allow foreign investors and banks to gather information about the destination country and hence serve to increase portfolio investment and bank lending to that country. This complementarity between portfolio investment and bank lending from abroad, on the one hand, and trade flows, on the other, is depicted in Figures C.20 and C.21.

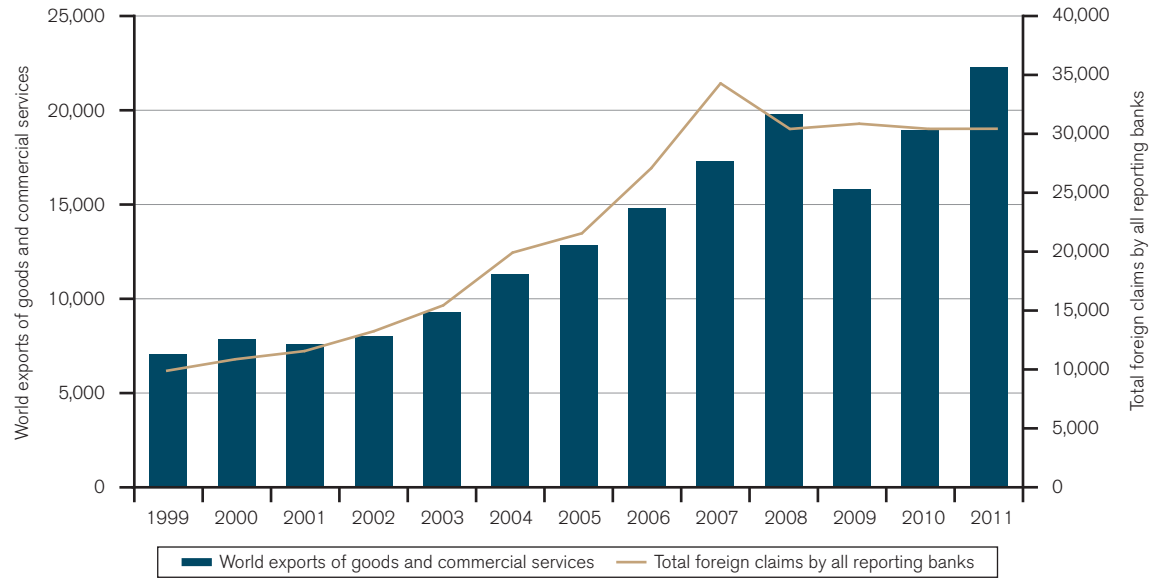
Empirical evidence, generated by rigorous statistical methods, also supports this complementarity. Using data for international portfolio holdings of 67 source countries (including all major international investors) and 200 destination countries, Lane and Milesi-Ferretti (2008) find that bilateral international equity

Figure C.20: **World trade and foreign portfolio investment, 2003-10**
(US$ billion)



Sources: World Bank WDI, WTO Secretariat.

Figure C.21: **World trade and foreign claims, 1999-2011**
(US$ billion)



Sources: Bank of International Settlements, WTO Secretariat.

Note: Foreign claims represent loans extended to residents outside the country in which the banks are headquartered.

positions are strongly correlated with bilateral trade. This evidence is indicative of an information-driven relationship between trade and capital flows that is particularly strong when the collection of information is simplified. The authors find that a common language, for example, raises equity holdings by 50 per cent. Similarly, Portes and Rey (2005) show that a gravity type equation explains 70 per cent of the variation in portfolio investment for a sample of developed countries. They test explicitly for information asymmetries using proxy variables, such as telephone traffic, and show that this channel is highly significant. Moreover, they include these proxies in trade equations and show that the results improve significantly.

Some studies in the literature use more sophisticated statistical techniques in order to establish causality in the relationship between trade and capital flows across countries. For instance, Aviat and Coeurdacier (2007) find that a 10 per cent increase in trade leads to a 6 per cent higher level of portfolio investment; causality in the other direction is weaker but still

significant. Similarly, Jeanneau and Micu (2002) find that while bilateral trade is significant and highly positive in explaining bank lending patterns from advanced economies (the United States, Japan, the United Kingdom, Germany, France, Italy and Spain) to Asian and Latin American economies (Argentina, Brazil, Chile, Indonesia, the Republic of Korea, Malaysia, Mexico, the Philippines, Thailand and Bolivarian Republic of Venezuela), there is also causality in the other direction.

(vi) Capital flows, exchange rates and international trade

Capital inflows can lead to an appreciation of the exchange rate in recipient countries, thereby hurting their export competitiveness (Corden and Neary, 1982; Agenor, 1998; Lartey, 2008). Inflows of foreign currency raise the demand for both tradable and non-tradable goods produced in an economy. In the context of a small open economy, an increase in the demand for tradable goods does not affect their prices since these are determined in world markets. At the same time, the increased demand for non-tradable goods places an upward pressure on their prices and thereby results in an appreciation of the real exchange rate. Under a flexible exchange rate mechanism, both the nominal and the real exchange rate appreciate as a reaction to the increase in the relative price of non-traded goods. Under a fixed exchange rate arrangement, the expanding money supply increases domestic prices, thereby leading to a real appreciation of the currency. It is worth noting that in most countries, exchange rate appreciation is sporadic, volatile and short-term in nature. Appreciation over a longer period occurs only in a relatively few number of cases (Sy and Tabarraei, 2010).

If policy-makers choose to dilute the effect of real exchange rate appreciation by sterilizing incoming resources through open market operations, it will lead to an increase in domestic debt along with a possible increase in the domestic interest rate. This, in turn, may further attract more inflows from abroad and create a vicious circle of expected devaluation and capital flight, thereby affecting investment and trade in the future (Calvo et al., 1993).

Several studies have shown that large capital inflows have resulted in exchange rate appreciation in developing economies (Corden, 1994; Lartey, 2007; Edwards, 1998). For instance, several countries in Latin America and Asia saw their exchange rates appreciate during the early 1990s when there was a surge of private capital inflows (Corbo and Hernandez, 1994). These included Argentina, the Republic of Korea, Mexico and the Philippines. In a more recent study, ADB (2007) finds that real effective exchange rates in the large emerging East Asian economies have appreciated against the US dollar since 2004, owing to larger private capital inflows.

In the context of least-developed countries (LDCs), especially in Africa, several cross-country empirical studies find that foreign aid inflows are associated with an appreciation of the real exchange rate (Lartey, 2007; Elbadawi, 1999). This is also reflected in country studies on Burkina Faso, Côte d'Ivoire, Senegal and Togo (Adenauer and Vagassky, 1998), Cape Verde (Bourdet and Falck, 2006), Ghana (Opoku-Afari et al., 2004) and Nigeria (Ogun, 1998). The same holds true for several oil-rich countries where exchange rate appreciation has been associated with the influx of petro-dollars (*The Economist*, 2007).

There is, however, a body of evidence that contradicts the results described above. For instance, countries in Latin America and Asia – Chile, Indonesia and Malaysia – that received the largest capital inflows (as a percentage of GDP), on average, between 1989 and 1992 avoided a significant real exchange rate appreciation (Corbo and Hernandez, 1994). Similarly, empirical evidence shows that foreign aid flows have often been associated with exchange rate depreciation. This includes the findings of Mongardini and Rayner (2009) for 36 sub-Saharan African countries, Issa and Ouattara (2008) for Syria, Li and Rowe (2007) for Tanzania and Sackey (2001) for Ghana.

It is argued that capital inflows associated with higher consumption put more pressure on the relative price of domestic goods than capital inflows associated with higher investment (Saborowski, 2009). Hence, by ensuring that inflows add to the productive capacity of an economy, a well-functioning financial system can attenuate the upward pressure on the relative price of non-tradables and therefore on exchange rates. Pro-cyclical capital flows for investment purposes, however, can exacerbate macroeconomic overheating and drive the real exchange rate to appreciate more. In some developing economies, for instance, pro-cyclical remittances spent on real estate have resulted in construction booms. In light of the above, countries have often used restrictive fiscal policy to counteract the exchange rate effect of capital flows from abroad (Corbo and Hernandez, 1994). The nature of the capital flow may also influence its effect on exchange rates. For example, the appreciation of the real exchange rate due to FDI is likely to be less than that due to more volatile capital flows, such as portfolio investment (Lartey, 2007).

(b) Finance for investment

(i) Domestic resources

Firms looking to make investments often draw on their retained earnings or other internally generated funds. Any industry with high growth prospects, however, is likely to experience relatively high investment demand compared with current cash flows and therefore be dependent on external financing. The supply of loanable funds comes primarily from household savings

(see Box C.6 for a brief account of its determinants). In addition, central banks can buy securities, often government bonds, in the open market by paying for them with money that they create. Given the above, a financial system that mobilizes and allocates these resources at low transaction costs to their most productive uses is crucial for promoting investment (see Box C.6 for a more detailed discussion). It is worth noting that public investment may be financed by government savings, which are defined as the excess of tax receipts over total expenditure.

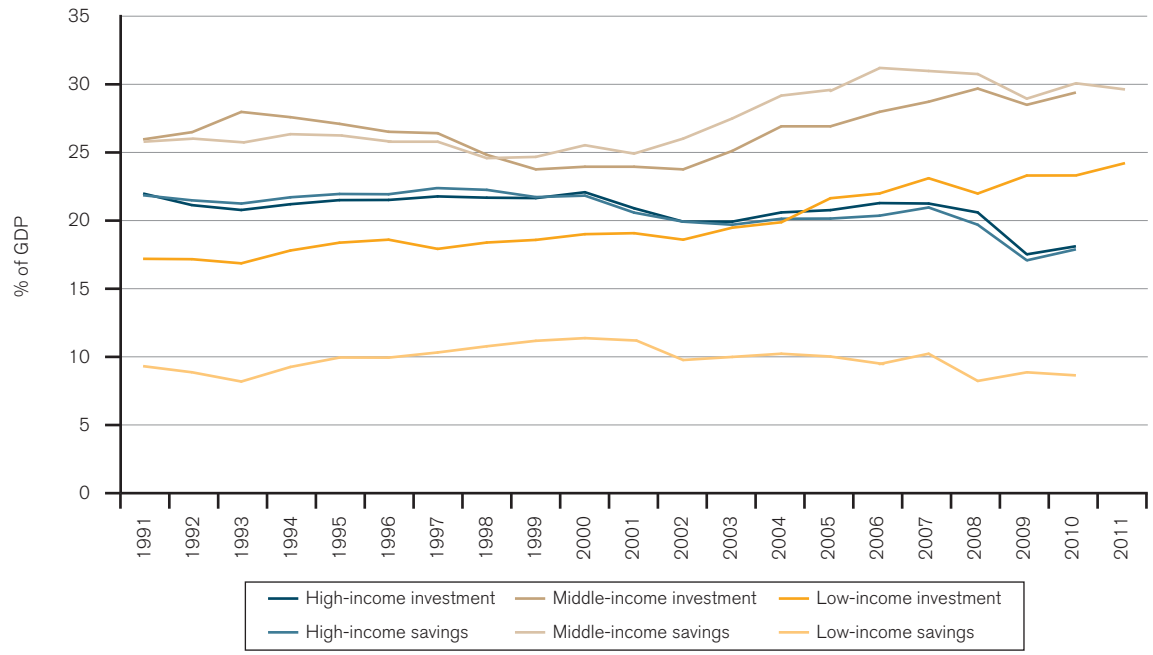
The relationship between domestic savings and investment, in quantitative terms, is best captured by the seminal paper of Feldstein and Horioka (1980). Analysing a sample of 16 OECD countries between 1960 and 1974, they find that the correlation between long-run averages of the saving-output ratio and the investment-output ratio was very close to unity. Several studies using time-series data validate these findings (Coakley et al., 1999; Coakley et al., 1996; Mamingi, 1997; Miller, 1988; Obstfeld, 1986; Tesar, 1993). The same holds true for several cross-country studies (Artis and Bayoumi, 1992; Coakley et al., 1996; Feldstein, 1983; Feldstein and Bacchetta, 1991; Golub, 1990; Obstfeld, 1986, 1995; Penati and Dooley, 1984; Tesar, 1991).

Murphy (1984) finds that the saving–investment correlation was significantly lower (0.59) for the ten smallest countries in his sample than for the seven largest countries (0.98). Similarly, Dooley, Frankel and Mathieson (1987) report that the average estimate was significantly lower in non-OECD economies than in OECD economies. More recently, empirical studies which have analysed variations, both across countries and over time, find that the saving–investment association is close to unity for OECD economies but lower for developing countries (Cadoret, 2001; Coakley et al., 2004; 1999; Kim, 2001).

Figure C.22 also shows that, on average, the savings rates of middle-income countries have exceeded that of high-income countries for the last two decades, In 2010, middle-income countries had a savings rate of 30 per cent, almost double the level of high-income countries. In fact, Table C.6 shows that among the 15 countries with the highest average savings rates between 2000 and 2010, almost all belong to the middle-income category. Resource-rich countries in the Middle East and North Africa – Libya, Qatar, the State of Kuwait and Algeria – occupy the top four positions. Going forward, economic growth is likely to continue to be high in these countries. The same holds true for labour-intensive economies in Asia, where China, Singapore, Malaysia and Viet Nam were in the top 15 in the world in the context of savings rates during the last decade. With rapid population growth in some of these countries, the active workforce is also likely to grow. Hence, high savings rates should continue to provide sufficient funding sources to support the development of capital markets and spur investment in physical capital. The same cannot be said for either low- or high-income countries.

For instance, Table C.6 shows that low-income countries, such as Côte d'Ivoire, and advanced economies, such as the United States and the United Kingdom, were among the 15 countries with the lowest average savings rates between 2000 and 2010.

Figure C.22: **Investment and savings rates, 1991-2010**
(percentage of GDP)



Source: World Bank.

Box C.6: **Domestic savings and investment**

Determinants of household savings

Income is the basic determinant of saving. The poor are likely to have just enough resources to meet the social minimum level of consumption. In contrast, richer people can afford the luxury of saving to assure their future consumption. Several empirical studies find that real growth of income, measured by GDP, has a positive and significant effect on savings (Fry, 1978; 1980; Giovannini, 1985; 1983; Mason, 1988; 1987). Savings may also depend on fluctuations in the level of income.

Given the predictions of the "permanent income" hypothesis (explained in Section C.1) and recognizing credit constraints faced by low-income households, rapid but transitory income growth is likely to raise the average savings rate if the growth were concentrated in relatively rich households with high saving rates (Collins, 1991). More wealth[90] would tend to reduce saving out of current income because it enhances an individual's ability to earn income in the future (Schmidt-Hebbel, 1987; Behrman and Sussangkarn, 1989).

The demographic composition of a household and country exerts an important influence on savings rates as well. The "life-cycle hypothesis", described in Section C.1, predicts that a higher percentage of old people and children – the non-earning section of a country's population – reduces the saving capacity of a country. Several empirical studies find that the dependency ratio, defined as individuals under the age of 15 or over 65 as a share of total population, had a strong negative effect on saving (Leff, 1969; Mason, 1988; 1987; Collins, 1991; Rossi, 1989; Webb and Zia, 1990).

When interest rates rise, individuals begin to switch from current consumption towards saving because the former becomes relatively more expensive. This is the "substitution effect". At the same time, for a net saver, an increase in the interest rate would increase his or her (expected) relative income, inducing greater current consumption and hence lower savings. This is referred to as the "income effect". Given that the income and substitution effects of higher interest rates work in opposite directions, the effect of rates of return on savings is ambiguous. In addition, interest rates can also affect saving through a wealth effect. Higher real interest rates reduce the present value of future income streams from fixed-interest financial assets. Savings therefore receive a boost even if the substitution and income effects cancel each other out (Schmidt-Hebbel et al., 1992). Much of the empirical literature shows that the real interest rate has a positive effect on saving rates (McKinnon, 1973; Shaw, 1973; Gupta, 1987; Balassa, 1990).[91]

Uncertainty about future asset values introduced by inflation could encourage saving for precautionary motives. At the same time, if increases in the rate of inflation exceed increases in the nominal interest rate, this would lower the real rate of return and hence discourage saving. The empirical evidence is inconclusive (Gupta, 1987; Lahiri, 1988).

Fiscal policy changes which raise public saving may also affect private savings rates. The "Ricardian equivalence" hypothesis, as reformulated by Barro (1974), states that public debt issues are indistinguishable from tax increases in the future. Thus, a change in public saving should be offset by an equal and opposite change in private saving. The hypothesis has been widely rejected in empirical studies, with the pervasiveness of borrowing constraints cited as the main reason for households not evenly spreading their consumption-savings behaviour over their lifetime (Haque and Montiel, 1989; Rossi, 1988; Schmidt-Hebbel and Corbo, 1991).

Cultural attributes may also have a significant impact on the level of savings. Using cross-country data, Shoham and Malul (2012) find that as the level of uncertainty avoidance and collectivism increases, the level of national savings also increases.

From savings to investment

The banking sector is the principal savings-investment conduit in most financial markets and therefore is central to the mobilization of domestic resources for development. Unfortunately, it has often not catered well to the investment needs of small and medium-sized enterprises (SMEs) and those in the informal sector, especially in developing countries (Zeldes, 1989). For instance, the top five banks serving SMEs in non-OECD countries reach only 20 per cent of formal micro enterprises and SMEs. In Sub-Saharan Africa, this number is even lower, at 5 per cent (Dalberg, 2011). Public sector banks, the postal system and microfinance schemes have played a role in mobilizing resources for groups who lack collateral.

Domestic savings may also spur investment by firms through holdings in stocks, bonds and related financial instruments. In most developing countries, owing to a weak legal framework and low participation rates of institutional investors, such as mutual funds, pension funds or insurance schemes, these markets are still

relatively underdeveloped. Economies in transition are a case in point (Mileva, 2008). With recent deregulation and liberalization measures, however, stock and bond markets are becoming an increasingly important means of mobilizing funds in several emerging economies, including for high growth potential SMEs (BIS, 2012; Dalberg, 2011).

It is worth noting that to the extent that purchases of stocks take place on the secondary market and do not constitute the purchase of newly issued equity, increased stock holdings are unlikely to increase the flow of capital to firms that wish to increase investment (Kraay and Ventura, 1999). During the recent financial crisis, the most seriously affected firms were those listed on stock markets with small capitalization – which suffer from a lack of investor interest – and SMEs – which suffer from the reluctance of banks to approve new loans or to roll over existing credit lines (OECD, 2012c; Dalberg, 2011). Section D.3 shows that this also holds true for the case of trade finance.

Table C.6: **Average annual savings rate, 2000-2010**
(percentage of GDP)

Top 15		Bottom 15	
Libya	59.81	Serbia	10.15
Qatar	55.81	Iceland	10.38
Kuwait, the State of	48.36	Côte d'Ivoire	11.64
Algeria	47.88	El Salvador	12.07
China	46.90	Cyprus	12.12
Singapore	42.27	Lebanese Republic	12.46
Iran	40.34	Greece	12.87
Saudi Arabia, Kingdom of	36.92	Bosnia and Herzegovina	13.05
Malaysia	35.55	Portugal	13.88
Azerbaijan	35.51	Guatemala	14.29
Norway	35.32	United States	14.61
Trinidad and Tobago	34.27	Cameroon	14.67
Venezuela, Bolivarian Republic of	33.92	United Kingdom	14.72
Oman	32.93	Dominican Republic	14.89
Viet Nam	32.70	Lithuania	15.15

Source: International Monetary Fund, *World Economic Outlook Database*, October 2012.

Note: Countries with an average GDP, between 2000 and 2010, below current US$ 10 billion were excluded.

Without sufficiently broad-based economic growth, a growing middle class that can propel savings rates in low-income countries is unlikely to emerge in the near future. In some advanced economies, such as the United States, low interest rates, prospects of inflation, stagnant incomes owing to the crisis and cultural factors are likely to hinder an increase in their future savings rates.

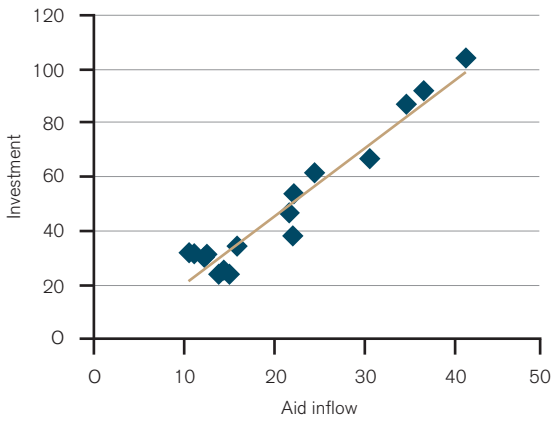
(ii) External resource flows

Overseas development assistance and migrant remittances

Figure C.22 showed that the gap between the rate of domestic savings and domestic investment for low-income countries has been consistently high in the recent past, widening considerably between 2002 and 2010. In 2010, the savings rate in low-income countries, on average, was about one-third the investment rate. Figure C.23 shows that overseas development assistance (ODA) is likely to have played a part in financing this savings-investment gap in low-income countries.

Given the limits to the growth of ODA in the future, owing to the recessionary situation in several advanced economies, the future importance of other resource

Figure C.23: **Overseas development assistance (ODA) and investment in low-income countries, 1990-2009**
(US$ billion)



Source: World Bank.

flows from abroad in raising investment rates in low-income countries cannot be under-estimated. This is particularly significant because data reveal that low-income countries, such as Myanmar and Kenya, were among the ten countries with the lowest average investment rates between 2000 and 2010. Certain middle-income developing economies, such as Côte d'Ivoire, Angola, Cameroon, the Plurinational State of Bolivia and Yemen, were also included in this group.[92] This suggests that private external resource flows are likely to be important for enhancing physical capital accumulation in middle-income countries as well.

Officially recorded migrant remittances to developing countries, estimated at US$ 406 billion in 2012, are now more than three times the size of ODA. Compared with other private capital flows, remittances have showed remarkable resilience during the recent financial crisis (World Bank, 2012a).

In 2012, large emerging economies, such as India, China, the Philippines, Mexico, Egypt and Viet Nam, were among the top ten recipients of migrant remittances in the world (World Bank, 2012a). Figure C.24 shows that as a percentage of GDP, however, low-income countries, including Tajikistan, Haiti, the Kyrgyz Republic and Nepal, were among the top ten recipients of migrant remittances over the last decade. No Sub-Saharan African country appears in this list. This may be related to the high cost of sending remittances. For example, according to Ratha et al. (2008), the average cost of sending US$ 200 from London to Lagos, Nigeria, in mid-2006 was about 14 per cent of the amount. Their estimates suggest that halving remittance costs from 14 to 7 per cent for the London-Lagos corridor would increase remittances by 11 per cent.

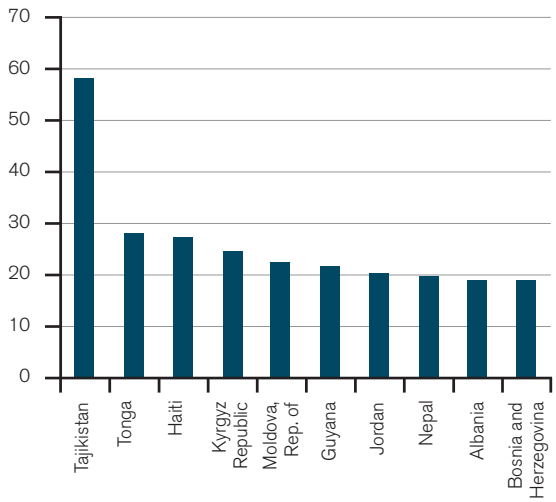
Remittance costs could be reduced by lowering remittance fees and by improving access to banking for remittance senders and recipients. This is relevant because forecasts show that the growth of remittances is expected to be stronger in the near future, especially in regions that rely on remittances from the United States, the Russian Federation and the Middle East (World Bank, 2012a). Importantly, however, while migrant remittances can enable investment in physical equipment to initiate a small household business, they are unlikely to be able to sustain capital investment by larger companies.

Portfolio investment and bank lending from abroad

When an economy liberalizes its capital account, it will see an increase in portfolio investment flows and bank lending if the marginal returns to capital are high in relation to the rest of the world. In general, this would mean that capital moves from capital-abundant countries with low rates of return to capital-scarce countries with high rates of return. The large inflow of private capital into emerging economies, starting in the 1990s, can partly be explained by this rate of return differential. At the same time, risk (both actual and perceived) could narrow this differential in effective terms. Hence, the increased inflow of portfolio investment and commercial bank lending may also be attributable to factors that reduced risk (Mody and Murshid, 2005) – policy reforms, regulatory changes and more stable macroeconomic policies.

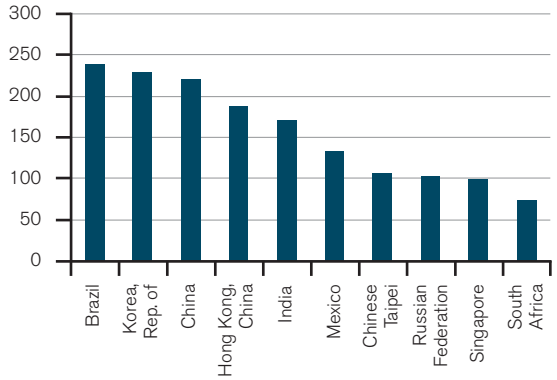
Figure C.25 shows that the top ten recipients of portfolio investment inflows among developing economies during the last decade were almost entirely in Asia or Latin America. Figure C.26 shows that the same holds true for bank lending from abroad. The continued importance of these investment flows in the future will undoubtedly be influenced by the health of global financial markets as well as the ability of recipient countries to strengthen independent

Figure C.24: **Top ten recipients of remittances from migrants as a share of GDP, 2000-10**
(percentage)



Source: World Bank, *World Development Indicators.*

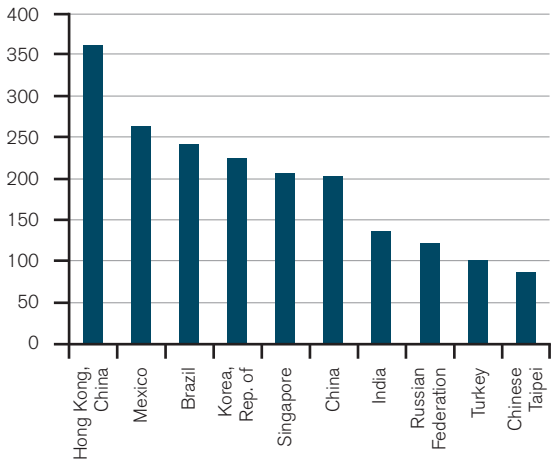
Figure C.25: **Average annual foreign portfolio liabilities of developing countries – top ten, 2001-10**
(US$ billion)



Source: International Monetary Fund, *Coordinated Portfolio Investment Survey.*

Note: Economies with an average GDP, between 2000 and 2010, below current US$ 10 billion were excluded.

Figure C.26: **Top ten recipients of bank lending from abroad amongst developing countries, 2001-10**
(US$ billion)



Source: Bank for International Settlements.

Note: Economies with an average GDP, between 2000 and 2010, below current US$ 10 billion were excluded.

regulation, improve transparency and conform to relevant international accounting and auditing rules. For developing countries in Africa, for example, the establishment of a strong legal framework and greater reliance on market-based credit assessment methodologies would be necessary first steps to create capital markets that can attract foreign portfolio investment and bank lending from abroad.

Foreign direct investment (FDI)

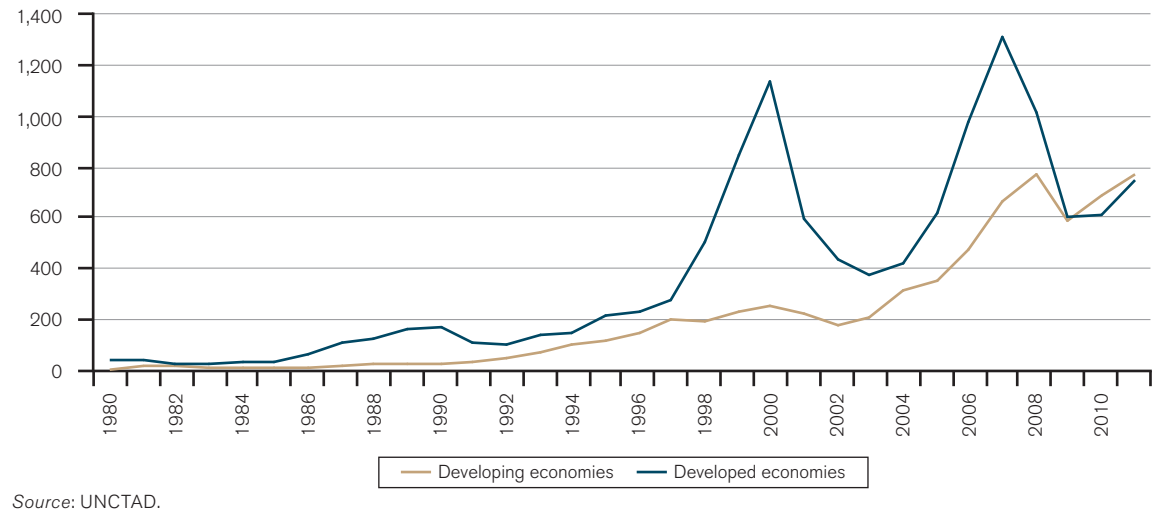
Traditionally, FDI consisted of intra-industry investment flows between similar developed countries (Forte, 2004). The latest World Investment Prospects Survey suggests that the European Union and North America will remain among the most important regions for FDI by multinational companies in the medium run (UNCTAD, 2012). During the 1990s, FDI directed at developing countries began to grow substantially (see Figure C.27). This largely represented investments by advanced economies' firms in developing countries, whereby the former offshored unskilled labour-intensive parts of the production process to the latter in order to take advantage of lower costs (Helpman, 1984).[93] In addition to such "vertical" FDI, advanced country firms also viewed developing countries with large markets and significant barriers to trade as appropriate destinations for "horizontal FDI" (Dunning, 1980).

Much like foreign portfolio flows and bank lending from abroad, FDI flows into developing economies were largely confined to Asia and Latin America. Table C.7 shows that with the exception of Turkey, the top 15 developing country recipients of FDI inflows during the last two decades were in these two continents. East Asia did particularly well, with as many as six countries in the top 15 and China at the top of the table. This may be explained, in part, by the availability of adequate supporting infrastructure and the quality of institutions because they reduce transaction costs (see Section C.6).

Countries in South-East Asia, for example, have concentrated their public resources on the development of infrastructure, including roads, ports, electricity and telecommunication services (Ando and Kimura, 2005). The World Investment Prospects Survey outlines the continued importance of Asia and Latin America, as respondents listed China, India, Indonesia and Brazil as four of the top five most likely destinations for their FDI in the medium term (UNCTAD, 2012).

Even in Africa, where public infrastructure investment is relatively inefficient, improving infrastructure has a

Figure C.27: **Inflows of foreign direct investment, 1980-2010**
(US$ billion)



Source: UNCTAD.

Table C.7: **Average annual FDI flows of the top 15 developing countries, 1990-2011**
(US$ million)

Inward FDI		Outward FDI	
China	55,253	Hong Kong, China	33,146
Hong Kong, China	28,758	China	15,473
Brazil	20,635	Singapore	10,435
Singapore	19,113	Korea, Republic of	7,423
Mexico	16,378	Chinese Taipei	5,899
India	10,370	India	4,922
Saudi Arabia, Kingdom of	7,872	Malaysia	4,291
Chile	6,537	Brazil	3,660
Argentina	6,089	Mexico	3,121
Turkey	5,578	Chile	2,986
Thailand	5,286	United Arab Emirates	2,621
Malaysia	5,055	Kuwait, the State of	2,135
Korea, Republic of	4,463	Thailand	1,551
Colombia	4,262	Colombia	1,446
United Arab Emirates	3,843	Panama	1,392

Source: UNCTAD.

Note: Economies with an average GDP, between 2000-2010, below current US$ 10 billion were excluded. Indonesia was excluded because of large gaps in the data.

positive impact on FDI inflows (Asiedu, 2002; Morrisset, 2000) . It is also argued that high domestic private investment is a signal for high returns to capital, which attracts foreign investment. For instance, analysing a sample of 38 Sub-Saharan African countries between 1970 and 2005, Ndikumana and Verick (2008) find that domestic private investment has a strong positive impact on FDI inflows. This suggests that efforts to improve incentives for private investment through improving the quality of institutions will result in foreign investors viewing African countries more favourably in the future. In fact, the World Investment Prospects Survey shows that FDI in Africa is expected to pick up over the medium run owing to stronger economic growth, on-going policy reforms and high commodity prices (UNCTAD, 2012).

In recent times, high savings rates, increased capital intensity and technological progress have resulted in certain developing economies becoming sources of FDI as well. Figure C.28 shows a steady increase in FDI outflows from developing economies between 2003 and 2010. The bulk of this FDI represents flows from emerging economies to low-income countries, contributing to increased investment rates in the latter (World Bank, 2011a).

Table C.7 shows that the top five sources of FDI among developing economies over the last two decades are in East Asia (with Hong Kong, China and China occupying the top two positions). Other important source regions include India as well as countries in Latin America and the Middle East. Furthermore, much of the FDI between developing countries is intra-regional (World Bank, 2011a). Inter-regional FDI among developing economies goes primarily from Asia to Africa. China and Malaysia are among the top ten sources of FDI in Africa (UNCTAD, 2006).

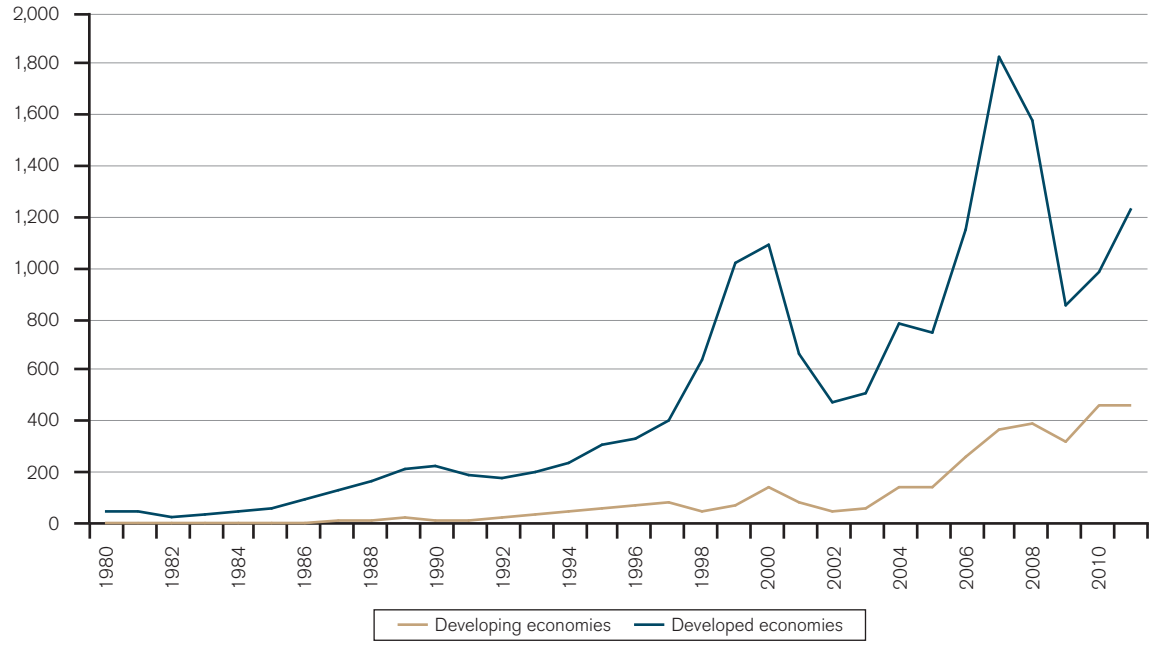
The World Investment Prospects Survey reports that, in marked contrast to developed countries, nearly one-quarter of respondents in developing economies foresaw a decline in their FDI budgets in 2013 and 2014 (UNCTAD, 2012). This may be explained by the fact that multinational companies from developing economies continued to invest at near record levels during the crisis and may focus on rationalizing their investments in the medium term. In the long run, however, high expected growth in emerging economies, a familiarity with similar policy environments and the overall strengthening of trade links between developing economies is likely to enhance FDI between these countries.

(c) Conclusions

Investment in infrastructure can lead to the emergence of "new players" in world trade in the future. This may be particularly important for low-income countries in Africa, hitherto less involved in global production networks. It may also change the nature of trade in other ways. Better transport infrastructure across neighbouring countries, such as road connectivity, could strengthen regional trade in Africa. More extensive ICT infrastructure could further expand services trade and alter the pattern of international specialization. English-speaking African countries, for example, could mark a presence in the area of business process outsourcing.

Governments in these countries must therefore focus on scaling up and improving the quality of public infrastructure. This may involve enhancing domestic savings rates. The implementation of growth-promoting strategies that raise household incomes would be central to promoting savings. Altering tax systems and macroeconomic policies may also play a part. Ensuring that savings are translated into investment through improving the efficiency of capital markets is likely to be

Figure C.28: **Outflows of foreign direct investment, 1980-2010**
(US$ billion)



Source: UNCTAD.

equally important. Governments could utilize overseas development assistance, FDI and bank lending from abroad to increase infrastructure investment as well. The WTO's Aid for Trade initiative for developing countries is also important in this regard as it can increase a country's supply capacity and hence its participation in the world market (see Section E).

Greater public and private investment in physical capital, financed by domestic savings or capital flows from abroad, may also influence the comparative advantage of countries. There is a possibility for some unskilled labour-intensive economies, such as Chile, China and Turkey, to become capital-intensive economies in the medium to long run. Savings rates in many of these economies are already high.

Therefore, in order to move up the product ladder (in terms of capital and technology intensity), governments must concentrate on creating adequate investment opportunities for both domestic and foreign capital. This lack of opportunity is perhaps reflected in the increasing outflow of FDI from certain developing economies, such as China, Singapore, the Republic of Korea and India, to other developing and even developed economies. Of course, it is important to highlight the fact that outward FDI from developing economies is associated with the emergence of developing country-based multinational companies which, by enhancing capital and technology intensity, can itself influence comparative advantage.

It is hard to predict how capital flows across countries (and therefore their contribution to capital accumulation) will evolve in the future. Existing forecasts from the World Investment Prospects Survey, for example, suggest that FDI flows are expected to increase at a moderate but steady pace over the medium term (UNCTAD, 2012). This baseline scenario, however, does not consider the possibility of negative macroeconomic shocks.

It is possible that the fragility of the world economy, the volatility of the business environment and uncertainties related to the sovereign debt crisis will negatively impact FDI flows in the medium term. Nevertheless, developing and strengthening institutions, such as a sound legal framework, would undoubtedly be important to attracting FDI. Preferential trade agreements with provisions for "deep integration" can play an important role in this regard. Establishing capital markets with sufficient depth is also crucial to attracting additional sources of investment finance, such as foreign portfolio investment and bank lending from abroad. This holds true for both low- and middle-income countries.

Reforms in the banking sector need to encourage financial institutions to move towards sound credit assessment methodologies. At the same time, stock and bond markets can play a larger role in domestic resource mobilization. This would require a strong legal framework, transparency requirements, financial accounting and auditing rules of international standard. The enforcement capabilities of independent regulation are also likely to play a part in reducing systemic risk and protecting investors' interests.

It is worth noting that external resource flows from abroad influence the nature of trade not only through

their impact on domestic investment but also directly. For instance, the trade literature suggests that portfolio investment and bank lending relationships across countries can increase trade flows by reducing information asymmetries between exporters and importers. Similarly, FDI flows complement trade by facilitating global supply chains – increasing exports of intermediate products and services from the home country and those of the final good from the host country. Moreover, exports from the host country to third country markets may increase. FDI flows can also affect the comparative advantage of developing economies by facilitating the transfer of technology across countries. China is an example of such technology upgrading.

In fact, to the extent that investment and trade are complementary, an international system of investment rules can increase the flow of foreign investment by promoting predictability and security of access for foreign investors (see Section E). So can bilateral or regional agreements, which are being increasingly used to govern international investment. These agreements, however, run the risk of affecting the "level playing field"[94] in the future by creating regulatory divergence. A set of multilateral investment rules could ensure a more efficient international allocation of resources (with investment not diverted because of preferential treatment) across borders, which in turn should help trade. It could also bring greater parity between big and small countries, reducing the power imbalance which may arise if a large country negotiates with a small country on a bilateral investment agreement.

3. Technology

Technological differences between countries are an important determinant of income levels and trade. Empirical research has shown that the accumulation of physical and human capital can only partially explain different income levels across countries (Easterly and Levine, 2001; Prescott, 1998) and different trade patterns. The residual is commonly attributed to technological differences between countries, whereby technology is defined as the information or knowledge required for production.

Technological progress is undoubtedly the major factor explaining the fast growth in income in the 19th and 20th centuries. Electrification, the telephone, the internal combustion engine and other breakthroughs have dramatically changed the way the world works (see Section B.1). Likewise, technological progress will be a major factor in explaining the future patterns of trade and growth. Simulations about the future of global trade discussed in Section B.3 highlight that the assumptions about the future path of technological progress play by far the largest role in affecting overall outcomes.

A country's technological level is determined not only by domestic innovation but also by the diffusion of technology from abroad. Typically, while the former is particularly important for high-income countries, the latter mostly affects technological progress in middle- and low-income countries. This section first looks at patterns of innovation and technology transfer. Then it discusses how technological changes affect trade. Thirdly, it looks at the determinants of technological progress. Finally, it explores what these trends imply for the future of trade and trade policy.

(a) Technology patterns

Section B found that there are important emerging players in international markets, that trade is becoming more regionalized and that it is highly concentrated in few global companies. This section explores whether innovation and technology transfers can help to explain these patterns. In particular, it explores whether there is evidence of emerging new countries (that have significantly accelerated their capacity to innovate or absorb existing technologies) and new sectors (where technological knowledge has increased faster), whether innovation and technology transfers are more localized, regionalized or globalized than in the past and whether there is a relationship between these trends and offshoring. Finally, it also looks at the role of large multinational companies versus small and medium-sized enterprises in driving technological progress.

(i) Measuring technological progress

Measuring technological progress is a difficult and imperfect field of study. Widely used measures of technological progress include total factor productivity, research and development (R&D) expenditure and patent applications (Keller, 2010). However, each measure captures a different and incomplete picture of technological progress.

Total factor productivity (TFP) measures an economy's efficiency in transforming inputs into outputs. Empirically, total factor productivity is defined as the output per unit of combined inputs (usually, a weighted sum of capital and labour) and is calculated as a difference between a country's GDP and the contribution of capital and labour. The residual output that is not explained by capital and labour inputs is considered "technology". This approach suffers from important limitations due to both a lack of data and its poor quality. For example, estimations of TFP may attribute to technology what should be explained by labour or capital (physical and human capital), were the data of better quality.

R&D expenditure measures the input into technological innovation activity. A drawback of this approach is that not all research investments generate innovations;[95] and even when they do, the rate of return can vary

significantly depending on the specific investor and the way investments were made. For example, the return to publicly funded R&D is typically lower than the return to privately funded R&D (Keller, 2010). Moreover, since data are typically collected on a geographical basis, it often fails to distinguish between R&D investment in domestic firms and in foreign-owned affiliates.

Measuring patent applications addresses several of the limitations of other approaches. Unlike comparisons of R&D expenditure, patent application data captures the outputs of the innovative process (the invention) rather than its inputs (the research).[96] This approach also distinguishes between innovations generated by residents and non-residents.[97] However, a simple count of patents may be a misleading indicator of country's level of technology for several reasons. First, there is not necessarily a direct correlation between inventions and innovations. Not all innovations are patented. For example, patents tend not to capture innovations in services or organizational methods. Nor are all inventions patented in the country where they were generated.

An invention produced in a developing country, for example, might not be patented there if it is likely that the technology will be manufactured or produced elsewhere. Patents also tend to have widely different scientific and commercial values – typically a relatively small number of patents accounts for a large share of the value of the patent stock[98] – meaning that there is a tenuous link between a country's number of patents and its technological output.

Regarding technology transfers, there are two aspects that can be measured: the purchase of technology (see Box C.7)[99] and technology spillovers. Included in measures of technology purchases are royalty payments, R&D services trade, trade in technology-intensive goods, the share of foreign-owned employment in total employment, and foreign direct investment. In each case, a certain technology is made available to the importing country in exchange for payment – i.e. a licensing fee, a wage, or the price of the good. This measurement implicitly assumes that the technology embodied in these imports is not permanently available to domestic producers. If the import of that good or service stops for any reason, or the licence expires, the productivity gains are also assumed to disappear, as the importing country is unable to produce the knowledge embodied in the good, service or licence on its own.

A limitation of measuring technology transfer in terms of the monetary value of the market transaction is that it does not account for technology spillovers – i.e. the technology that is absorbed by the importing country without payment. This may happen through a variety of channels, including worker training, interaction with suppliers or reverse engineering. When an importing country acquires technology this way, the knowledge is retained even if the act of importing is interrupted or stopped.

Spillovers are difficult to distinguish empirically from knowledge flows, although there are at least two conceptual differences. First, knowledge flows, unlike spillovers, do not necessarily involve externalities; and secondly, they are consistent with a two-way interaction between actors rather than involving the one-way transfer of technology from one actor to another. One common way to estimate technology spillovers is to study the impact of foreign R&D on productivity or, alternatively, the impact of technology developed abroad on the rate of innovation of the home country. Evidence on technology spillover is discussed later in the section.

(ii) The geography of technological progress

New leaders

In recent years, there have been important changes in the geography of innovation. Although the technological gap between high- and low-income countries persists, R&D investments have become more globalized (Fu and Soete, 2010; Lundvall et al., 2009).

Figure C.29 shows the distribution of business R&D in a sample of 37 countries for 1999 and 2010.[100] It can be seen that over the sample period, R&D expenditures have become less concentrated. For example, while countries representing 20 per cent of total population accounted for about 70 per cent of R&D expenditure in 1999, these countries accounted for only about 40 per cent of R&D in 2010.

Most importantly, certain countries that traditionally have served simply as production platforms for developed countries increasingly base their economic growth on their own capacity to innovate and contribute to the technology pool (Mahmood and Singh, 2003). For example, Table C.8 provides the total number of patent applications by country of origin of the applicant. It shows that the contribution of China and other Asian countries, such as Singapore, India and the Republic of Korea, to the "pool" of technological innovation has significantly increased from 1985 to 2010.[101]

One possible explanation for the growing importance of these Asian countries in innovation is the relocation of significant manufacturing capacity to them (including the development of new and existing domestic industries as well as the location of foreign subsidiaries). As Pisano and Shih (2012) point out, producers benefit from the interaction with innovators and vice versa. The transfer from R&D into production can be complex and require significant coordination between those who design a good and those who

Box C.7: **Limits of traditional measures of market- and intellectual-property-based technology transfer: a statistical perspective**

Changing economic environments and business practices require statistical frameworks to adapt. Methodological research has helped clarify a number of conceptual issues which were left untackled in previous statistical frameworks. Consequently, the 1993 System of National Accounts and the fifth edition of the Balance of Payments Manual (BPM5) were both revised in 2008 to reflect better the economy and trading structure. Subsequently, the Manual on Statistics of International Trade in Services was also revised to guarantee consistency with the main frameworks and to add conceptual clarification on aspects that were not fully elaborated in the previous version, such as the measurement of international supply of services by mode of supply.

The new guidelines – the sixth edition of the Balance of Payments Manual (BPM6) and the 2010 Manual on Statistics of International Trade in Services (MSITS 2010) – also provide clearer conceptual guidance as to how to classify and measure transactions related to intellectual property, and in particular those related to technology transfer. The category "royalties and licence fees" has been replaced by "charges for the use of intellectual property not included elsewhere" and the item "research & development services" has been broken down by additional categories to allow for a clearer conceptual measurement.

Transactions relating to the right to use the results of research and development[102] are covered under charges for the use of intellectual property not included elsewhere. Transactions related to research and development services as well as the outright sales of property rights arising from research (e.g. patents, industrial processes and designs, copyrights arising from research and development) are covered under the research and development services item. MSITS 2010 proposes a breakdown of this item into "work undertaken on a systematic basis to increase the stock of knowledge" (reflecting the coverage of research and development within the national accounts) and "other". The former is further broken down into "provision of customized and non-customized research and development services" and "sale of proprietary rights arising from research and development" which is itself broken down into "patents, copyrights arising from research and development, industrial processes and designs" and "other".

To collect the respective information requires drafting of appropriate guidance for data collection systems, such as the international transaction reporting system or general trade in service surveys. For example, when considering multinational enterprises, many of the technology transfer transactions take place within this particular group of firms and consequently the valuation of trade (i.e. transactions) may be distorted as the pricing used may significantly be influenced by tax policies in the locations where these multinationals have established affiliates and therefore may significantly differ from the actual "real"-market value of transactions. Economic ownership of intellectual property assets may be an additional barrier to the appropriate measurement of transactions. Indeed, multinationals may choose to register their patent or industrial process in one country rather than another based on "tax evasion" strategies. Consequently, the country of registration is not necessarily the same as the one of the economic owner of the intellectual property – the same invention may be patented in multiple countries. For example, statistics from the World Intellectual Property Organization (WIPO) report that about 40-50 per cent of all patents are so-called secondary filings.

In other cases, firms may not be affiliated but a client enterprise may outsource completely the production of a product (i.e. virtual manufacturing), providing all the knowledge to the manufacturer for the production of these goods. Again, it is unclear how the relevant transactions, and in particular the ones pertaining to knowledge transfer, should be accounted for or not, as this may differ significantly according to the different types of arrangements which are adopted. In other words, although international guidelines clarify the conceptual classification of transactions, they fail to provide clear recommendations as to how to clearly compile the respective statistics. The compilation guidance that is currently being drafted by the UN expert group on compilation of trade in services statistics[103] should, however, help clarify the situation. In addition, a Task Force on Global Production has been established by the Conference of European Statisticians to set up clearer guidelines in relation to global production arrangements from the perspective of national accounts as well as from the perspective of the trade in services and balance of payments statistics.

Following the establishment of these more detailed guidelines, it is expected that some specially targeted surveys should help improve the situation, in particular when it comes to the more detailed information sought. Nevertheless, many countries/compilers will probably not be in a position to collect accurately such detailed information, often for budgetary reasons. A solution could be to complement their more general data collection systems with the information collected and disseminated by those countries which will engage in a more detailed and sophisticated data collection system (probably for countries which have a particular interest in this information because of significant research and development activities). However, this can only function if there is efficient cooperation between compilers of different countries. In addition, it will be necessary to have detailed bilateral information published by countries that will be engaging in detailed data collection.

Table C.8: **Patent applications by country of origin, 1985-2010**
(top 30 countries)

	Number of patent applications			Global ranking		
		US office only			US office only	
Origin	**2010**	**2010**	**1985**	**2010**	**2010**	**1985**
Japan	468,320	84,017	274,404	1	2	1
United States	432,911	241,977	64,308	2	1	3
China	308,318	8,162	4,066	3	9	10
Korea, Republic of	178,644	26,040	2,703	4	4	15
Germany	173,532	27,702	32,574	5	3	4
France	65,623	10,357	12,240	6	8	6
United Kingdom	50,865	11,038	19,846	7	7	5
Switzerland	39,393	4,017	3,344	8	13	13
Netherlands	33,388	4,463	1,994	9	11	20
Russian Federation	32,835	606	3	10	26	71
Italy	27,910	4,156	2,137	11	12	18
Canada	24,209	11,685	2,110	12	6	19
Sweden	22,443	3,840	3,871	13	14	12
India	14,862	3,789	982	14	15	27
Finland	13,046	2,772	1,732	15	17	23
Belgium	11,804	2,084	807	16	18	30
Australia	11,556	3,739	21	17	16	54
Denmark	11,233	1,773	872	18	19	29
Austria	11,062	1,661	2,282	19	20	16
Israel	10,928	5,149	800	20	10	31
Spain	10,733	1,422	2,163	21	22	17
Democratic People's Republic of Korea	8,055	-	-	22	-	-
Norway	5,595	936	928	23	24	28
Singapore	4,229	1,540	4	24	21	69
Brazil	4,212	568	1,954	25	27	22
Turkey	4,211	150	132	26	36	38
Ireland	4,102	796	730	27	25	32
Poland	4,061	185	5,124	28	35	8
New Zealand	3,223	541	1,010	29	28	26
Ukraine	3,038	64	-	30	48	-

Source: Authors' calculation based on data from WIPO IP Statistics, at http://ipstatsdb.wipo.org/ipstatv2/ipstats/patentsSearch, accessed in March 2013.

manufacture it. Similarly, designing a product may be difficult if the designer does not understand how production works. Thus, as manufacturing shifts to Asia, it is likely that so too will know-how, research and eventually innovation.

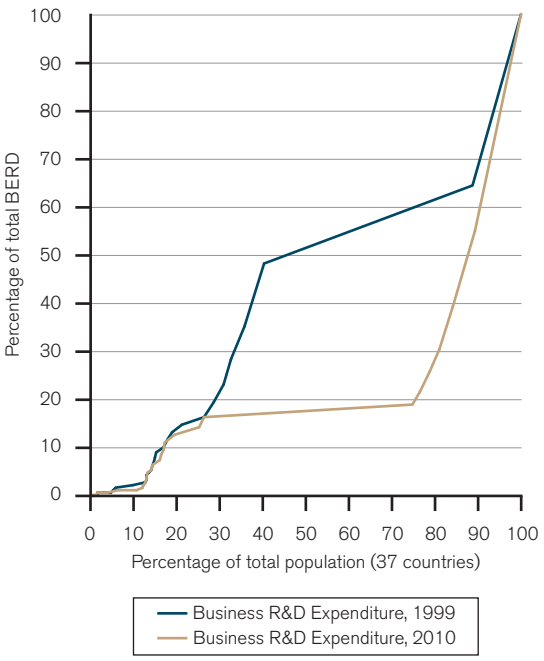
However, the growing importance of Asian countries in innovation is not driven by multinational firms alone. For example, the great majority of patents and the bulk of R&D activity in China are generated by Chinese entities. R&D conducted by foreign subsidiaries still represents a relatively small share.[104] As shown in Figure C.30, the number of patent applications by residents[105] in Asia has increased significantly since 1995, as have applications in the OECD from non-residents.

Internationalization of technological progress

As discussed above, technological progress is determined not only by domestic innovation but also by international technology spillovers. In developing countries, where domestic innovation is low, spillovers acquire relatively greater importance. Understanding their geographical extent – i.e. whether the spillovers are localized or global – is crucial to determining their nature and impact. Indeed, the prevalence of international technology spillovers is a major determinant of the world's income distribution. While global technological spillovers promote income convergence worldwide, local spillovers do not.

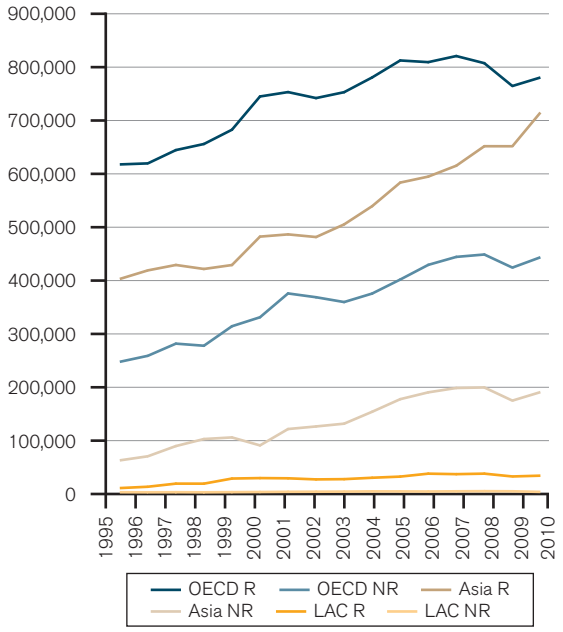
In general, the empirical evidence supports the view that spillovers tend to be local – i.e. stronger within than across countries. Using patent citations as a measure of technological spillovers, Jaffe et al. (1993) find that US patents are more often cited in other US patents than in other foreign patents (Branstetter, 2001; Eaton and Kortum, 1999). Looking at a wider set of countries, Keller (2002) also finds that international technological spillovers are conditional on geographical distance. Measuring the impact of

Figure C.29: **R&D distribution, 1990-2010** (cumulative shares)



Source: Authors' computations based on R&D data from OECD Science, Technology and R&D Statistics, at http://www.oecd-ilibrary.org/science-and-technology/data/oecd-science-technology-and-r-d-statistics_strd-data-en, and population data from World Development Indicators (WDI), at http://databank.worldbank.org/

Figure C.30: **Patent applications from residents and non-residents, 1995-2010**



Source: Authors' computations based on data from WIPO IP Statistics Database, at http://ipstatsdb.wipo.org/ipstatv2/ipstats/patentsSearch.

Note: "R" indicates residents and "NR" non-residents. Italy is excluded from the OECD group due to the limited data availability. The regions of Asia is represented by top patent applicants. The region Asia includes China, Japan and Republic of Korea; Latin America and the Caribbean (LAC) includes Brazil, Chile and Mexico.

R&D expenditure in the five OECD countries on industry-level productivity of another nine OECD countries, he finds that the impact decreases with distance. The degree of localization, however, has decreased over time. For the period 1973-83, Keller (2002) estimates that at a distance of 2,000 kilometres between the senders and the receivers of technological knowledge only 5 per cent was actually absorbed. However, for the period 1986-95, he finds this percentage increased to 50 per cent.[106]

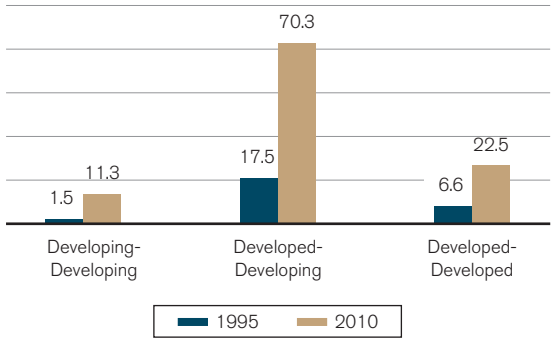
One possible explanation for the widening geographical radius of technology spillovers is the internationalization of the innovation process, including the growing mobility of experts and expertise, the increasing number of international co-authorships and the rising share of patents that list inventors from more than one country (WIPO, 2011). As shown in Figure C.31, one of the most interesting recent developments is the increased incidence of co-authorship between developed and developing country scientists and researchers.

A second possible factor driving the growing radius of R&D spillovers is the increased importance of production networks. The international fragmentation of the production process increases cross-border interactions, which in turn increases technological spillovers. Following the approach suggested by Keller (2002) and Bottazzi and Peri (2003), this report also calculates how R&D spillovers decline with distance but it distinguishes between countries that are highly integrated and those that are not.[107]

As shown in Figure C.32, R&D spillovers from vertically integrated countries remain more significant over longer distances than R&D spillovers from countries that are on average less vertically integrated. Specifically, a 10 per cent increase in foreign R&D spending in countries that are located within 300 km translates on average into 0.04 per cent increase in patenting in the home country. However, the result is higher for vertically integrated country-pairs, for which a 0.08 per cent increase in patenting at home is estimated if the foreign country is highly vertically integrated with the home countries (details of the methodology used are provided in Box C.8).

Although production networks may have helped to widen the radius of technology spillovers, these networks tend to be regional rather than global – i.e. they tend to increase trade and investment flows between closer international locations than between locations farther apart. It follows that technological diffusion may also have become more regionalized rather than more globalized – an observation that is supported by the results of this report. As shown in

Figure C.31: **International co-authorship of science and engineering articles, 1995-2010** (in thousands)



Source: Authors' computations, based on data from Appendix Table 5-41 of Science and Engineering Indicator 2012, National Science Foundation (NSF). Retrieved at: http://www.nsf.gov/statistics/seind12/append/c5/at05-41.xls

Figure C.33, technology spillovers are much higher among countries within a region than outside it.

Observed patterns of trade in high-technology products also support the idea that technology spillovers may have regionalized. Figure C.34 shows the percentage of trade in high-technology products within a region versus between regions. Interpreting an increase in trade in high-tech products as a measure of stronger technological spillovers, the increasing share of trade in high-technology goods within a region seems to point to an intensification of technology diffusion at the regional level.

One implication of the regionalization of technology spillovers is the possible emergence of "convergence clubs", that is groups of countries that become increasingly similar in terms of technology levels, trade more among themselves, share similar economic interests and possibly engage in building stronger regional institutions.

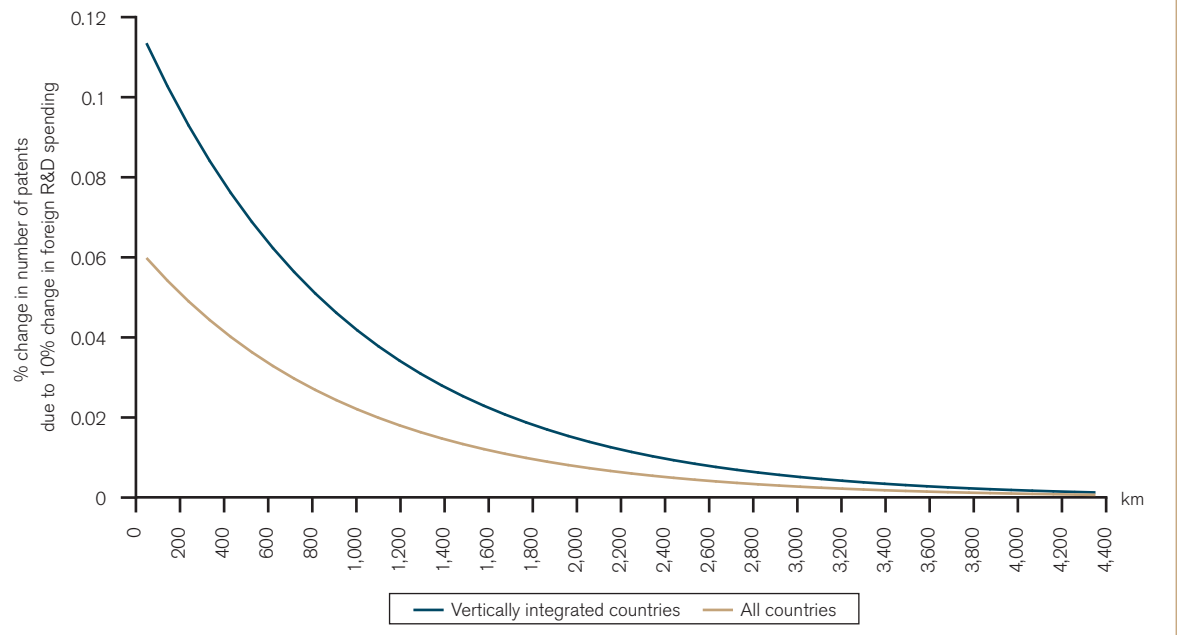
(iii) The changing nature of technological progress

Sectoral distribution

R&D spending is highly concentrated. Nearly 90 per cent of R&D investment takes place in the manufacturing sector, and within this sector over 90 per cent of investments occur in just four industries: chemical products, electrical and non-electrical machinery (covering information communication technology – ICT) and transportation equipment (see Table C.9 and Appendix Table C.1 for details on composition).

Although most R&D takes place in the manufacturing sector, R&D in the services sector has experienced the fastest growth since the early 1990s. Table C.9 shows that R&D expenditure in services increased from 6.7 per cent of total business R&D between 1990 and 95 to nearly 17 per cent between 2005 and 2010. Within services, business services saw the biggest increase in R&D expenditure over the period (see Appendix Table C.2). In general, knowledge-intensive business services (KIBS) are emerging as key drivers of knowledge accumulation and may in the long run replace manufacturing as the engine of global innovation. Eurostat's 2008 Community Innovation Survey[108] shows that the proportion of innovative firms in some categories of KIBS, including 59 per cent

Figure C.32: **R&D spillovers by distance and degree of vertical integration**



Source: Authors' calculations based on Piermartini and Rubinova (2013). See Box C.8 for details.

Note: "Vertically integrated countries" are defined as those country-pairs with a share of trade in intermediates above the median.

Box C.8: **Production network and the geography of technological spillovers: methodology**

The estimates for international R&D spillovers in Figures C.31 and C.32 were obtained through an econometric model (Piermartini and Rubinova, 2013). Following the economic literature (Keller, 2002; and Bottazzi and Peri, 2003), a country's patents applications were related to its R&D spending and the R&D undertaken in foreign countries. Intuitively, if the level of foreign R&D matters for domestic innovation, some of the technology created abroad must cross international borders.

In particular, using a panel of 41 countries over the period 1996-2007, the following equation was employed:

$$\ln(Patents)_{it} = \alpha + \beta \cdot \ln(R\&D)_{it} + \gamma \cdot PoolR\&D_{it} + X_{it} \cdot \delta + t + e_{it}$$

where *Patents* indicates the number of patent applications of country i at time t, *R&D* denotes domestic business expenditure in R&D and *PoolR&D* is the pool of R&D available to the home country and generated abroad. All variables are in logarithms (ln). In particular, the variable *PoolR&D* is calculated as a weighted average of all foreign countries' R&D expenditure, where the weights are the distances between the home country and each foreign country. The formula used to construct this variable is: $PoolR\&D_{it} = \sum_{j \neq i} \ln(R\&D)_{jt} \cdot \exp(-distance_{ij})$

A set of control variables (denoted by *X* in the equation above) was also introduced. These include population and real GDP per capita to control for a country's market size, the share of tertiary graduates in total population to capture the country's capacity to generate innovation, and the level of patent protection and the origin of the legal system to control for quality of institutions – an important determinant of the incentives to innovate.

The coefficient of interest is γ. This indicates the percentage change in domestic patenting activity due to a 1 per cent increase in the pool of foreign R&D. A positive value of this coefficient suggests international technological spillovers.

To test how production networks affect international spillovers, the variable *PoolR&D* was split into two components. One is the pool of R&D from countries that are highly vertically integrated with the home country. The other is the pool of R&D from the rest of the world. The vertical connection was defined on the basis of the share of machinery parts and components country *i* imports from country *j* relative to the total machinery imports of country *i*. Thus, country *j* is identified as a country highly vertically integrated with country *i* if its exports of intermediates to country *i* are above the median.

When the R&D spending pool was split, it was found that R&D spending only from countries that are important input suppliers has a positive and significant effect on the home country's patenting activity.

in information and communication and 52 per cent in finance and insurance activities, exceeded the 51 per cent share in the manufacturing sector (Meliciani, 2013).

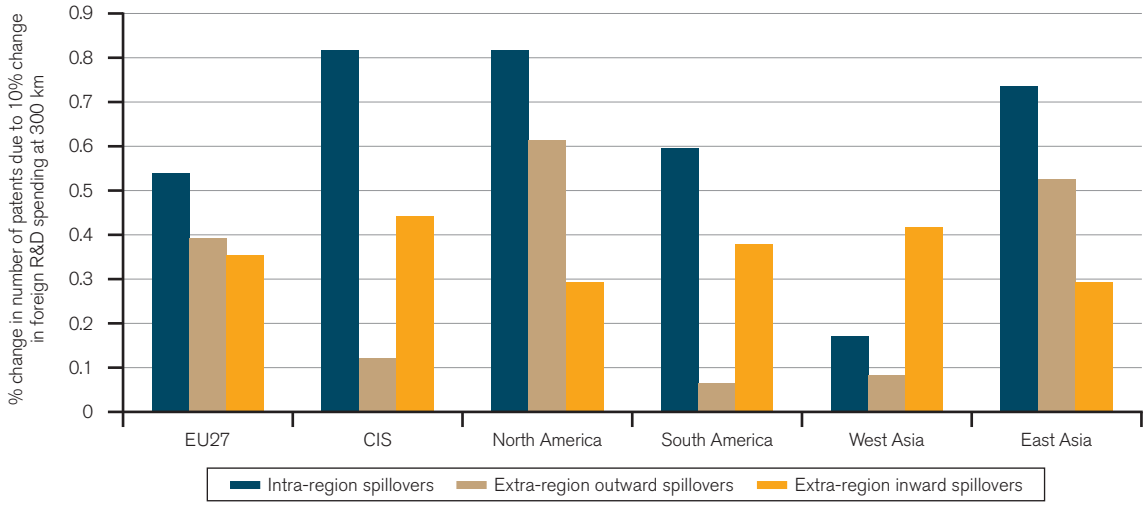
Data on patent applications highlight the significant contribution of ICT-related technologies to innovation over the past three decades. Table C.10 shows the ten technology fields that experienced the fastest growth in terms of patent applications over the period 1980-2010. Among these top ten technology fields, five are related to ICT development – namely, IT methods for management, digital communication, computer technology, semiconductors and telecommunications.

The importance of the ICT sector in innovation over the past decades has led many to identify the ICT revolution as the third period of industrial innovation. This revolution began in 1960 and followed two previous waves of innovations. The first, between 1750 and 1830, created steam engines, cotton spinning and railroads. The second, between 1870 and 1900, produced electricity, the internal combustion engine and running water with indoor plumbing. Jorgenson et al. (2005) extensively study the contribution of IT to productivity and growth. They estimate that as a group, IT-producing industries contributed more to the growth of total factor productivity between 1977 and 2000 than all other industries combined.

However, other economists have questioned whether ICT innovations have had as profound an impact on economic growth as previous technological advances, such as steam power or electrification. In a recent paper, Gordon (2012) argues that the ICT revolution has not fundamentally changed living standards and that its economic impact is already diminishing. In support of his argument, he notes the slowdown in US productivity growth since the 1970s.

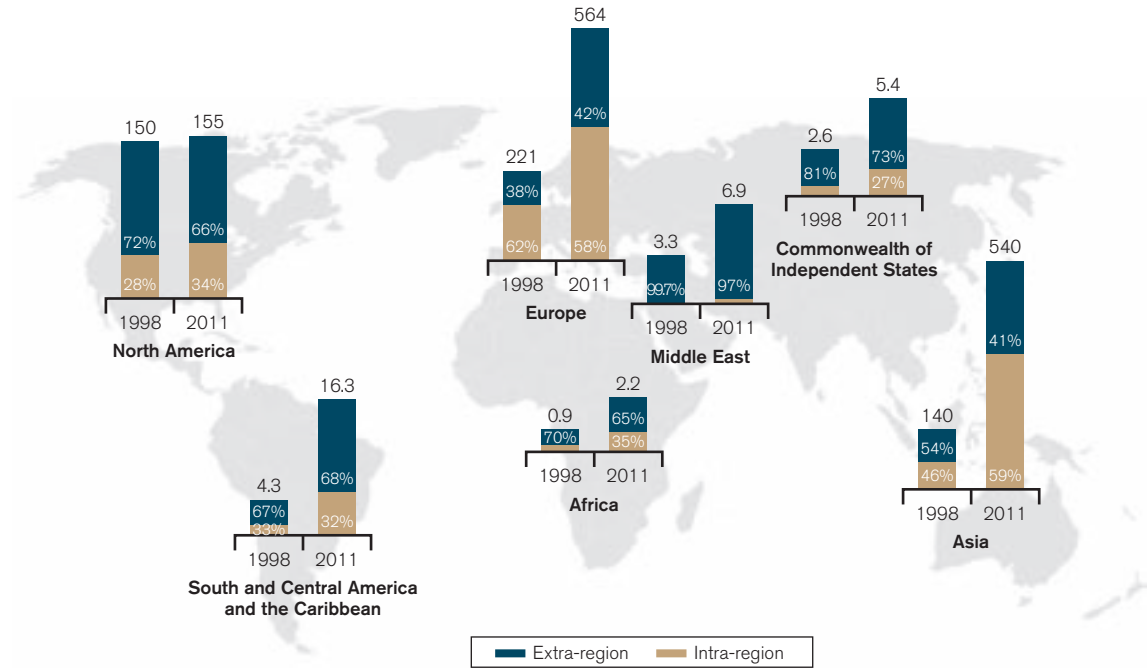
Others highlight other explanations for the US productivity slowdown and are more optimistic about the potential growth impact of the ICT revolution. First, energy price shocks in the 1970s and 2000s may

Figure C.33: **Technology spillovers within a region versus spillovers into other regions**



Source: Authors' calculations based on Piermartini and Rubinova, 2013. See Box C.8 for details.

Figure C.34: **Exports of high-tech products within a region versus between regions, 1998 and 2011** (US$ billion and percentage)



Source: Authors' computation, based on data from World Integrated Trade Solution (WITS), World Bank, at http://wits.worldbank.org/wits/. The definition of high-tech products follows OECD Working Party on International Trade in Goods and Trade in Service Statistics (2008).

Note: Boundaries do not imply any judgement on the part of the WTO as to the legal status of any frontier or territory.

better explain the productivity slowdown, which started in the 1970s and gradually spread to the wider economy via the most energy-intensive sectors. Secondly, the information technology revolution may still be in its early phase, with its major economic impacts yet to be felt. The past two major technology waves, in the early 19th century and in the early 20th century, required almost a century before their impact fully diffused throughout the economy.

Moreover, the influence of technology and innovation on the economy may be cumulative. While doubling technological capacity may not matter much when the initial level is low, it can have huge effects when the level rises.[109] The exponential growth of the internet over the past two decades, as the synergies between existing communications and information technologies are recognized and exploited, illustrates this cumulative effect.

Table C.9: **Business R&D by sector, 1990-2010**

Sector	1990-95 average		2005-10 average	
	Value	Share of total BERD (%)	Value	Share of total BERD (%)
Agriculture, hunting and forestry	578.5	0.4	606.1	0.2
Manufacturing	126,442.8	88.9	200,273.1	81.0
Services	9,470.8	6.7	41,703.0	16.9

Source: Authors' computations, based on data from OECD Science, Technology and R&D Statistics, at http://www.oecd-ilibrary.org/science-and-technology/data/oecd-science-technology-and-r-d-statistics_strd-data-en

Note: Total over 24 countries; values in US$ million, PPP adjusted, 2005 constant prices, share in percentage. For the purpose of consistency and comparability, the aggregation of business R&D by sectors is done using only countries with data for all three sectors, both in the period of 1990-95 and the period of 2005-10. As a result, 24 countries are in the sample – i.e. Austria, Canada, Czech Republic, Denmark, Finland, Germany, Greece, Hungary, Iceland, Ireland, Japan, the Republic of Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, Romania, Singapore, Slovak Republic, Slovenia, Spain, Sweden and Turkey.

Table C.10: **Patent publication by technology field (ten fastest growing), 1980-2010** (percentage)

Technology field	Average growth rate 1980-2010	Share of world total patent publication in 2010
Micro-structural and nano-technology	98	0.17
IT methods for management	58	1.31
Digital communication	39	4.27
Computer technology	26	7.37
Biotechnology	24	2.28
Semiconductors	22	4.35
Medical technology	20	4.41
Telecommunications	18	3.20
Analysis of biological materials	17	0.67
Audiovisual technology	16	4.57

Source: Authors' computations, based on data from WIPO IP Statistics Database, at http://ipstatsdb.wipo.org/ipstats/patentsSearch

The role of multinationals versus SMEs

Most R&D spending is conducted by firms based in OECD countries; multinational firms in particular are major drivers of R&D spending.[110] Available data for 1999 show that in the United States 83 per cent of all manufacturing R&D was conducted by parent companies of US multinationals (NSF, 2005).

So far, small and medium-sized enterprises (SMEs) have underperformed relative to larger firms, both in terms of R&D spending and innovation. In a recent report on SMEs and innovation, the OECD (2010a) observes that "SMEs innovate less than large firms across a range of categories including product innovation, process innovation, non-technological innovation, new-to-market product innovation and collaboration in innovation activities". This observed gap still persists even after adjusting for firm size – i.e. SMEs have lower innovation rates per employee than larger firms (Audretsch, 1995). However, this statistical gap tends to obscure the fact that there is substantial interaction between large firms and SMEs in innovation. SMEs that have produced breakthrough innovations are often acquired by large firms which then build upon and commercialize the initial innovation.

There are reasons to expect that SMEs will become increasingly important in the global landscape of innovation. Recent developments in production technologies and consumer tastes suggest that economies of scale and scope in R&D and production – the competitive edge of larger firms – will become less significant and advantageous in the future. The OECD (2010a) points to two particular trends which may reduce the importance of economies of scale and scope, and potentially empower SMEs. First, some innovations, such as 3D printing, will make it possible for SMEs across numerous industries to produce on a small scale as efficiently as large-scale production. Secondly, as global consumers' incomes rise, their desire for variety increases as well. This increases the scope for SMEs to fill niche markets.

Both trends mean that the multinationals' current advantage in producing standardized products on a large scale at a low cost may diminish in the future. As a consequence, one may expect that small innovating firms will be more likely to commercialize their own innovations and to invest more in additional innovations.

(b) Technology and trade: A two-way relationship

Traditional economic theory viewed a country's level of technology as an exogenous explanatory variable of trade – that is to say, technology is taken as a given factor shaping other economic variables, including exports and imports. However, in the real world, technological change is not drawn randomly from a global pool of innovation but rather is the outcome of economic forces. When firms decide how much to invest in R&D, they consider the expected economic returns from innovation. The greater the expected rewards for a dollar spent in R&D, the greater their incentive to invest in innovation.

Several factors affect firms' incentives to innovate, one of which is trade. Thus, to understand how technological progress will affect future patterns of trade, it is also important to understand how trade itself affects technological progress.

This section first looks at how technological progress affects trade, then it discusses how trade and other factors shape technological progress.

(i) How does technology affect trade?

Shaping comparative advantage

Economic theory views technology as a factor determining the patterns of trade. According to traditional theory, trade occurs because countries are different and one of these differences is technology. In shaping comparative advantage, technological differences between countries help to shape the patterns of trade. In the simplest Ricardian model, a country exports the good which it is relatively more efficient at producing than its trading partner – that is, the good with the lowest opportunity cost.

Until recently, trade theory ignored differences across firms, and trade models assumed that all firms in a country shared the same technology. However, these traditional models failed to explain evidence that not all firms export, and that exporting firms tend to be larger and more productive than non-exporting firms. In the new trade models, firm-specific technological knowledge is seen as a key determinant of whether a firm exports or just serves the domestic market (Melitz, 2003).

A firm's relative productivity also helps to explain whether it will export its products or sell them through a foreign subsidiary – i.e. through so called "horizontal" FDI (Helpman et al., 2004). The assumption is that exporting involves lower fixed costs than FDI, while FDI requires lower variable costs than exporting. Because of existing fixed costs of exporting, only the most productive firms will export, and among these only the most productive will engage in FDI.

In a world where firms produce final goods by assembling a range of intermediate goods, technology is also an important determinant of whether a certain input or task is produced domestically and exported or whether it is offshored. In general, trade models of vertically integrated firms assume that technology can be transferred from the parent to the affiliate company (this includes recent models of trade in tasks, which then occurs in line with comparative advantage in factors of production).

However, when technology transfer is costly for a given market, technologically complex inputs will be produced at home and exported, and only the more standardized inputs will be produced abroad. This is because more complex inputs may involve higher costs of transferring the technological information needed for offshore production. Moreover, if the technology involved in the production of intermediate goods can only be transferred through face-to-face communication, inputs imported by an affiliate from its parent company will be increasingly technologically complex as the distance between the parent company and the affiliate increases. In fact, US exports show a positive relationship between the complexity of exports (measured as the average R&D intensity of exports) and the geographical distance to the destination markets (Keller and Yeaple, 2009; 2012).

The traditional Ricardian models of trade, as well as heterogeneous firms' models, do not account for technological spillovers. Imports embody foreign technology but they do not change the importer's technological know-how. Similarly, in the traditional model of vertically integrated firms, there are no technological spillovers from the affiliate company to the domestic firms. However, evidence clearly supports the view that knowledge spillovers exist.

What does this imply for trade patterns? If countries' access to technology were identical – i.e. if technological diffusion were perfect and global – trade would occur only on the basis of relative factor abundance rather than technological differences (Heckscher-Ohlin theory). However, clearly, technological diffusion is neither perfect nor global. Thus, understanding the geographical extent of technology transfers and their impact is essential to understanding which factors shape trade – relative factor abundance or technological differences.

The concepts associated with the new economic geography can provide important additional insights into the way technology diffusion has an impact on production and trade patterns (Krugman, 1991; Head and Mayer, 2004; Krugman, 1998). Since technology spillovers are greater among firms located in close proximity to one another – helping to drive down their production costs and make them more competitive in international markets – these spillovers indirectly create agglomeration forces that shape trade. To benefit from technology spillovers, industries will tend to be concentrated in certain places, especially in a country with a large domestic market for the good being produced. Locating in a large market will also benefit firms by reducing transport and trade costs. It follows that, under these circumstances, a country will export the product for which it has a home market advantage – that is to say, the product for which it has the largest domestic demand.[111]

Reducing trade costs

Trade costs are generally estimated to be a more significant obstacle to trade than policy barriers. In 2004, for example, aggregate expenditure on shipping only was three times higher than the aggregate tariff duty paid (Anderson and Van Wincoop, 2004). Thus, any change in trade costs is likely to affect trade significantly.

Technological innovation has had a major impact on trade costs. The introduction of containerization and jet engines has significantly reduced sea and air transport costs. More recently, the use of radio frequencies, identification tags and the internet has allowed firms to keep track of where a product is at any time. This has significantly improved logistics services and made possible the development of a more efficient multi-modal transport system. As will be

discussed in Section C.4, the reduction of transport costs has a significant impact on both the volume and composition of trade.

Technological advances have also significantly reduced communication costs. Exporters need information on profitable trading opportunities. Importers need information on suppliers of intermediate goods, on product specifications, and on scheduling production processes. The telephone is still a primary means of communication but the internet is becoming an increasingly important, versatile and low-cost communications tool. Mobile phones are becoming increasingly important to commerce, especially in developing countries, because they require less infrastructure and are untied to location.

Lowering the cost of communications affects trade in several ways. First, it can lower the variable costs of trade and thus help to increase trade volumes – in much the same way that lowering tariffs increases trade volumes. Secondly, it can lower the fixed costs of trade by improving exporters' or importers' access to information – everything from market intelligence to potential trade partners. As discussed above, when fixed entry costs are high, only the most productive firms can export, so a reduction in communication costs can be expected to encourage smaller, less productive firms to enter international markets.

Examining eBay transactions, a recent study by Lendle et al. (2012) shows that while most "offline" sellers export only one product to one market, most sellers on eBay export to more than five markets and in more than five product categories, suggesting that the internet has significantly lowered cross-border trade costs for small business, especially the cost of matching buyers and sellers. Thirdly, lower communication costs can affect the composition of trade. Because some tradable sectors are more information-sensitive than others – such as goods with short product cycles (e.g. consumer electronics) or ones that feed into complex production chains (e.g. automotive parts) – falling communications costs will disproportionately benefit them. Fink et al. (2003) show that the impact of a reduction in communication costs is as much as one-third higher for trade in differentiated goods (e.g. technologically advanced manufacturing goods) than for trade in homogenous products (e.g. agriculture or standardized manufacturing goods).

ICT and trade

The development and diffusion of ICT has had a particularly powerful impact on trade – including the growing importance of intermediate goods in trade, of services trade, of e-commerce and of developing countries. ICT has been an essential prerequisite to the rapid growth of global supply chains by making production coordination across borders easier. Production chains require deep and continuous coordination between headquarters and affiliate activities. Sharing information between terminal operators, shippers and customs brokers and a wide range of other actors is essential for the efficient management of production networks, where just-in-time delivery is required. One by-product of the ICT revolution is that world trade in parts and components has increased much faster than total merchandise trade since the early 1990s.[112]

ICT developments have also underpinned the growth of services trade, including the offshoring of service activities, such as data processing, research and development and business processes to lower-cost locations around the world. Services which were non–tradable in the past – or tradable only at very high costs – have become highly tradable today. This is particularly true of knowledge-intensive business services (KIBS): legal services, accounting, tax consultancy, market research, auditing, management consultancy, architectural, engineering and technical consultancy, technical testing and analyses, advertising and other business activities.

KIBS's share of world trade grew at an annual rate of 8 per cent between 1990 and 2000, and at 10 per cent between 2000 and 2010 (National Science Board, 2012), in no small part because of the impact of ICT developments (see Section B). Particularly significant is the growth of KIBS in emerging markets. Since 1990, China, India, Indonesia and the Russian Federation have experienced particularly high growth in terms of their share of global value-added in KIBS. Specifically, China reached 5.5 per cent of global value-added in KIBS in 2010, up from 1.6 per cent in 1990; India accounted for 2 per cent in 2010, up from 0.8 per cent in 1990 (Meliciani, 2013).

ICT developments have also changed the nature of the products that are traded – from trade in physical goods to trade in digital goods, from trade in "atoms" to trade in "bits". Music and film markets, for example, are being completely transformed by e-commerce and downloading, making trade in physical CDs or DVDs increasingly obsolete. Blinder (2006) suggests that as the distinction between tradable and non-tradable goods and services becomes increasingly blurred, so too will trade theory predictions based on the traditional factor endowment of skilled and unskilled labour. In particular, he argues that as an economy becomes more service-oriented, the new trade theory should focus on personal versus impersonal services as a source of comparative advantage, as the latter can be easily offshored while the former cannot.

Given current trends, it is also likely that ICT infrastructure will become an increasingly important factor shaping trade flows in the future.[113] For example, developing countries' potential to "leap-frog" to the next level of ICT infrastructure – as many are already

doing in the case of mobile phone technology – may be a source of competitive advantage *vis-a-vis* developed countries which are burdened with the sunk costs of traditional communication infrastructures. Although the so-called "digital divide" between high and low-income countries is still large, there are clear signs that it is narrowing (see Figure C.35 and Appendix Table C.3). Over the last two decades, the growth in fixed line and mobile connections as well as in the number of internet hosts has been faster in developing than in developed countries. One reason for this is that while fixed-line communications requires a substantial investment in infrastructure, the initial investment in mobile networks is relatively modest.

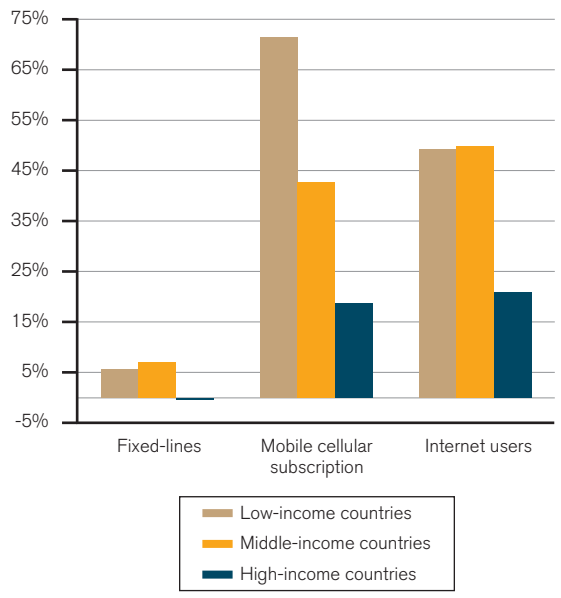
Other indirect channels

Technological changes also affect trade indirectly through their impact on other factors shaping trade.

The ICT revolution provides a clear example of the many dimensions in which technology's impact on trade can be analysed. The use of the internet for banking, for buying and selling goods, for organizing travel and accommodation are a few examples of the many ways in which ICT developments increase international competition, reduce trade costs and create new markets. However, the effects of the ICT revolution go well beyond their direct impact on services trade and product market competition.

First, ICT has significantly changed the way that the labour market operates. The internet reduces search costs for a new job and vastly expands the geographical scope, creating a better match between employers and employees, and reducing the frictional rate of unemployment. It also allows individuals to work or conduct business outside the office or company premises. New and more flexible forms of employment are opening up, improving employment prospects, especially for disadvantaged people in the job market (e.g. older workers and women).[114] These and other impacts of labour supply on trade are analysed in more detail in Section C.1.

Figure C.35: **Annual growth in telecommunications infrastructure by income group, 1995-2011**



Source: Authors' computations, based on data from World Bank, *World Development Indicators*.

Secondly, ICT has an impact on human capital accumulation. For example, online universities offer an expanded array of course options – from professional courses to post-educational programmes – and increase access to specialized knowledge from remote locations. The effects of human capital accumulation on trade are analysed in Section C.1.

In general, technology changes and technology transfer have a strong impact on income distribution and inequality. The effects of income inequality on trade are analysed in Section D.1.

In sum, the diffusion of ICT worldwide may be expected to yield significant changes in international trade. Not only will the trend towards lower communication costs and increased trade volumes be likely to continue, but changes in the patterns and nature of trade are also inevitable. First, the importance of e-commerce over other forms of trade will continue to increase. Secondly, the role of SMEs in exporting can be expected to assume greater importance. Thirdly, as the ICT network expands, new players will be likely to emerge in information-intensive sectors, such as consumer electronics and automotives, and the relative importance of factors of comparative advantage will change.

(ii) How does trade affect technological progress?

To understand how technological progress will affect future patterns of trade, it is also important to understand the factors shaping technological progress. One of these factors is trade itself. Trade affects technological progress in two ways: through its effect on the incentive to innovate and through technology transfers.

Trade and innovation

Trade affects firms' incentive to innovate through its effect on the size of the market in which a firm operates as well as through its effect on competition, technology transfers and institutions. Firms spend on R&D to increase profits or to keep up with competition from other innovating firms. All else being equal, the larger the market, the larger the firm's expected profits from innovation. By increasing the size of the market in which a firm operates, trade provides firms with the

opportunity for greater profits, thus increasing their incentive to invest in R&D and therefore the probability of innovation – i.e. there are positive scale effects.

Trade also increases competition. The effects of competition on innovation, however, are less clear cut. On the one hand, by reducing the monopoly rents[115] associated with innovation, competition is expected to reduce incentives to innovate (Schumpeter, 1942). On the other hand, more rigorous competition may give firms a greater incentive to innovate because if a competitor innovates first, rival firms are likely to lose market share, experience losses and possibly be forced to exit the market.

Trade can also affect innovation incentives through its effects on technological spillovers. Again, the effects of technological spillovers on the innovation rate are not one-way. While imitation may foster R&D investments in an effort to rise above the competition (Helpman, 1993), the reduced returns to innovation may reduce firms' incentive to engage in R&D activity – i.e. there are ambiguous effects of imitation.

Finally, trade shapes the institutional framework, which in turn shapes the economic incentives of firms. As will be discussed in Section C.6, there is a positive correlation between trade and quality of institutions, and countries with better institutions tend to invest more in education and infrastructure. These linkages generate a positive relationship between trade and the returns to innovation, thus fostering firms' incentive to invest in R&D.

The economic literature on the empirical relationship between trade and technological progress is extensive, and includes both country-level and firm-level studies. In general, empirical evidence based on country-level data shows a correlation between trade and innovation.[116] However, one general criticism of these studies is that they do not manage to distinguish fully between cause and effect. This is because it is difficult to disentangle trade policy changes from other domestic policy changes undertaken by governments that simultaneously affect growth (Rodriguez and Rodrik, 2001).

More recent studies based on firm-level data also support the view that trade increases the incentive to innovate. Focusing on trade opening between Argentina and Brazil between 1992 and 1996, Bustos (2011) finds that Argentinian firms in sectors with the largest market access gains were more likely to increase technology spending than firms operating in sectors where trade opening was less ambitious.[117]

Trade and technology transfers

To the extent that technical knowledge is embodied in a product, it also travels with the product. In other words, imports of technologically advanced goods provide firms with access to the technologies embodied in the imported good. Such imports can increase productivity both by using the good in production processes and by providing opportunities for "reverse engineering" – learning about how an imported product is produced and imitating it. To the extent that the expense of reverse engineering is less than the expense of developing the technology independently, the importing country derives a gain from importing – or from technological spillover.

In addition, international trade provides a channel of communication that encourages cross-border learning of production methods, production design and market conditions. Through exporting, firms also interact with foreign customers. These customers may also demand higher quality standards than domestic customers while at the same time providing information on how to meet those higher standards. Thus, exporting becomes a channel for technology transmission for "learning-by-exporting".

Several empirical studies confirm that imports are an important channel of technology diffusion. In particular, the extent of technological spillovers appears to be linked to the composition of imports. Technology transfer is higher when imports come from industrial countries and are presumably characterized by a higher embodied technological content than imports from developing countries (Coe and Helpman, 1995; Coe and Hoffmaister, 1999; Keller, 2000). Furthermore, technology spillovers are stronger for imports of capital goods, machinery and ICT goods (Coe et al., 1997; Gera et al., 1999; Xu and Wang, 1999; Acharya and Keller, 2009; Van Meijl and van Tongeren, 1998). A study by Amiti and Konings (2007) also shows that technology transfers are stronger for imports of inputs than final products.

Empirical evidence supporting the existence of a learning-by-exporting effect is less extensive. This is partly because studies attempting to assess this impact face two methodological hurdles: first, how to control for self-selection of the most productive firms into export markets. Does exporting – and learning-by-exporting – make firms more productive or do only the most productive firms export? The second dilemma is how to distinguish between productivity gains that are the result of learning-by-exporting and gains that are the result of high profits from exporting and of greater incentives to invest in technology (i.e. scale effects). Despite the extensive evidence that exporting firms tend to be more productive than firms only serving the domestic market (Bernard and Jensen, 1999), this might simply reflect the fact that only the most productive firms (self-selection) export in the first place.

However, some evidence based on micro-level data supports the learning-by-exporting hypothesis. For example, using firm-level data for Slovenian

manufacturing, De Loecker (2007) finds that the productivity of exporting firms increases once they start exporting and that the productivity gap between exporters and their domestic counterparts increases over time.[118] However, while firm-level evidence takes into account self-selection, it still does not distinguish between whether productivity gains arise mainly from technology transfers or from higher incentives to innovate.

(iii) What other factors affect technological progress?

One determinant of technological progress is the strength of intellectual property (IP) rights. Theoretical arguments on the relationship between IP protection and technological progress are mixed.[119] Advocates of stronger IP protection claim it will lead to more innovation by increasing firms' rewards for undertaking research. Moreover, even if much of the research takes place in advanced economies, stronger IP protection will facilitate technology transfer by encouraging more FDI, especially from high-technology firms.[120] Others argue that strong IP protection will reduce technology transfers and may even reduce the incentive to innovate by entrenching monopolies and by diminishing the competitive-threat incentive to innovate.

The empirical evidence is equally mixed. For example, Coe et al. (2009) find that strong patent protection is associated with higher levels of total factor productivity, higher returns to domestic R&D, and larger international R&D spillovers. Using data on US multinationals, Branstetter, Fisman and Foley (2006) also support the view that there is an increase in technology transfers to countries that strengthen their IP regime. However, several studies, such as Bessen and Maskin (2000), Lerner (2002a, 2002b), Sakakibara and Branstetter (2001) and Scherer and Weisburst (1995), suggest that there is a negative correlation between strengthening IP protection, on the one hand, and increasing innovation or technology diffusion on the other.

Other important determinants of technology transfers are FDI flows, movement of people[121] and direct trade in knowledge through technology purchases or licensing. Any policy that affects these channels has an impact on technology transfer. For example, Hovhannisyan and Keller (2012) show that business travel plays an important role in diffusing innovation and suggest that lifting limits on the cross-border movement people as well as liberalizing international passenger air travel could have additional benefits in terms of increasing innovation.

A large body of literature analyses the potential spillover effects of FDI. FDI can increase technology transfer by encouraging interaction between domestic and foreign firms. One channel is vertical FDI spillovers. Linkages between upstream and downstream producers can encourage the direct transfer of technology from the multinational to the local buyer. Higher-quality requirements on intermediate inputs from suppliers can also result in technology transfers. Another channel is horizontal FDI spillover. Geographical proximity to multinationals can reduce the costs of learning or adopting a new business technology within the same industry. While older empirical studies suggest that technology spillovers were associated with more vertical rather than horizontal FDI, more recent empirical work finds significant technology spillovers from horizontal FDI too (Keller and Yeaple, 2009).[122]

It is important to note that the international diffusion of technology is not automatic. Technology transfer is not just a question of "supply" but of "demand" – and, in particular, of a firm's or country's "absorptive" capacity. For example, in order for technology to be transferred through the use of specialized and advanced machineries invented abroad, it is necessary for workers to have the skills needed to use the machinery and organize the production process. Mayer (2001) shows that it is the combination of the know-how of the workforce and the imports of machinery which has a positive effect on economic growth. Even reverse engineering requires skills. The capacity to absorb international R&D spillovers differs across countries. A recent study by Coe et al. (2009) suggests that technological spillovers increase with the ease of doing business in a country and the quality of its tertiary educational system.

(c) What do these trends mean for the future of trade?

Several trends are discernible from this analysis of the global patterns of innovation and technology transfer. One is the emergence of new players among the countries that are driving technological progress. Some countries have significantly accelerated their innovative ability and capacity to absorb existing technologies. Among these are China, the Republic of Korea and Singapore. However, there are also countries, especially in Africa, that continue to lag behind. The low quality of education and the institutional framework in these countries is primarily responsible for their low absorptive capacity.

A second trend is the regionalization of technology transfers. By reducing coordination costs, the ICT revolution has fostered the development of supply chains. Supply chains embody several related dimensions of international economic relationships – investment, competition and movement of people – all of which intensify technology transfers. However, supply chains do not increase the flow of technological knowledge at the global level. They increase it among countries with regional networks, thus encouraging the formation of regional "convergence clubs".

Thirdly, ICT developments have significantly increased the share of services in world trade. In particular, knowledge-intensive business services (KIBS) are emerging as key drivers of knowledge accumulation. These trends – together with reduced productivity growth in manufacturing – may point to a potential shift from manufacturing to services as the engine of global innovation.

Finally, SMEs appear to benefit from improved access to the international market. By dramatically reducing information, transaction and searching and matching costs, the ICT revolution has significantly reduced the fixed costs of entering markets, thus increasing opportunities for SMEs' participation.

What should we expect from these trends?

The emergence of new global players, together with technological convergence at the regional level, is likely to lead to the emergence of economic actors that no longer see countries as the unit of reference for international relationships. This could have important consequences in terms of how negotiations are conducted at the multilateral level.

Secondly, technological advancements have been key to the development of supply chains. Supply chains, in turn, have encouraged technology transfer and convergence across countries. If the process of production fragmentation continues or intensifies, governments will be pressured to adopt policies that facilitate domestic industries' integration into production chains. These can take the form of R&D subsidies, infrastructure investments and stronger IP protection to encourage FDI inflows.

Furthermore, the globalization of R&D, the fragmentation of production processes and the diffusion of digital technologies are creating a mismatch between the geographical scope of economic agents and the regulatory regime under which they operate. For example, while the internet allows consumers to shop globally, IP protection and competition laws are administered and enforced nationally.

To allow for the full potential of e-commerce and the globalization of production to materialize, IP and competition regimes will need to adapt. Pressures to extend rules beyond national borders are already manifested in the multiplication of "deep" preferential trade agreements that include IP and competition policy provisions. More generally, the link between trade and technological progress points to the need for freer flow of goods, services and ideas at the multilateral level. If technology spillovers result from trade, for example, coordinated action to reduce trade obstacles would increase economic well-being. This is further discussed in Section E.

Thirdly, while the analysis of trade patterns in Section B reveals a relocation of labour-intensive activities to developing countries and the emergence of a small number of firms as global trade players, recent innovations, such as 3D printing and robotics, are likely to challenge this status quo. 3D printing is a process of making a three-dimensional solid object from a digital model by adding material layer by layer. With only raw materials and encrypted data streams required for manufacturing, and as production becomes more individualized, access to these new technologies may make it far easier for SMEs to enter export markets. In addition, by reducing the importance of labour costs for comparative advantage, robotics and 3D printing may also shift manufacturing, together with whole supply chains, back to developed countries.

As of 2012, 3D printing technology is used for prototyping and manufacturing in sectors such as construction, aerospace, jewellery and healthcare. But, it is foreseeable that as the printing speed increases, its use may spread to households. If this happens, one may even predict a reduction of global trade in certain types of goods, if end users can easily manufacture them.

However, traditional production methods (sometime referred to as subtractive processes) and 3D printing are likely to complement each other rather than compete. 3D printing may prove advantageous for the production of components characterized by internal voids, such as tubes. But for production processes that start with a solid mass from which material is removed in order to obtain the desired design, traditional manufacturing may continue to prevail. The effect of 3D printing is therefore likely to vary significantly across sectors.

4. Energy and other natural resources

Like labour and capital, natural resources are factors of production that serve as inputs in goods and services production. While there is a broad range of natural resources that could be discussed, the focus here will be on energy and, to a limited extent, on land and water, which are the natural resources typically included in aggregate production functions (for discussion of trade and a wider variety of natural resources, see the 2010 *World Trade Report* (WTO, 2010) and Ruta and Venables (2012).

The section covers four themes – uneven geographical distribution, volatility of prices, exhaustibility and innovation, and negative environmental externalities – that correspond to fundamental characteristics of natural resources and which can affect both production and the pattern of trade.

Part (a) discusses the uneven geographical distribution of natural resources, which affects countries' comparative advantage and hence the pattern of

international trade. Differences in factor endowments confer market power on resource-abundant countries and have geopolitical implications. Part (b) describes how increases in natural resource prices can have major contractionary effects on economies, which can in turn dampen international trade. Natural resource prices also tend to be volatile. This has an impact on trade by increasing the uncertainty faced by importers and exporters.

Part (c) takes up the issue that natural resources are potentially exhaustible, which can act as a brake to future economic expansion. This also implies that comparative advantage conferred by nature can be dissipated. It also discusses the role of innovation in increasing efficiency in the use of natural resources, discovering new supplies and developing alternatives. This means human innovation can offset limited natural resources. Part (d) examines how natural resource use can be subject to environmental pressures and the role of public policy in that context. Part (e) presents possible scenarios in the future evolution of natural resource supply and costs and international trade. Part (f) offers some concluding observations.

(a) Uneven geographical distribution of natural resources

This section presents evidence of the uneven geographical distribution of natural resources in the case of energy, water and land and discusses the implications for the pattern of trade. It then describes how concentration in resource endowments confers market power on some supplying countries and how this could be exploited through the use of export restrictions. Finally, the repercussions for geopolitics are considered as resource-abundant countries make use of monopoly power to pursue their international interests and resource-scarce countries prioritize the pursuit of resource security in their international relations.

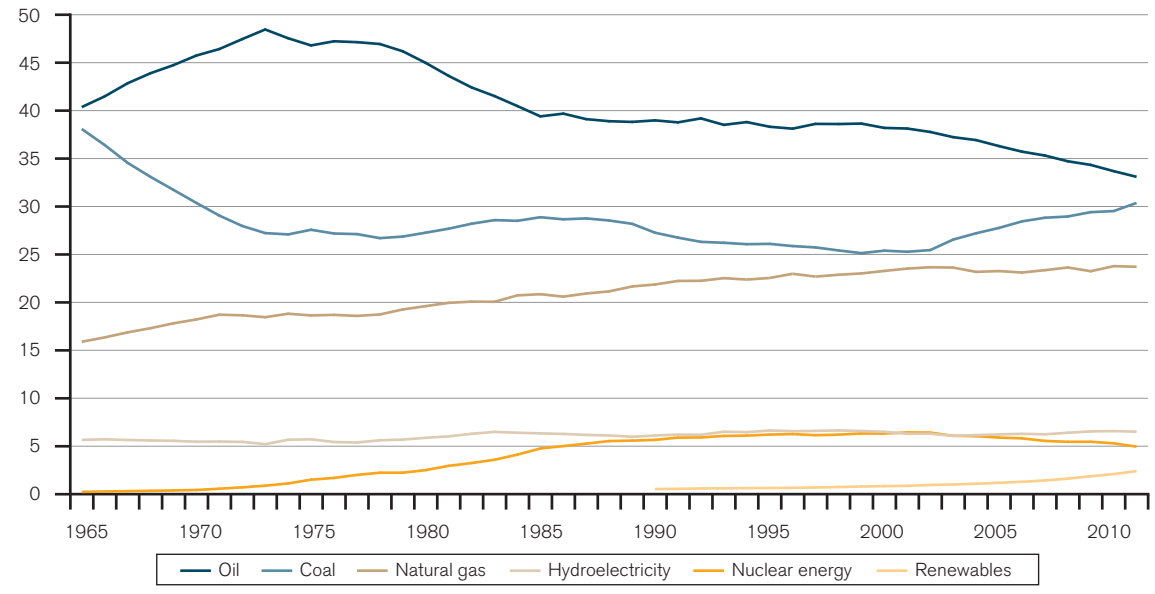
(i) Resource abundance and trade patterns

Oil, coal and natural gas were the sources of almost 90 per cent of worldwide energy use in 2011, as can be seen in Figure C.36. Of these, oil is the most important, accounting for a third of total energy use in 2011. However, this is down from its peak of 48 per cent in the mid-1970s (around the time of the first oil crisis). Coal had about as large a share as oil in the mid-1960s but then underwent a long decline. This was reversed at the turn of the millennium, with the surge in coal consumption by China and India. Natural gas has risen in importance, with its share climbing from 16 per cent in 1965 to 24 per cent in 2011. This increase is likely to continue because of new discoveries and extraction methods in North America (see the discussion on shale oil below).

The contribution of nuclear energy, hydroelectricity and other renewable sources is small but the share of renewables has picked up in the last decade, driven in part by higher energy prices (see the discussion below on changes in energy prices).

The standard Heckscher-Ohlin theory predicts that countries which are relatively abundant in a factor of production will export the commodity which uses that

Figure C.36: **World energy consumption by type, 1965-2011**
(percentage)



Source: BP, *Statistical Review of World Energy*, June 2012.

Note: Oil consumption is measured in million tonnes; other fuels in million tonnes of oil equivalent. Renewables are based on gross generation from renewable sources including wind, geothermal, solar, biomass and waste. Renewables consumption is converted into million tonnes of oil equivalent on the basis of thermal equivalence assuming 38 per cent conversion efficiency in a modern thermal power station.

factor intensively. A contemporary variant of this story argues that a country will capture larger shares of world production and trade in commodities that more intensively use its abundant factor (Romalis, 2004). The factor-proportion explanation has traditionally assumed that factors of production are non-exhaustible (such as Ricardo's "indestructible powers of the soil"). Kemp and Van Long (1984) show that the prediction of the Heckscher-Ohlin theory also applies to situations when all of the factors of production are exhaustible as well as when exhaustible factors are combined with non-exhaustible factors.

The theory is about relative rather than absolute factor abundance and links that to exports of products that are intensive in those factors rather than to exports of the resource itself. Notwithstanding these caveats, Tables C.11 to C.13 corroborate the relationship between countries' endowments of natural resources and their export performance. The countries listed in Table C.11 – the most prominent being the Kingdom of Saudi Arabia, Canada and Iran – have 95 per cent of the world's proved reserves of crude oil and 86 per cent of total oil exports in 2010. Those countries in Table C.12 – with the Russian Federation, Iran and Qatar having the largest reserves – account for 91 per cent of proved reserves of natural gas and 77 per cent of all natural gas exports in 2010. Finally, the countries shown in Table C.13 – with the United States, the Russian Federation and China being the top three – have 96 per cent of total recoverable coal and 93 per cent of total exports of coal in 2010.

Water and land

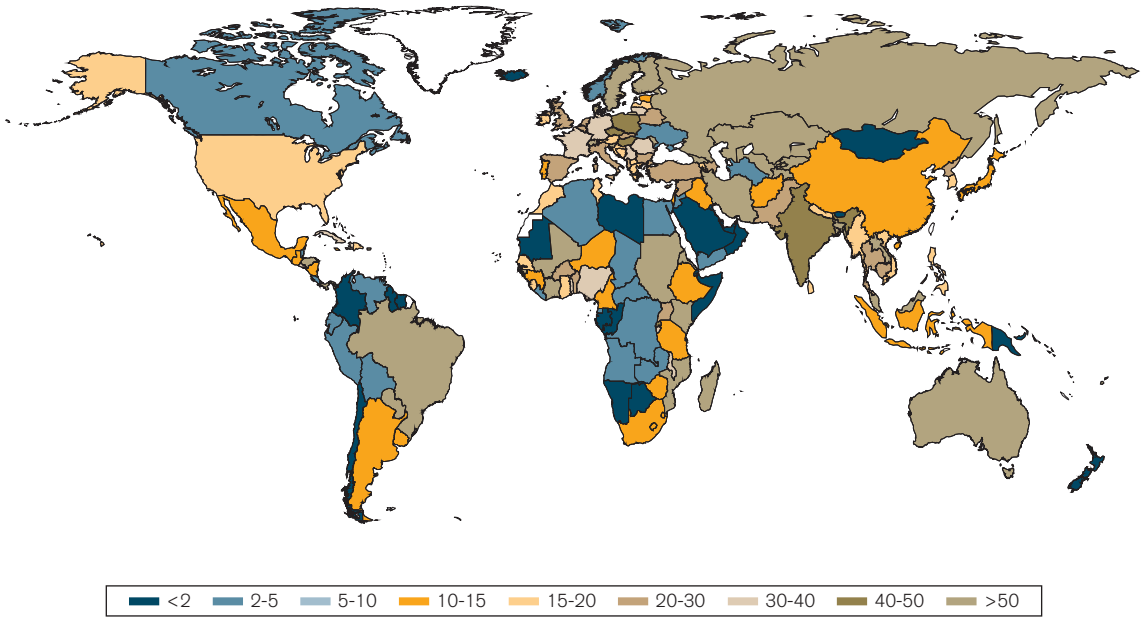
The availability of land suitable for agricultural production, especially arable land, determines the patterns of agricultural production and the dependency of countries on imports of crops. Figure C.37 shows countries listed in terms of the share of land area that is arable. Most of the world's arable land is situated in Southern and Eastern Asia, North America and Sub-Saharan Africa. The share of total land area that is arable varies considerably by region, from 23 per cent in Western and Central Europe to only 4 per cent in North Africa.

There is a positive correlation between the size of a country's per capita arable land endowment and the value of its agricultural exports. This is depicted in Figure C.38, which uses data for 195 countries in 2008.

Freshwater is a renewable but scarce resource with an uneven geographical distribution. Figure C.39 shows this geographical pattern using renewable water resources per capita as a measure of availability. The most water-abundant regions are Sub-Saharan Africa and South America. The regions of North Africa, Central Asia and the Middle East are at the other end of the spectrum, with severely limited water resources.

Figure C.40 shows how water resource availability has changed over time. Reflecting their more rapid population growth, water resources per capita in

Figure C.37: **Arable land as a percentage of total land area, 2011**



Source: FAO, *Aquastat*, http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

Note: Arable land is the land under temporary crops, meadows, gardens and fallow. It does not include areas under permanent crops such as coffee or cocoa. Surfaces in white: Data unavailable at the time of writing. Colours and boundaries do not imply any judgement on the part of the WTO as to the legal status of any frontier or territory.

Table C.11: **Countries with the largest proved reserves of crude oil, 2008**

Country	Proved reserves (billions of barrels)	Share of world exports of oil (2010)
Saudi Arabia, Kingdom of	267	16.0%
Canada	178	3.4%
Iran	136	5.6%
Iraq	115	4.5%
Kuwait, the State of	104	3.3%
Venezuela, Bolivarian Republic of	99	3.8%
United Arab Emirates	98	5.0%
Russian Federation	60	11.4%
Libya	44	3.2%
Nigeria	36	5.5%
Kazakhstan	30	3.3%
United States	21	0.1%
China	16	0.1%
Qatar	15	2.6%
Brazil	13	1.4%
Algeria	12	2.6%
Mexico	11	3.4%
Angola	9	4.5%
Azerbaijan	7	2.1%
Norway	7	3.7%
Share of world total	95.2%	85.6%

Source: US Information Energy Administration.

Note: Amount of recoverable coal is based on 2008 data.

Table C.12: **Countries with the largest proved reserves of natural gas, 2009**

Country	Proved reserves (trillions of cubic feet)	Share of world exports of natural gas (2010)
Russian Federation	1,680	22.3%
Iran	992	0.9%
Qatar	892	11.5%
United States	273	4.3%
Saudi Arabia, Kingdom of	258	0%
United Arab Emirates	214	0.5%
Nigeria	184	2.6%
Venezuela, Bolivarian Republic of	171	0%
Algeria	159	5.3%
Iraq	112	0%
Indonesia	106	3.9%
Turkmenistan	94	0%
Kazakhstan	85	1.0%
Malaysia	83	3.3%
Norway	82	9.8%
China	80	0.3%
Uzbekistan	65	1.2%
Kuwait, the State of	63	0%
Egypt	59	1.1%
Canada	58	8.9%
Share of world total	90.8%	76.9%

Source: US Information Energy Administration.

Note: Amount of proved reserves based on 2009 data.

Sub-Saharan Africa have declined at the highest rate, followed by Southern and Eastern Asia.

Agriculture accounts for 69 per cent of global freshwater withdrawals and 90 per cent of its consumptive use, i.e. water lost due to evaporation and transpiration (FAO, 2012). Thus, one might reasonably assume that the geographical distribution of water observed in the previous figures will be reflected in the pattern of agricultural trade.

However, water endowments do not seem to have a strong influence on agricultural trade patterns. Hoekstra (2010) attributes this to heavy government intervention in agriculture through, among other things, subsidies, tariffs and sanitary and phytosanitary measures as well as in domestic water markets where the resource is severely under-priced. All these policy distortions work to blunt the effect of endowments on agricultural trade. He suggests that water endowments affect trade patterns only in cases where there is absolute water shortage, which forces water-scarce countries to import water-intensive products because they simply cannot be produced domestically.

However, recent work by Blackhurst et al. (2010) and Debaere (2012) suggest that manufacturing surpasses agriculture in total water use if one accounts for the water-intensiveness of the power used in manufacturing.

Table C.13: **Countries with the largest total reserves of recoverable coal, 2008**

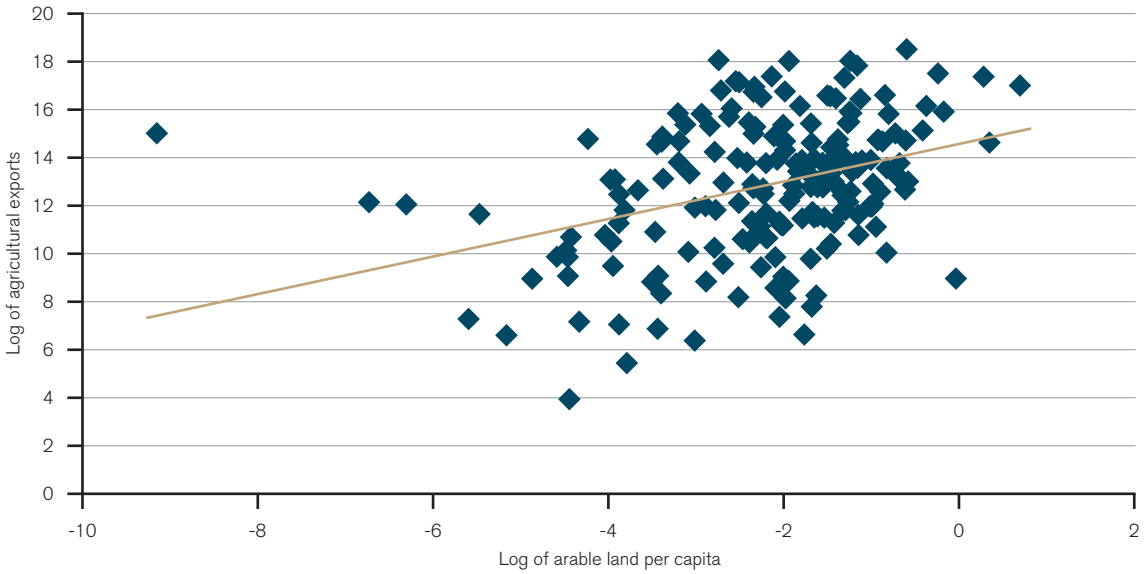
Country	Recoverable coal (million short tons)	Share of world exports of coal (2010)
United States	260,551	6.9%
Russian Federation	173,074	10.1%
China	126,215	1.9%
Australia	84,217	27.1%
India	66,800	0.2%
Germany	44,863	0%
Ukraine	37,339	0.6%
Kazakhstan	37,038	3.0%
South Africa	33,241	6.3%
Serbia	15,179	0%
Colombia	7,436	6.3%
Canada	7,255	3.0%
Poland	6,293	1.5%
Indonesia	6,095	26.1%
Share of world total	95.5%	92.9%

Source: US Information Energy Administration.

Note: Amount of recoverable coal is based on 2008 data.

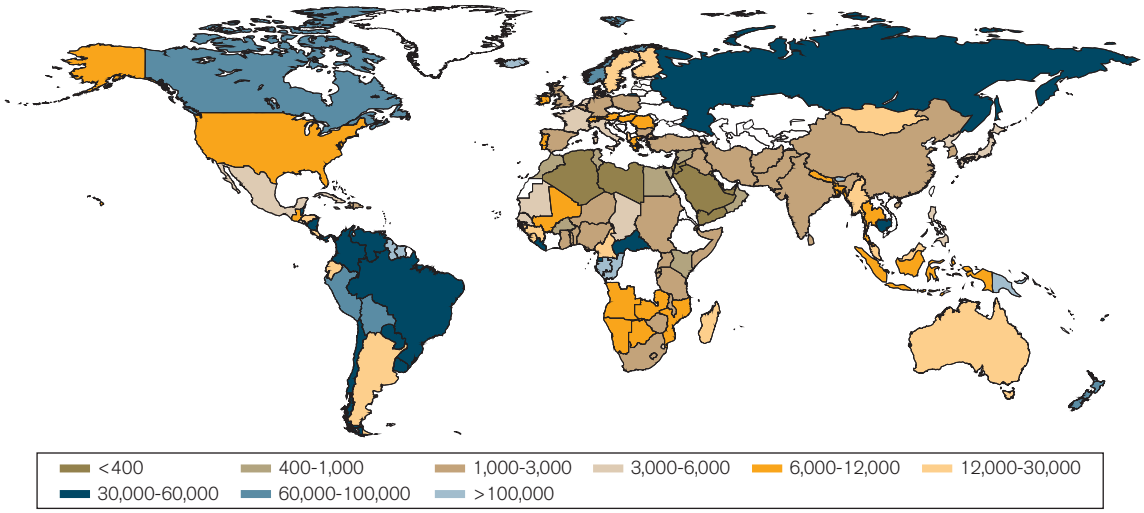
Debaere (2012) finds that countries that are relatively water abundant tend to export more water-intensive products. His results support the hypothesis that water is a source of comparative advantage. However, he also finds that water contributes significantly less to the

Figure C.38: **Agricultural exports and endowment of arable land per capita, 2008**



Source: *World Development Indicators* and UN Comtrade.

Figure C.39: **Renewable water resources per capita by region, 2011** (1,000m^3/inhabitant/year)



Source: FAO, *Aquastat*, http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

Note: Surfaces in white: data unavailable at the time of writing. Colours and boundaries do not imply any judgement on the part of the WTO as to the legal status of any frontier or territory.

pattern of exports than the traditional production factors, such as labour and physical capital.

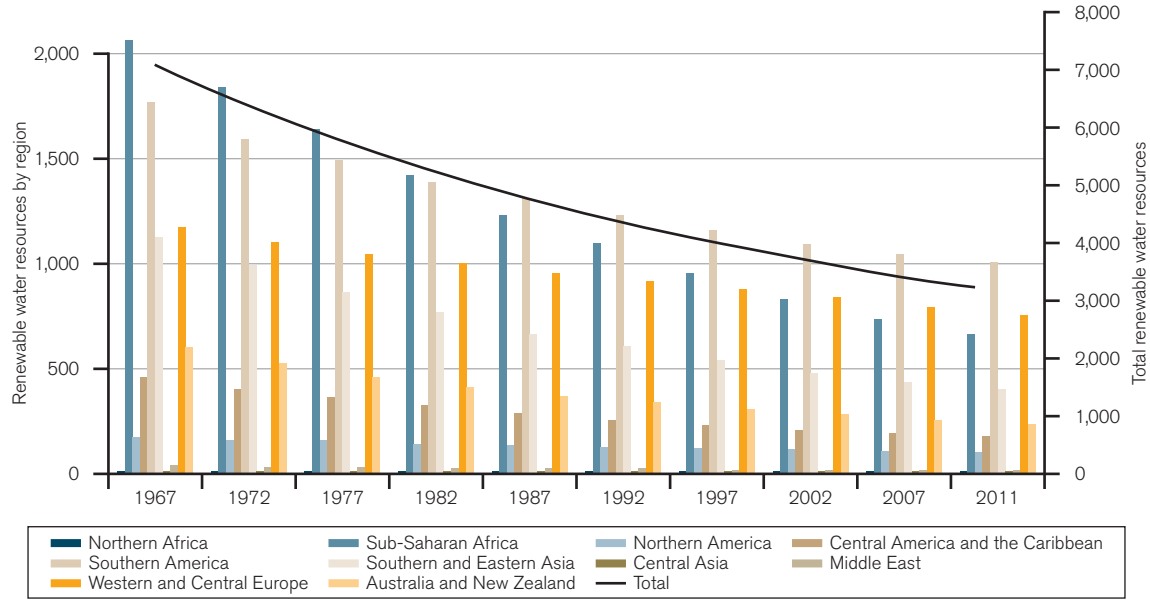
(ii) Market power and geopolitics

The uneven geographical distribution of natural resources means that some resource-abundant countries will have market power in trade. This may create a temptation to exploit that market power through the use of export restrictions. By reducing supply of the natural resource in international markets, the world price of the resource rises, creating a terms-of-trade gain for the exporting country and a terms-of-trade loss for the importing countries.

While the temptation to exploit market power could apply to other sectors as well, there is evidence that export taxes and other restrictions are more frequently applied to natural resources than to other merchandise goods. While just 5 per cent of world trade is covered by export taxes, the share more than doubles to 11 per cent for natural resource products (WTO, 2010). Of all export restrictions notified to the WTO, more than a third – some 2,577 out of a total of 7,328 notified – have been applied to natural resource products.

The uneven distribution of natural resources can also have geopolitical impacts – i.e., monopoly power over natural resource supplies in some countries and

Figure C.40: **Renewable water resources per capita by region, 1967-2011**
(1,000m^3/inhabitant/year)



Source: FAO, *Aquastat*, http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

Note: Renewable water resources include renewable surface and ground water, internal and external.

scarcity of these resources in other countries can affect their political, military, and diplomatic behaviour.

Countries with abundant supplies can use control over these resources to support their international goals and causes. In the 1973 Arab-Israeli war, Middle Eastern members of the Organization of the Petroleum Exporting Countries (OPEC) launched an oil embargo against Western countries supporting Israel. The energy infrastructure of major supplying countries can also become so crucial to the global economy that they become targets. There have been persistent attacks on energy infrastructure by insurgent groups in Algeria, Colombia, the Niger Delta and Iraq (Lacher and Kumetat, 2011). In early 2013, a massive natural gas facility in Algeria became the target of a violent takeover by terrorist forces.

Even if energy supply is not threatened, geopolitical tensions between countries can prompt some to incur additional costs. For example, in order to not become overly dependent on natural resource transit countries, some of which were once part of the Soviet Union, the Russian Federation constructed new outlets for its oil to Europe through the Baltic Pipeline System (Laurila, 2002). It is also started building a major new gas pipeline under the Black Sea to transport gas to Southern Europe.[123]

Countries threatened by scarcity make securing access to natural resource supply a priority of their international relations. China's state oil companies have several oil supply contracts with foreign firms and countries. The major Chinese oil companies have acquired a variety of holdings in Angola, Azerbaijan, Canada, Chad, Indonesia, Iraq, Iran, Kazakhstan, Myanmar (Burma), Nigeria, Peru, the Russian Federation, the Kingdom of Saudi Arabia, Sudan, Turkmenistan, Uzbekistan and the Bolivarian Republic of Venezuela (Hayward, 2009; U.S. GAO, 2013).

Foreign investment in farm land has increased significantly over the past few years. These flows are global in scope, involving 62 countries, where such acquisitions have occurred, and 41 countries whose enterprises have made foreign land investments (Rulli et al., 2013). Although exact figures are hard to obtain, the latest estimates indicate that these farm deals range between 47 million (Rulli et al., 2013) and 56 million hectares (Deininger et al., 2011).

Table C.14 lists the top ten investors or acquirers of foreign farm land as well as the top ten destination countries for these investments. Although countries where arable land and water are particularly scarce (e.g. countries in the Middle East and countries with a growing demand for food, energy and raw materials, such as China and India) are active players, the top investors are companies from the United Kingdom and the United States. The destinations of these investments are countries in Africa, South-East Asia, South America as well as the Russian Federation and Ukraine. These investments frequently take the form of long-term leases, outright purchases or contracts, with the acquired land being devoted to raising crops for food or biofuel (von Braun and Meinzen-Dick, 2009).

To the extent that foreign investors are able to increase agricultural productivity in land and water-abundant countries, there are economic benefits from such

Table C.14: **Top ten destinations and countries of origin for foreign investment in land**

Country of land acquisition	Area acquired (millions of hectares)	Country acquiring foreign land	Size of acquisition (millions of hectares)
Democratic Rep. of the Congo	8.1	United Kingdom	4.4
Indonesia	7.1	United States	3.7
Philippines	5.2	China	3.4
Sudan	4.7	United Arab Emirates	2.7
Australia	4.6	Israel	2.0
Russian Federation	2.8	Egypt	1.4
Brazil	2.3	Korea, Rep. of	1.3
Tanzania	2.0	India	1.2
Mozambique	1.5	South Africa	1.1
Ukraine	1.2	Malaysia	1.0

Source: Rulli et al., 2013.

investments. A major concern, however, is that property rights are often weakly enforced in the countries where such acquisitions have been made, raising the possibility that the local owners may have been unfairly or illegally displaced (Deininger et al., 2011). Clearly, the often negative attention these activities have attracted underscore how increased competition for natural resource supplies can raise international tensions, especially if the natural resource is seen as vital for food or national security by other states.

In conclusion, differences in natural resource endowments appear to explain trade patterns relatively well. In addition, more concentrated control over natural resources confers market power, which can be enhanced through the use of restrictive trade policies. Concentration may also enable resource-abundant countries to use it to pursue non-economic objectives. Countries faced with acute resource scarcity may in turn pursue natural resource security at the expense of international relations. To the extent that these geopolitical factors create or exacerbate international tension, they can increase the price of natural resources beyond what would have been created by monopoly power and also increase price volatility. Both of these can have harmful effects on the global economy and trade (see the discussion below).

(b) Changes in natural resource prices and volatility

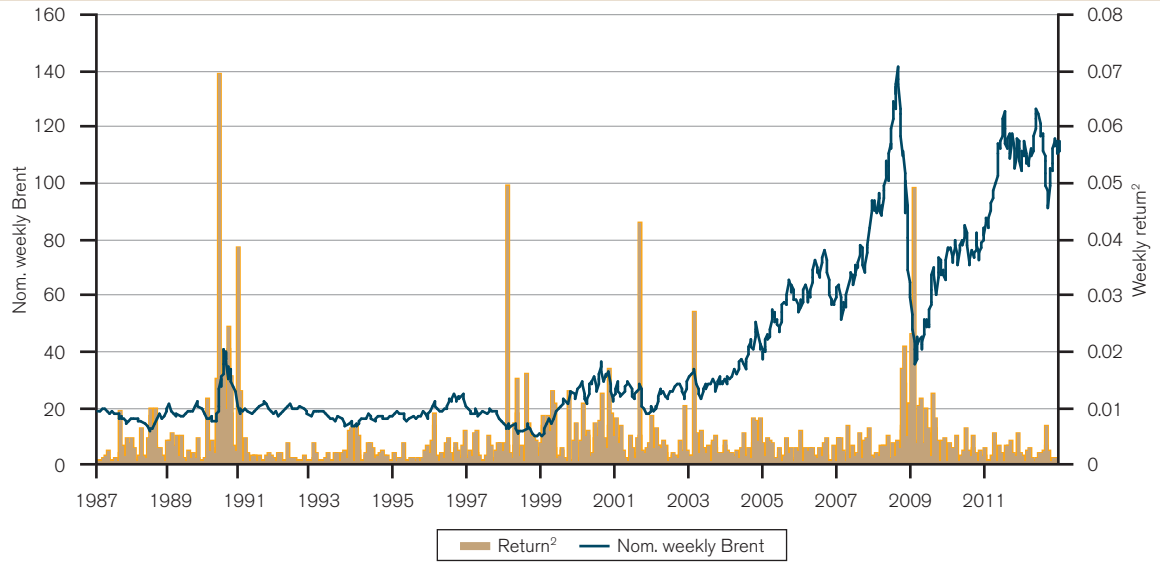
As was noted earlier, natural resource prices tend to be volatile. The following section focuses on energy – rather than land or water – price changes and volatility because of data availability. The world economy is characterized by a group of net oil-importing industrial economies which absorb a large share of global output, on one side, and a group of net oil-exporting countries, on the other. Changes in the price of oil represent large terms-of-trade shocks that adversely affect industrial economies while benefiting oil exporters (Backus and Crucini, 2000). Because of the size of industrial countries and the importance of oil, these terms-of-trade changes reverberate throughout the global economy.

Energy is a major factor of production and it is difficult to substitute capital or another factor of production for oil in the short run, so an increase in the oil price will reduce production of net energy-importing countries and slow their rate of economic growth (Hamilton, 2009). This, in turn, leads to a lower rate of import expansion. Of course, higher oil prices should expand output and increase GDP growth of net energy exporters (Korhonen and Ledyaeva, 2010). However, for the global economy as a whole, the evidence suggests that the negative effect on output and trade tends to dominate.

Secondly, changes in the cost of energy can alter the commodity composition of a country's export and imports depending on their energy intensity (Sadorsky, 2012). Although there is no standard list of energy-intensive products or industries, information from the energy balance sheet of the European Union (Eurostat, 2011) points to these being aluminium, iron and steel, chemicals, glass, pottery and building material (e.g. cement), and pulp and paper. All things being equal, an increase in energy prices will raise the prices of these energy-intensive products. It will consequently reduce demand for them and decrease their share (in real or volume terms) in international trade. The extent of this effect will depend on, among other factors, the ability of producers to substitute other factors of production for energy and the elasticity of demand for these products – the responsiveness of buyers to higher prices. The more inelastic the demand, the less the impact of higher energy prices.

Another salient feature of global energy markets is price volatility. Figure C.41 shows the weekly nominal crude oil spot price (i.e. the price of crude oil traded on a "spot" market and available for almost immediate delivery) between 1987 and 2012 and the square of the weekly return of oil prices that is used as a rough measure of volatility.[124] Based on this, price volatility tends to cluster at specific points in time. Some of the large rises or falls in the spot price of crude oil can be linked to specific instances of economic and political crises, which have the potential to disrupt global energy supply or demand significantly.

Figure C.41: **Weekly nominal oil spot prices and squared returns (Brent, Europe), 1987-2012**
(US$/barrel and weekly return^2)



Source: US Energy Information Administration (EIA), own calculations.

Note: Brent crude oil (in US$/barrel) is traded at the Intercontinental Exchange (ICE) Futures in London. Weekly prices as of closing time on Mondays.

The highest peak in short-term volatility occurred in 1990-91 and is linked to Iraq's invasion of Kuwait and the first Gulf War. Other periods with large fluctuations in oil prices were the terrorist attack on the World Trade Centre in the United States in 2001 and the Iraq war that began in March 2003. Both the commodity price spike of 2007-08 and the financial crisis in 2008-09, which led to the biggest drop in oil prices that the spot market has ever experienced, are also evident.

The underlying reasons for volatility are complex, involving demand and supply factors and shocks to both. Evidence from Hamilton (2009) and Smith (2009) point to the role of low demand and supply elasticities, particularly in the short run. A longer-term explanation has been provided by Dvir and Rogoff (2009), who contend that volatility spikes whenever periods of rapid industrialization have coincided with uncertainty regarding access to energy supply. They point to 1861-78 and 1973-2009 to support their argument. These were periods of rapid industrialization – by the United States in the first period and East Asia in the latter period – as well as periods of supply uncertainty due to the monopoly of railroads on transportation in the United States and to OPEC's ability to restrict access to supply in the latter period.

Many popular accounts of the increase in oil prices in the last decade attribute it to the growing appetite of emerging China and India for energy to power their rapid development. Beyond these explanations, a number of authors have argued that speculation has played a role in the recent increases in commodity and natural resource prices (Masters, 2008; Caballero et al., 2008; Robles et al., 2009). This is discussed in some detail in the 2010 *World Trade Report* on natural resources (WTO, 2010).

Volatility of oil prices can reduce trade flows because it increases the risks faced by importers (Chen and Hsu, 2012). In oil-importing countries, fluctuations in current prices create uncertainty about the future trend for oil prices, leading households to postpone purchases of consumer durables and firms to postpone investment decisions (Elder and Serletis, 2010; Henriques and Sadorsky, 2011). This reduction in spending by both households and firms reduces aggregate demand and hence total imports as well. The empirical study by Chen and Hsu indicates that total exports by oil-importing countries also fall as a result of oil price volatility.

(c) Exhaustibility and the role of innovation

Following Sweeney (1993), exhaustible natural resources can be defined as those whose adjustment speed – or renewability – is so slow that they can meaningfully be conceived of as being made available once and only once by nature.[125] Oil or natural gas deposits are typical examples of exhaustible natural resources.

The exhaustibility of some natural resources has frequently caused alarm. In 1972, the Club of Rome – a global think tank – famously claimed that pressures from economic activities and population growth would lead to the collapse of the economy and the environment given the finite supplies of natural resources (Meadows et al., 1972). Others have proposed "peak" theories, where the extraction of exhaustible resources is predicted to follow a bell-shaped curve, initially increasing exponentially, reaching a peak, and then declining exponentially until the resources are totally exhausted (Hubbert, 1956).

It can be argued that the idea that the rate of extraction of an exhaustible resource eventually reaches a

maximum, after which it declines is basically tautological (Hamilton, 2012). What makes the peak theory sound apocalyptic is the implied prediction that the peak is either behind us or about to come. By comparison, economists tend to be more sanguine about the exhaustibility of natural resources and concerned with other questions. How will markets, whether competitive or not, determine the rate of extraction of an exhaustible resource (Hotelling, 1931)? What is the optimal way of taking inter-generational equity into account, i.e. how much should current generations consume and how much should be left behind to future generations (Solow, 1974; Hartwick, 1977; Chichilnisky, 1996)? There are several reasons for this.

First, the total amount of the exhaustible resource is not known for certain, so given sufficient economic incentives, reserves can be maintained or increased through the exploitation of deposits initially considered as not economically accessible (Pindyck, 1978). Secondly, history has shown that technological innovation offers a potent response to the problem of exhaustibility. Innovations can increase efficiency in the use of an exhaustible resource so that the amount required to produce a unit of output is reduced over time. New methods of exploration can increase the likelihood of making new geological discoveries (Arrow and Chang, 1982). Innovation can lower the extraction costs of the resource (Hamilton, 2012). Finally, technology may advance enough so that it becomes possible for reproducible or renewable resources to take the place of the exhaustible resource (Dasgupta and Heal, 1974). Ultimately, it is an open question as to how long innovation will allow us to keep one step ahead of natural resource exhaustion.

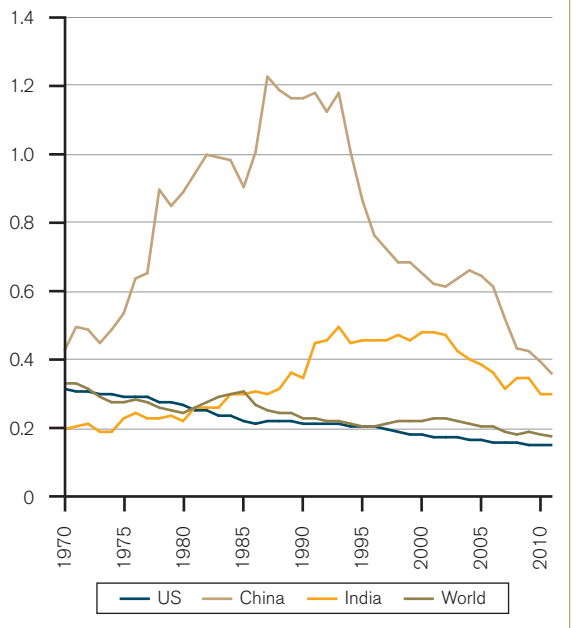
Using energy as an example, Figure C.42 shows long-run trends in energy intensity, which measures how many units of energy are needed to produce a unit of GDP. The lower the indicator, the more energy efficient an economy is. It can be seen that global energy intensity has been decreasing every year since 1970. This is true for large advanced economies, such as the United States, but interestingly, even emerging countries, such as China and India, have exhibited falling energy intensities in the last ten to 20 years, which were assumed to be periods of extensive energy use.

Geller et al. (2006) estimate that without energy efficiency improvements, the OECD countries would have used approximately 49 per cent more energy than was actually consumed as of 1998. They attribute this increased efficiency to, among other measures, the development and commercialization of a number of new energy efficiency technologies (e.g. energy-efficient building technologies, appliances, electronic lighting ballasts, etc.). Technological improvements also played an important role in reducing China's energy intensity (He and Zhang, 2006). Kiang et al. (2011) estimates that technology improvements accounted for 40 to 60 per cent of China's energy savings.

The rise of shale gas in the United States is a good case study of how technological change can dramatically augment the supply of an exhaustible natural resource. Shale gas refers to natural gas that is trapped within fine-grained sedimentary rocks. A combination of other innovations was needed before these deposits could be commercially exploited. The extraction technology – hydraulic fracturing ("fracking") – requires pumping water, chemicals and sand underground to open cracks in the rock and allow natural gas to be released from the shale.[126] However, it could only be used productively and predictably once know-how to map shale expanses and to drill horizontally in rock formations was developed (Trembath et al., 2012). As a result of these advances, shale gas production in the United States has grown nearly twenty-two fold since the 1990s.

A more dramatic illustration of how technological change could delay or offset exhaustibility is shown in Figures C.43 and C.44. Figure C.43 shows the stock of proven oil reserves and the ratio of these reserves to world oil consumption over the last three decades. During that period, the stock of proven reserves rose by more than 140 per cent while the ratio of reserves to global consumption actually rose from 11 to 19. A similar picture can be drawn for the case of natural gas, which is shown in Figure C.44. Proven reserves rose by about 160 per cent in the last three decades

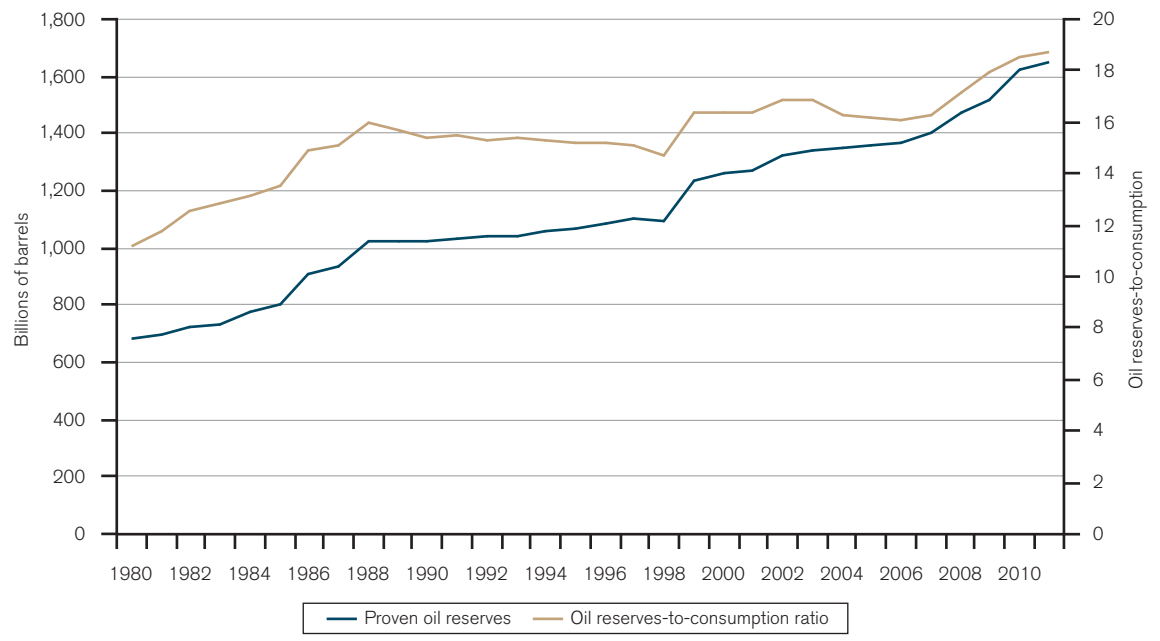
Figure C.42: **Energy intensity, 1970-2011**



Source: BP, *Statistical Review of World Energy*, June 2012; World Bank's *World Development Indicators* (WDI); own calculations.

Note: The unit of energy intensity is defined as kilogrammes of oil equivalent per constant 2011 US$. Current GDP in US$ has been deflated to 2011 US$ levels by using the world GDP deflator provided by the WDI.

Figure C.43: **Proven oil reserves and reserves-to-consumption ratio, 1980-2011**



Source: BP (2012).

while the reserve to consumption ratio continued to rise. The pattern of rising global reserves can be shown to hold for a wider range of exhaustible resources – bauxite, copper, iron and zinc (Lomborg, 2012).

Rising energy and natural resources prices as a result of scarcity will create incentives for firms to invest in innovation. However, the level of R&D investment may still be lower than the social optimum because the potential payoffs will not be realized for decades, which is beyond the planning horizons of most firms (Sathaye et al., 2007). This market failure – the divergence between private and social benefits – can warrant the use of R&D subsidies in the energy sector to increase innovation and find technological solutions to the exhaustibility of natural resources.

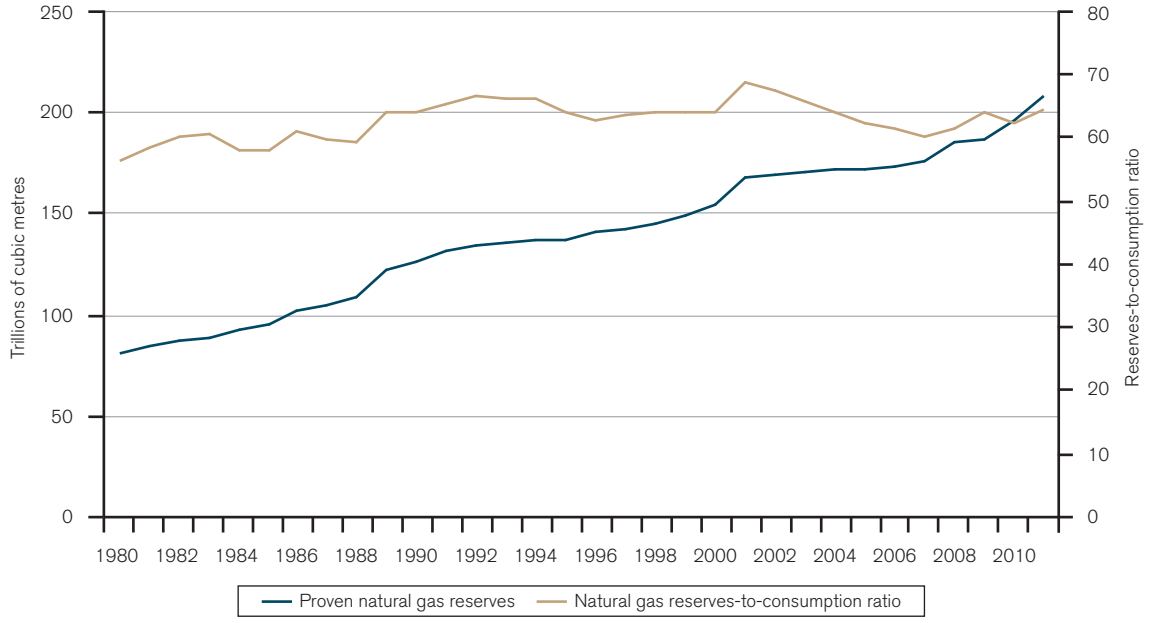
Geller et al. (2006) attribute a prominent role to government-funded R&D in the long-term improvement in energy efficiency in OECD countries. Similarly, Trembath et al. (2012) have pointed to the crucial role played by the US government in the successful development of shale gas. Innovation and progress in the development of hydraulic fracturing and other key gas recovery technologies came about from public-private research and commercialization efforts. At the same time, subsidies give governments greater leeway to pursue a kind of industrial policy, where the new objects of largesse are future "winners", such as biofuels, solar and wind.[127] This gives rise to the risk of industries being promoted not for public policy reasons but in order to benefit domestic producer groups.

What are the trade implications of the exhaustibility of natural resources? First, it means that a country favourably endowed with a large stock of exhaustible natural resources could see its comparative advantage erode over time. While empirical analysis of the dynamics of trade specialization with respect to natural resources has received little attention,[128] there are several studies that appear to demonstrate shifts in comparative advantage in natural resource-exporting countries.

Leamer (1984) shows that between 1958 and 1975, countries such as Australia, the Dominican Republic, Honduras, Paraguay and the Philippines experienced a significant increase in mineral extraction while the level of mineral extraction of Cyprus, Ghana and Yugoslavia decreased significantly. Davis (1995) finds that between 1973 and 1991, Botswana, the Democratic Republic of the Congo, Angola, Guinea, Niger, Papua New Guinea, the Syrian Arab Republic, South Africa, Cameroon, Togo and Ecuador gained comparative advantage in mineral extraction while Tunisia diversified away from mineral activities.

A recent paper by Alvarez and Fuentes (2012), using a large sample of countries between 1962 and 2000, finds that comparative advantage in raw materials tends to be less persistent than in manufactured goods. It is, however, unclear to what extent these changes are the result of the exhaustion in natural resource endowments or the result of other factors, including changes in policy (Davis, 2010). Furthermore, as this discussion of exhaustibility has highlighted, technological change is a potent force that can be harnessed by natural resource-abundant countries that wish to maintain comparative advantage in that sector.

Figure C.44: **Proven natural gas reserves and reserves-to-consumption ratio, 1980-2011**



Source: BP (2012).

(d) Environmental costs

Sometimes, the process of extracting natural resources or their consumption can have environmental costs. For instance, the current technology for extracting shale gas – hydraulic fracturing (fracking) – creates a number of environmental risks. Hydraulic fracturing fluid could leak into and contaminate groundwater. Methane could be accidentally released while exploiting shale gas reserves. Fracking itself could cause small earthquakes.

At present, the most serious example of negative environmental impacts associated with natural resource use is the burning of fossil fuels. This produces carbon emissions which accumulate in the atmosphere and can remain there for centuries. These carbon emissions are the main reason for the observed (and projected) increase in average global temperatures (Intergovernmental Panel on Climate Change, 2007). Climate change has adverse consequences at a physical level (rising sea levels, changes in ice cover and frequency of extreme weather events) and biological level (agriculture, forestry and human health). It is believed that the doubling of greenhouse gas emissions in the atmosphere (to 450 parts per million) relative to pre-industrial times will increase these risks dramatically.

As a result, many countries have taken steps, sometimes unilaterally and sometimes with others, to mitigate the adverse consequences of using fossil fuels. They include taxes on fuels, emission trading schemes covering sectors that are considered emission-intensive, increasing energy efficiency, spurring efforts to find alternatives to fossil fuels, etc. The joint report of the WTO and the United Nations Environment Programme (UNEP) on trade and climate change (WTO and UNEP, 2009) contains a comprehensive account of various national and international initiatives.

Section D.2 of this report will discuss the trade effects of environmental policies, including those arising from climate change mitigation efforts. However, it is important to mention two points. First, climate change policy will be crucial to the evolution of energy prices and to the future mix of energy sources. Secondly, there may be continued differences in the stringency of climate change policies adopted by governments, thus possibly creating cost differences between countries especially in energy-intensive sectors. These points are taken up below in the discussion of future scenarios.

(e) Future of natural resources and trade

The focus of the following section is on water and energy since much more work has been done on these natural resources than on land. Based on projections made by the OECD (2012c), the International Energy Agency (2012), the US Energy Information Administration (2012) and leading energy companies, such as BP (2012b), the potential implications of future supply and demand developments of natural resources for international trade as well as trade policy are considered.

Water and international trade

The OECD (2012c) projects that global demand for water will rise by 55 per cent between 2000 and 2050. This growth in demand will come mainly from

manufacturing, electricity and domestic use. Increasingly, the future will see agriculture and the environment competing for water with cities, energy suppliers and industries (see Figure C.45). In the face of these competing demands, there will be little scope for increasing water for irrigation, and thus, also for food and agriculture.

This pressure on water resources has two possible implications for international trade. The first implication is with respect to the pattern of agricultural trade among countries. The OECD's environmental outlook projects that, by the turn of this century, there will be severe water shortages for the entire populations of South Asia and the Middle East and large shares of China's and North Africa's population.

As noted before in the discussion on the uneven geographical distribution of natural resources, under conditions of severe water shortage, water-scarce countries will be forced to import water-intensive products. This suggests that food and agricultural products will become a larger share of the future imports of the countries in water-scarce regions. The second implication pertains to the product composition of international trade, and in particular, to the possibility that the long-term decline in the share of food and agricultural products in international trade, which was discussed in Section B, might be arrested or even reversed.

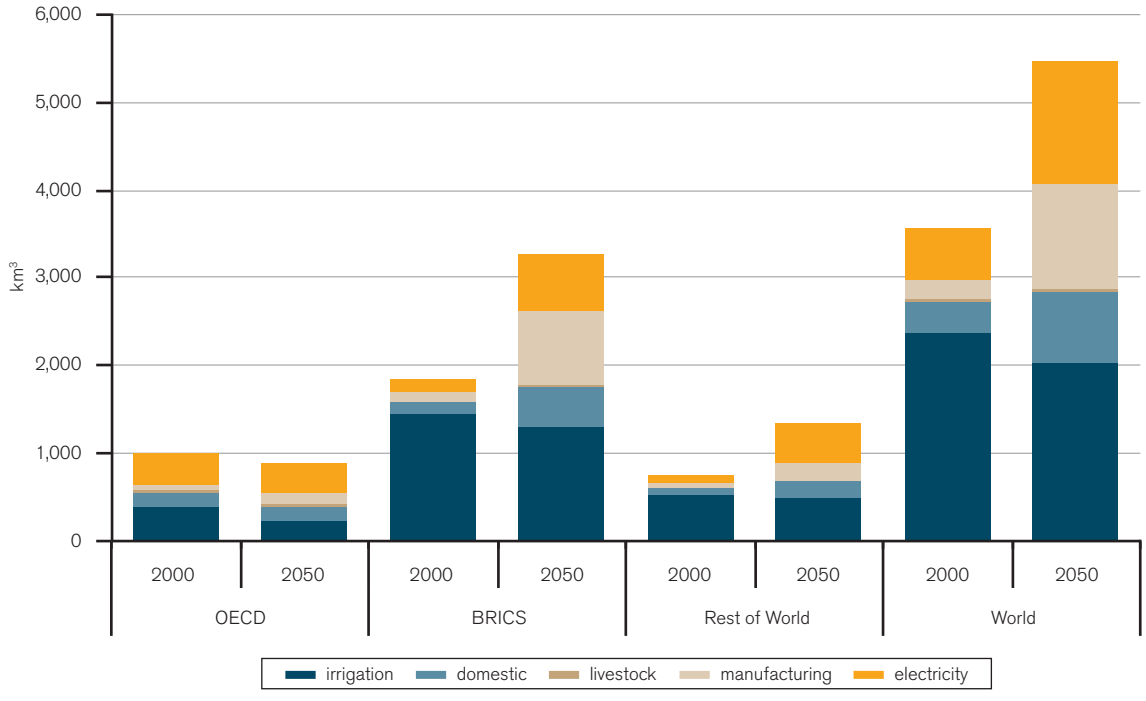
Energy and international trade

Given the rising trajectory of world GDP and population, energy needs are projected to rise by nearly a third by the year 2035 (International Energy Agency, 2012b). Most of this growth will come from increased energy demand by emerging economies, whereas there will be no significant changes in energy consumption by developed nations (BP, 2012b; International Energy Agency, 2012).

The energy mix is expected to change, with the shares of coal and oil declining while the shares of natural gas and renewable sources are expected to rise. In particular, US natural gas production is expected to increase from 21.6 trillion cubic feet in 2010 to 27.9 trillion cubic feet in 2035 (US Energy Information Administration, 2012). Almost all of this increase will be due to shale gas production, which will grow from 5 trillion cubic feet in 2010 to 13.6 trillion cubic feet in 2035. Fossil fuels will continue to meet the bulk of the world's energy needs in the future, making up 75 per cent of the world's source of energy (see Figure C.46). Natural gas will contribute the most to the estimated growth in energy demand. While the share of renewables in total energy consumption will rise to 15 per cent by 2035, it will not be able to satisfy growing energy demand on its own.

An important concern for international trade is the future evolution of energy prices. The International

Figure C.45: **Global water demand: baseline scenario, 2000 and 2050**
(cubic kilometre)



Source: OECD (2012b).

Note: This graph only measures blue water demand and does not include rain-fed agriculture. (BRICS: Brazil, the Russian Federation, India, China, South Africa.)

Energy Agency's latest outlook considers three scenarios in detail. These are differentiated by the kinds of policies it is assumed countries will adopt, either unilaterally or as part of international agreements. The policies of concern are those related to renewable energy, energy efficiency, fossil fuel subsidies and mitigation of climate change.

The "New Policies" scenario, which is the baseline projection in the International Energy Agency (IEA) report, assumes that policies that are in place now will continue in the future and, more importantly, that announced (but not yet implemented) governmental policy actions will be realized in the near future. The "Current Policies" scenario assumes that only current policies, and not announced policies, will be in force ("business as usual"). The third scenario is the so-called "450 Scenario",[129] in which it is assumed that new national and supranational policy actions will be adopted to limit the global average temperature increase to 2°C. Here, it is assumed that all OECD countries will eventually apply carbon taxes on CO_2 emissions.

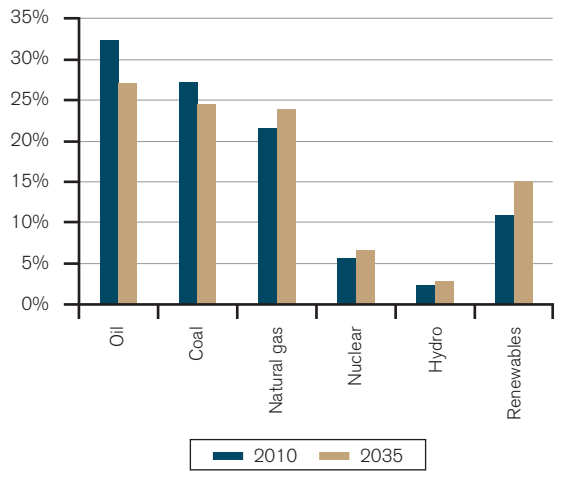
Figure C.47 shows the resulting projections of the real price of crude oil imports, which serves as a proxy for international prices of petroleum. These have been normalized to 100 in the base year 2011. The future trend for energy prices is highest (rising by 35 per cent) under the business as usual assumption. The "New Policies" scenario would see a more modest increase in energy prices (they would rise by 16 per cent) by 2035. This is because implementation of climate-friendly policies in the New Policies scenario means energy demand is lower than in the Current Policies scenario. Therefore, there is less need to exploit very costly reserves and thus prices are lower. Finally, the forecast change in energy prices for the 450 Scenario is negative. The assumption is that stronger abatement policies (relative to the first two scenarios) succeed in substantially limiting energy demand so that energy prices actually fall (by 8 per cent) below their level in 2011.

In terms of the likely effect on international trade, the rapid development of shale gas in the United States will create a "sea-change" in global energy flows and the pattern of international trade in oil (International Energy Agency, 2012). The United States will re-emerge as a major producer and exporter of energy rather than just consumer and importer of energy. It will become a net exporter of natural gas by 2020. As a result, North America will become self-sufficient in energy and a net oil exporter by 2035.

Another country that will have a large impact on energy markets is Iraq, with the IEA projecting that it will be the largest source of global oil export growth up to 2035. This will represent a dramatically successful rehabilitation of its energy sector driven by the country's ample reserves, low extraction costs and investor-friendly policies. Both these changes will thus require Middle East oil to find an alternative to the North America market, with the most likely scenario being that it will be redirected to consumers in Asian markets.

The higher energy prices predicted in the future may lead to shifts in the composition of trade as well. Assuming there is only limited scope for substitution in production towards other factors, such as capital or

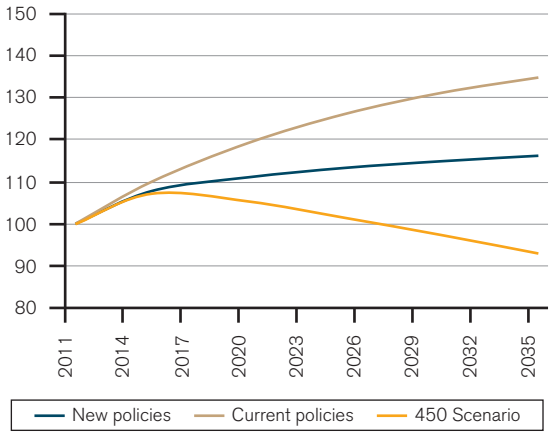
Figure C.46: **Energy mix, 2010 and 2035**



Source: International Energy Agency (2012).

Note: The energy mix projected for 2035 corresponds to the "New Policies" scenario in the IEA Report.

Figure C.47: **Projections for energy prices up to 2035**
(percentage)



Source: International Energy Agency (2012).

Note: Real import prices for crude oil are expressed in 2011 US$ and have been normalized to 100 for the year 2011. "New Policies" scenario assumes that policies that are in place now will continue in the future and that announced (but not yet implemented) governmental policies actions will be realized in the near future. The "Current Policies" scenario assumes that only current policies will be in force. The "450 Scenario" assumes that new national and supranational policy actions will be adopted to limit the global average temperature increase to 2°C.

labour, energy-intensive industries will be penalized more than other sectors by rising energy costs. Furthermore, it is likely that countries will differ in the stringency of their climate change mitigation policies. This means that countries with tougher environmental policies might see a deterioration in their competitiveness in energy-intensive sectors relative to countries with much weaker regulations. Finally, the projected rise in energy prices also has an important bearing on fuel costs and therefore on transportation costs. These impacts and what they imply for international trade are considered more fully in Section C.5.

Beyond these impacts, a number of policy issues discussed above are likely to continue to be relevant or even grow in importance in the future. They include the use of export restrictions by resource-abundant countries to enhance their market power in international trade, the use of subsidies to provide incentives in the search for alternatives to fossil fuels and their possible misuse for industrial policy, agricultural protection and the pricing of natural resources such as water, and varying adoption of climate change mitigation measures.

(f) Conclusions

One of the patterns identified in Section B.2(c) was the highly concentrated exports of natural resource-abundant developing countries. An important lesson that these countries can draw is that comparative advantage built on exhaustible resources can be fragile. For those countries and the world as a whole, investments in R&D are crucial if these advantages are to be maintained over time.

In the case of energy trade, a major shake-up in the next two decades is likely, with the re-emergence of the United States and, to a lesser extent, Iraq in global energy production and trade. Middle East oil exports will shift decisively to Asia. Higher population growth and a much larger global economy will push energy prices up as demand increases, possibly reducing the share of energy-intensive products in world trade. Severe water shortages in South Asia, the Middle East, North Africa and China are likely to lead to rising food and agricultural imports in those water-scarce regions. This will probably result in a continued focus on a number of trade policy issues in the natural resources sector, with the most prominent being export restrictions and subsidies. Policies in other areas, such as trade-distorting measures in agriculture and varying application of climate change mitigation measures, are likely to play important roles as well.

5. Transportation costs

The cost of transporting goods from producers to users affects the volume, direction and pattern of trade. It determines where the line between tradable and non-tradable goods is drawn and shapes which firms are able to participate in trade and how they organize their production internationally. The cost of transportation is in turn influenced by a wide range of fundamental determinants. These include the geographical features of countries, the quantity and quality of the physical infrastructure that support transportation services, the procedures and formalities used to control the movement of goods from one country to another, the extent of competition in the transportation sector, the pace of technological innovation in the sector and the cost of fuel (Behar and Venables, 2010). The characteristics of the products being shipped also affect transportation costs.

Part (a) of this section discusses how transportation costs can affect international trade. Part (b) examines in detail each of the major determinants of transportation cost and their importance. Part (c) concludes by presenting possible scenarios in the evolution of transportation costs.

(a) How transportation costs affect trade

After decades of significant tariff cuts around the globe, which can partly be attributed to successful negotiations within the General Agreement on Tariffs and Trade (GATT) and the WTO, average tariff barriers are now lower than many components of trade costs, including transportation costs. This is documented in a comprehensive survey of trade costs by Anderson and van Wincoop (2004) (see Section B).

Taking the United States as an example, Table C.15 compares its *ad valorem* transportation costs with its average *ad valorem* tariff rates, weighted by import values. The figures for the United States are in line with the conclusions drawn by Anderson and van Wincoop; US *ad valorem* tariff rates in most cases are lower than *ad valorem* transport costs. The measure of transport costs used in these calculations only includes the international part of transportation. If inland transportation is also included, the total costs involved will be even higher. The reversal in importance of transportation costs and tariff rates highlights the way in which transportation costs is similar to protectionist policy measures in that they lead to an "anti-trade bias" – a greater incentive to produce for, and rely on, the domestic rather than the world market.[130]

Following Samuelson (1954), most trade models that include transportation costs assume they are proportional to the price of the traded good (transportation costs are the "iceberg costs"). As a result, transportation costs drive a wedge between origin and destination prices but they do not produce changes in the relative prices of goods. Consequently, higher transportation costs reduce the volume of trade but do not necessarily change the composition of trade. However, if all or a significant part of transportation costs is additive – i.e. charged on a per

Table C.15: **Ad valorem transport costs for US imports, 1996 and 2011**

	All modes of transport	Seaborne	Airborne	Other modes	Tariffs
1996					
Total merchandise	3.35	4.55	2.90	1.84	2.49
Agricultural products	6.93	8.32	20.92	3.87	2.94
Fuels and mining products	5.40	6.51	0.94	3.27	0.47
Manufacturing products	2.84	3.73	2.82	1.45	2.76
2011					
Total merchandise	2.63	3.48	2.34	1.11	1.38
Agricultural products	5.02	5.79	18.99	2.50	1.50
Fuels and mining products	1.94	2.15	0.61	1.28	0.82
Manufacturing products	2.75	3.96	2.39	0.96	1.59

Source: US Census Bureau's US *Imports of Merchandise*, own calculations.

Note: Average for all modes and every other aggregation is weighted by imports (data originally in HS10-digit disaggregation). The average tariff rate is constructed by weighting individual tariff lines (aggregated by TRAINS at the HS6-digit level) with respective import values.

unit basis rather than purely proportional to the price of the traded good – then the conclusion that relative prices are left unchanged no longer holds. In particular, transportation costs can be expected to have pronounced effects on the relative prices of both high-quality and low-quality products as well as goods with different weight-to-value ratios.

Since a higher-quality good will typically sell for a higher price than the low-quality good, fixed transportation costs per shipment will make up a bigger share of the price of the low-quality good. An increase in transportation costs will consequently raise the price of the low-quality good proportionately more than that of the high-quality good. This will encourage consumers in export markets to switch towards the high-quality good, thereby increasing its share in international trade.[131] A greater share of the low-quality good will be left in the home market (see Box C.9). Conversely, a reduction in transportation costs will lead to an increase in the share of low-quality products in international trade. The greater the disparity in prices between high-quality and low-quality goods, the bigger will be the impact of transportation costs on the pattern of trade.

Hummels and Skiba (2004) test whether data on transportation costs are more consistent with the additive rather than the iceberg story and whether transportation costs alter relative prices of high and low-quality products. Their study is based on imports, at the six-digit level of the Harmonized System, of a number of Latin American countries – Argentina, Brazil, Chile, Paraguay and Uruguay – and the United States from all countries. The study finds that transportation costs are not proportional to price (not of the iceberg form) and closer to being additive[132] and that the share of high-quality goods relative to low-quality goods increased when per unit freight rates rose.

Beyond quality differences, another characteristic of traded products which turns out to be important is the value-to-weight ratio (Hummels, 2007). Box C.10 discusses some estimates of the value-to-weight ratios of EU and US imports disaggregated by mode of transportation. All things being equal, transportation costs will have a smaller impact on the landed price of the good with a high value-to-weight ratio. To see this, compare the effect of shipping a metric ton of iron ore worth US$ 120 to a metric ton of gold bullion worth US$ 54.7 million.[133] Since they have the same weight, shipping costs will be very similar; only the higher insurance costs will probably be different for these shipments. However, given the vastly different value of a metric ton of these products in *ad valorem* terms, transportation costs will have a bigger impact on the delivered price of iron ore compared with the delivered price of gold. Given these relative price effects, higher transportation costs will tend to increase the share of goods with higher value-to-weight ratio in international trade.

A recent paper by McGowan and Milner (2011) provides some corroborating empirical evidence of how the composition of trade is affected by increased trade costs (of which transport cost is an important element). They focus on "trade cost intensive industries" which produce goods that have a large share of imported intermediates. These industries include: coke, petrol and nuclear fuel; pulp, paper and paper products; and electrical machinery. Using a sample of 37 industrialized and transition countries, they find that industries located in countries with low trade costs capture significantly higher shares of world exports, with this effect being stronger in trade cost-intensive industries.

Another channel through which changes in transportation costs can affect the pattern of trade is through its impact on the "extensive margin of trade" – the increase in the number of products a country trades. Not all products that a country produces are exported. However, by reducing the wedge between prices at the origin and destination, declining

Box C.9: **The mysterious case of the missing delicious red apples**

Before it became associated with corporate behemoths like Amazon, Boeing, Microsoft and Starbucks, as well as the cultural phenomenon that was grunge music, the US state of Washington was famous for its apples. To some irate state residents though, it appeared that only the small and old-looking ones remained in the state, while all the red and delicious apples were being shipped out of state. To the state residents who wrote to their local newspaper the *Seattle Times* expressing their disappointment, it was a mystery that had no obvious explanation.

However, the answer to this mystery had long been part of the lore in the economics department at the University of Washington and was even part of classroom discussions and exams. The answer to the mystery relied on the fact that a per unit transportation charge applicable to both high-quality and low-quality products lowers the relative price of the high-quality product at the point of destination. This leads consumers at the destination to purchase a greater proportion of the high-quality product than consumers in the place of origin. The explanation provided by the economists of the University of Washington to the readers of the 28 October 1975 edition of the *Seattle Times* is reproduced below:

> "Suppose, for example, a good apple costs 10 cents and a poor apple 5 cents locally. Then, since the decision to eat one good apple costs the same as eating two poor apples, we can say that a good apple in essence costs two poor apples. Two good apples cost four poor apples. Suppose now that it costs 5 cents per apple (any apple) to ship apples East. Then, in the East, good apples will cost 15 cents each and poor ones 10 cents each. But now eating two good apples will cost three, not four poor apples. Though both prices are higher, good apples have become relatively cheaper, and a higher percentage of good apples will be consumed in the East than here. It is no conspiracy, just the law of demand."

Source: Borcherding and Silberberg (1978).

transportation costs can increase the range of goods available for international commerce, making goods that are currently non-traded tradable.

Moreira et al. (2008) provide estimates of the potential diversification arising from reductions in transportation costs for nine Latin American countries – Argentina, the Plurinational State of Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru and Uruguay. They note that the degree of diversification of these countries' export bundles is smaller than would be predicted from their size and below or just about average in terms of their levels of development. The authors measure the degree of product diversification by the number of tariff lines at the six-digit HS level that show positive trade flows for each pair of countries. They estimate that a 10 per cent decline in average transport costs would be associated with an expansion of more than 10 per cent in the number of products exported and with a 9 per cent increase in the number of products imported. Obviously, there are going to be differences across these countries in the extent to which falling transportation costs generate changes in the extensive margin of trade. They estimate that larger economies such as Argentina and Brazil would increase the number of products exported to other countries in the region by between 210 and 253 items whereas smaller economies such as Colombia and Peru would see an increase of about 50 items.

Beyond simply moving goods from origin to destination, transportation services have a temporal dimension as well – i.e. the time it takes to deliver a good to its destination. Figure C.48 shows that the time needed to export varies considerably by country and level of development. The time needed to export is much shorter in Europe, North America and Australia compared with most African and landlocked Central Asian countries. For the former group, it takes less than 12 days on average to make a container ready to leave the country by ship including inland transportation, customs clearance and loading. For most Central Asian and African countries, the time to export such a container is longer than 25 days.

There are several ways to think about the cost of time or of delays in the context of trade. First, one can think of the cost in terms of the working capital that is tied up while shipments wait in the holds of ships. With this perspective, the cost of time is just the interest cost of these shipments. A second way to think about the cost of time is as the rate of depreciation or technical obsolescence of the tradable good, which could be quite significant for fresh produce, fashion items subject to fads or consumer electronics (e.g. smart phones) where innovation is extremely rapid. A third and qualitatively different way to think about the cost of time is in terms of uncertainty (Harrigan and Venables, 2006).

There are at least two sources of uncertainty. The first arises from the way that much of global production is organized. The rise of global supply chains (see Section B.2(e)), just-in-time inventory management and lean retailing is making a broader range of products more time-sensitive. For global supply chains that depend on manufacturing final products from a

Box C.10: **Value-to-weight ratios of EU and US imports**

The value-to-weight ratio of traded goods has been increasing for all modes of transportation but most strongly for air transportation during the late 20th century (Hummels, 2007). Table C.16 illustrates this relationship for EU and US imports in the last ten years, with the increase stronger for sea, rail and road transportation. This might be related to the surge in jet fuel costs in particular, which shifted parts of international trade back to these modes of transportation.

However, the huge differences in the value-to-weight ratio between air transportation and other modes as well as between different product groups seem to be similar for both the European Union and the United States. On average, goods that are moved by planes instead of vessels are about 100 times more valuable in terms of this ratio. Most of these differences can be attributed to the trade in manufactured goods, which is responsible for a major part of world trade.

Table C.16: **Value-to-weight ratios for EU and US imports, 2001 and 2011**

	Sea	Air	Rail	Road	Other modes of transport
EU 2001					
Total merchandise	364	80,323	164	2,676	448
Agricultural products	486	4,828	111	627	629
Fuels and mining products	140	18,759	87	505	166
Manufacturing products	2,042	107,911	498	5,198	4,645
EU 2011					
Total merchandise	1,080	123,546	398	5,184	952
Agricultural products	1,142	8,140	267	1,349	1,482
Fuels and mining products	600	53,606	248	1,776	677
Manufacturing products	3,935	146,445	1,210	9,100	7,178
US 2001					
Total merchandise	612	85,377	-	-	-
Agricultural products	981	5,159	-	-	-
Fuels and mining products	155	281,670	-	-	-
Manufacturing products	2,561	96,087	-	-	-
US 2011					
Total merchandise	1,497	133,167	-	-	-
Agricultural products	1,969	7,804	-	-	-
Fuels and mining products	704	293,260	-	-	-
Manufacturing products	4,495	140,344	-	-	-

Source: *Global Trade Atlas*, maintained by GTIS (Global Trade Information Services), own calculations.

Note: Value-to-weight ratios are shown in US$ per metric ton. Averages for aggregations are weighted by imports (data originally in HS6-digit and HS10-digit disaggregation, respectively). Only external imports (from outside the EU) are used. The US only reports consistent weight data for its maritime and airborne imports, other modes cannot be computed.

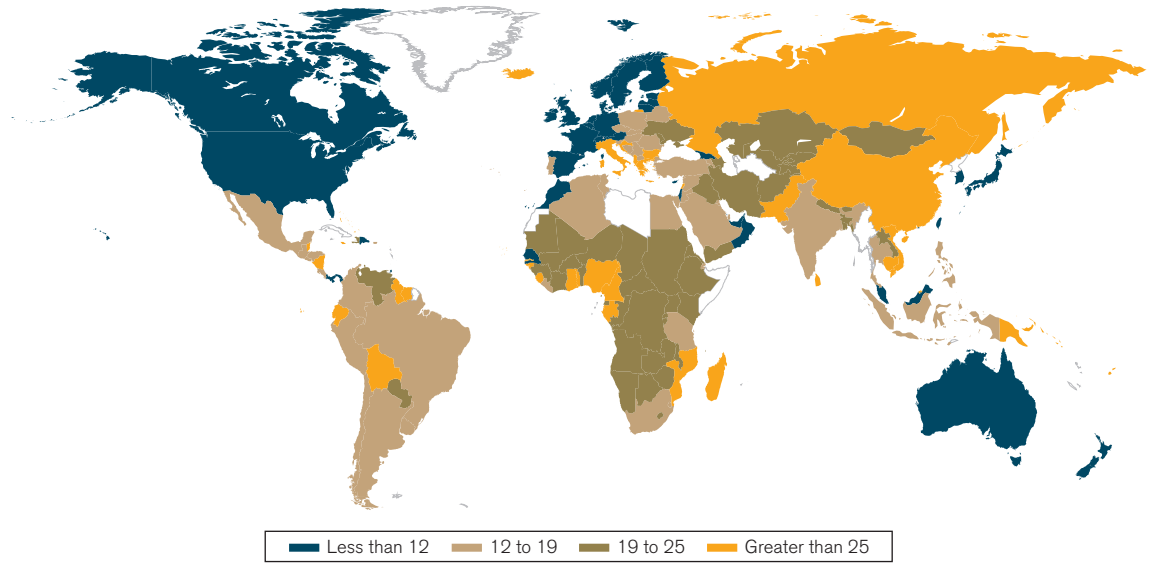
large array of parts and components, unsynchronized deliveries can disrupt the entire production process.[134] Uncertainty about exact delivery times can reduce trade as companies might source more of their inputs locally to reduce the risk of production interruption.

A second source of uncertainty arises from volatility in product demand (Hummels and Schaur, 2010). If a firm fails to correctly guess the tastes of foreign consumers, it will be saddled with products that no one wants. If the firm decides to be cautious by producing only a limited amount of a given design, it will fail to take full advantage of the market opportunity even if it guessed right about foreign consumer tastes. The firm can avoid this dilemma if it can move its products rapidly to international markets, allowing it to time and adjust its production to match foreign tastes.

Empirical work that attempts to measure the cost of time delays approaches the issue in several ways. Some studies estimate the cost in terms of the reduction in trade volume. Djankov et al. (2010) show that an additional day in the average time to export – meaning the time a shipment requires to move from the company grounds to being actually exported – reduces exports by more than 1 per cent. Others try to measure the percentage increase in the price of the tradable good at the point of destination.

Hummels and Schaur (2010) estimate that each day spent in transit is equivalent to charging an *ad valorem* tariff rate of 0.6 per cent to 2.3 per cent. Trade flows that consist of parts and components were found to be 60 per cent more time sensitive and hence more likely to be transported by airplanes. Air transportation is

Figure C.48: **Time needed to export goods**
(in days)



Source: World Bank, *Doing Business – Trading Across Borders* (2013).

Note: Countries are grouped according to the time to export (in days) a standardized container, meaning how long a good on average takes from the production site to being ready to leave the exporting country by ship. Surfaces in white: Data unavailable at the time of writing. Colours and boundaries do not imply any judgement on the part of the WTO as to the legal status of any frontier or territory.

obviously faster but also more costly than sea transportation. Other studies consider the likelihood that countries may not be able to enter specific export markets or participate in global supply chains if there are lengthy delays in trade shipments (Nordas et al., 2006; Hummels and Schaur, 2012). The Hummels and Schaur study estimates that a delay of three days can reduce the probability to export by 13 per cent (see Section B.2(a)).

All in all, these estimates paint a similar picture – the cost of time delays in international trade is high. The estimates in these studies suggest that a delay of one week in shipments can reduce the volume of exports by as much as 7 per cent or raise the delivered price of goods by 16 per cent. For exceptionally time-sensitive goods, such as parts and components, the volume can be reduced by as much as 26 per cent.

(b) Determinants of transportation costs

What factors are likely to influence transportation costs? The possible determinants include product characteristics, geography, infrastructure, market competition, technological change, trade facilitation and fuel costs.

(i) Product characteristics

As discussed above, *ad valorem* transportation costs differ depending on the characteristics of the product being shipped. Two features particularly relevant in this regard are the quality of the product and its value-to-weight ratio. All things being equal, *ad valorem* transportation costs will be lower for high-quality goods and for goods which have a higher value-to-weight ratio.

(ii) Geography: landlocked countries and distance to markets

The geographical characteristics of countries can have a significant bearing on transportation costs and hence on countries' ability to participate in international trade. One of the most salient of these geographical features is access to an ocean or ocean-accessible sea.

There are more than 40 landlocked countries in the world. Of these, 31 are developing countries, with 16 of them being least developed.[135] An important reason why being landlocked is disadvantageous to a country's trade is that the country becomes dependent on the transit states (Arvis et al., 2007) and thus the location, size and quality of the transportation infrastructure to support trade are not fully under its control. Neither are the policies or regulations that will apply to the transportation and logistics sectors. These have to be negotiated with the transit states and the outcome is not necessarily what the landlocked country would have chosen. Also, the transit countries may have political and economic incentives to impose costs on the landlocked countries (Gallup et al., 1999).

Using the difference between c.i.f (cost, insurance and freight) and f.o.b (free on board)[136] values as a measure of transportation costs, Radelet and Sachs (1998) find that landlocked countries face 63 per cent higher costs. Moreira et al. (2008) show that the cost to import goods into Paraguay, a landlocked country, is

about twice as high as the average for other Latin American countries that have access to the Atlantic or Pacific Ocean.

Using a different measure of transportation costs – shipping rates – Limao and Venables (2001) estimate that being landlocked increases transportation costs by 55 per cent, which is similar in magnitude to the estimate found by Radelet and Sachs. As a consequence of this, they estimate that being landlocked reduces trade volume by about 40 per cent on average. At the same time, recent research (Borchert et al., 2012) cautions against imputing all these estimated negative effects to geography as many landlocked countries also restrict trade in service sectors – e.g. telecommunications and air transportation – that connect them with the rest of the world.

Another important geographical feature that affects transportation costs is a country's distance to other markets and to transportation routes.[137] Hummels (2007) estimates that a 10 per cent rise in the distance between the exporting country and the destination port within the United States increases the corresponding transportation costs by 2.7 per cent for air and 1.5 per cent for sea shipments. Most other studies do not directly try to estimate the effect of distance on shipping or airline transportation charges; instead, the effect of distance is measured by how much it reduces trade volumes. These studies show a high and persistent negative impact, suggesting that claims about the declining impact of distance may be premature.

Disdier and Head (2008) review more than 1,400 gravity model estimates to systematically analyse the effect of distance on trade.[138] The objectives of this analysis are to determine the central tendency of the results indicated above as well as to identify sources of variation in the results. On the first question, they are able to conclude that the elasticity of trade to distance is about 0.9. This means that, on average, a 10 per cent increase in distance between trading partners lowers bilateral trade by about 9 per cent. On the second issue, they find a great deal of variation in the estimated impact of distance from the studies. They attribute the large variation to differences in data sets, econometric methods and, most important of all, the time period of the data used in the estimation. They find that the distance effect decreased slightly between 1870 and 1950 and then began to rise again.

One problem with most gravity estimates involving distance is that some factors which vary with distance may not be fully taken into account. For example, tastes, cultural characteristics and information costs may vary systematically with distance so that trade will decrease with distance even if transportation is costless (Feyrer, 2009; Allen, 2012). Using the closure of the Suez Canal as a natural experiment to take into account these other factors, Feyrer (2009) estimates an elasticity of trade with respect to distance of between 0.2 and 0.5, which is half that found in the gravity model estimates reviewed by Disdier and Head.

Irrespective of the magnitude of the distance effect, why does it persist as an impediment to trade? First, technological progress may have been less important in reducing transportation costs than has been assumed. Secondly, changes in the composition of trade might be biased toward goods with high distance costs. Related to this hypothesis, as was discussed earlier, the influence of time on trade is increasing so that distance may be serving as a proxy for the increased time sensitivity of trade.

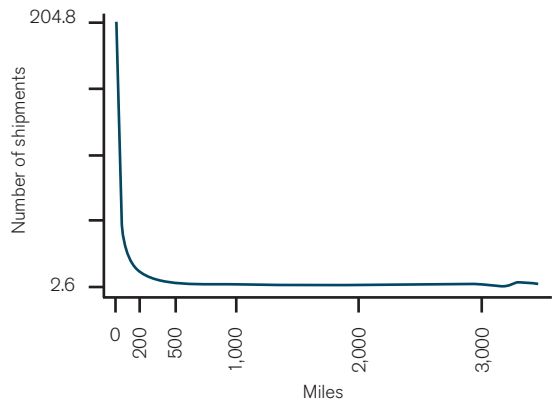
Thirdly, Hillberry and Hummels (2008) point out that a substantial part of trade is intra-industry exchange of intermediate inputs for assembled outputs. If inputs are highly specific to a producer, there may only be a very small possibility of substitution from other sources. Thus, industrial import demands will be much more sensitive to trade costs – as proxied by distance – and firms would rather respond to higher transportation costs by relocating close to the source of the inputs. Some sense of this effect can be gleaned from Figure C.49, which is taken from Hillberry and Hummels (2008). It uses US manufacturers' (both origin and destination) location at the ZIP code level and products identified at a very disaggregated level. The figure shows the value of shipments dropping very rapidly over distance, particularly within the first 200 miles, testifying to the large negative impact of distance on trade in intermediate goods.

(iii) Infrastructure

The amount and quality of transportation infrastructure in source, destination and transit countries have a major impact on transportation costs. The following discussion focuses in particular on the effect of investments in road and port infrastructure (Section C.2 discusses how investments in transportation infrastructure can lead to the emergence of new players in trade).

Although there has been a huge surge of studies documenting the importance of transportation infrastructure, their findings are quite similar – there is a critical role that infrastructure plays in reducing transportation costs and enabling trade. Unfortunately, almost all of these studies estimate the benefits from investing in transportation infrastructure based on the perspective of a single country. This is too narrow a view since a country's infrastructure investment also reduces the transportation costs incurred by its trading partners and neighbouring countries that are landlocked, allowing them to benefit as well. Thus, the magnitude of the benefits presented in the trade literature probably understates the overall gains from expanding investments in transportation infrastructure.

Figure C.49: **Estimated relationship between shipments of intermediates and distance**



Source: Hillberry and Hummels (2008).

Limao and Venables (2001) rank countries using an infrastructure index designed to measure the costs of travel in and through a country. They estimate that a country whose road infrastructure quality placed it on the 75th percentile globally, i.e. three-quarters of the way down the list, had transportation costs that were 12 percentage points greater than the median country. As a consequence, its trade was on average 28 per cent lower than the median country. For landlocked countries, an improvement in own and transit countries' road infrastructure could overcome more than half of the disadvantage associated with being landlocked. Applying their estimates to Sub-Saharan Africa, Limao and Venables conclude that transportation costs there are higher and trade volumes lower than would be predicted given the economic characteristics of the countries – incomes, distance, etc. They then attribute much of this result to the poor state of transportation infrastructure in the continent.

A later study by Freund and Rocha (2010) on African exports shows that uncertainty in road transport had a negative and significant effect on a country's ability to export. Their results point to improvements in road systems – especially infrastructure, security and policies that improve competition in trucking – as key to stimulating Africa's exports. Blyde (2010) and Volpe et al. (2012) look at the impact of increasing investments in road infrastructure in a couple of Latin American countries – Colombia and Peru.

Blyde (2010) first establishes that lower domestic transportation costs in Colombia can significantly improve the prospects of exporting. He finds that regions within the country with lower transportation costs (regions in the 25th percentile) export around 2.3 times more than regions with higher transport costs (regions in the 75th percentile) once other factors are taken into account. He then simulates a reduction in transport costs that would arise if the condition of all the roads identified as "bad" and "regular" by the national road authority were improved to "good". He concludes that this simulated improvement in road conditions decreases average transport costs by about 12 per cent and boosts average exports by around 9 per cent.

Volpe et al. (2012) assess the effects of new roads constructed in Peru between 2003 and 2010 on Peruvian firms' exports. The authors conclude that exporters whose routes were shortened due to the construction of new roads had exports that were about two-thirds higher than exporters whose route length remained the same. Overall, the additional investments in road infrastructure meant Peruvian exports were 20 per cent higher in 2010 than they would have been without the new roads.

The studies by Clark et al. (2004) and Abe and Wilson (2009) look at the relationship between port infrastructure and transportation costs.[139] Clark et al. (2004) use data on all US imports transported by sea. They construct an index of port efficiency using survey measures drawn from the World Economic Forum's *Global Competitiveness Report*, which depends, among other determinants, on the general condition of the country's infrastructure: the more efficient a country's port, the higher its score in this index. Clark et al. estimate that a country which improves its ranking in port efficiency from the 25th to the 75th percentile reduces shipping costs by 12 per cent; this, in turn, implies an increase in bilateral trade of around 25 per cent.[140]

The study by Abe and Wilson (2009) focuses on the growing problem of port congestion in East Asia. This has worsened not only because of the rapid growth in East Asia's trade but also because much of that trade is seaborne. Port congestion leads to bottlenecks, which significantly increase the cost of transporting goods to and from East Asia. Their analysis suggests that expanding facilities in East Asian ports so as to cut congestion by 10 per cent could decrease transportation costs by up to 3 per cent.

(iv) Market competition

The transportation sector is a service industry whose efficiency will depend, in part, on the existing regulatory regime and the extent of competition. There are a number of reasons for a lack of competition in the transportation sector, including natural monopolies, market access barriers that prevent foreign firms from entering and competing, and the cartelization of transportation service providers. In some cases, governments may even allow practices, e.g. price-fixing, that would otherwise be illegal under anti-trust laws.

Because the literature on competition in the transportation sector is immense, the following discussion focuses on a specific sector – maritime transportation – to illustrate the scope for more competition to reduce transportation costs and expand trade volumes (see WTO Secretariat Notes

S/C/W/315 and S/WPDR/W/48 for a fuller discussion of competition issues in maritime transport).[141]

The maritime transportation market is usually subdivided into two: the tramp (or bulk) market and liner market. Tramp ships have no fixed route or schedule and can be chartered for a period of time or for a specific voyage. In contrast, liner companies operate vessels between fixed ports on a strict timetable (UNCTAD, 2010a).

In the tramp market, the carrier chases the cargo (Brooks, 2011) and price competition is generally considered intense (Clarkson Research Studies, 2004). In this unrestricted market, freight rates are volatile because capital costs are high and supply difficult to adjust in the short run (Brooks, 2011). Ships cost millions of dollars; it takes years to build one and the operating lifetime of ships is counted in decades.

In the liner market, companies typically organize themselves into a consortium, with a view to providing a joint transportation service. In stark contrast to the tramp market, operators in the liner market have been exempt from national anti-trust laws since the turn of the 20th century. Part of the reason for this exemption was the desire to reduce price volatility. If operators can fix prices and if they collude to maximize industry profits, prices will be higher – set at a mark-up to marginal cost. The size of the mark-up will vary inversely with the elasticity of demand of the good that is transported, i.e. the more inelastic is the final demand, the higher the mark-up. Thus, while this exemption from anti-trust laws may reduce price volatility, it will be at the cost of higher freight charges and lower trade volumes.

In 2010, the European Union removed the anti-trust exemption on price fixing although operational cooperation among consortia members, such as sharing space on their respective vessels, continued to be exempted.[142] Liner members are expected to market and price their services individually. There was a similar legislative effort made in the US Congress in 2010 to remove the liners' exemption from US anti-trust laws but the bill was not passed.

Beyond government policies, one of the reasons discussed above for lack of competition may simply be the existence of a natural monopoly. Hummels et al. (2009) have argued that there may be such an element operating in the case of developing countries. First, the volume of their trade – particularly of small, developing countries – is tiny compared with the capacity of modern container ships. Secondly, there may be substantial economies of scope in offering transport services over a network of ports. As a consequence, it may be difficult to sustain more than one or two operators to service shipping routes to some developing countries. A similar pattern has been highlighted in a recent report by the United Nations Conference on Trade and Development on maritime transport (UNCTAD, 2010) . Between 2004 and 2011, the average number of liner companies dropped by nearly 23 per cent while the size of the largest ship deployed nearly doubled.

A trend featuring increasing containership sizes and carrying capacities and declining competition within the industry has continued for several years. This limited competition means developing countries pay higher transportation costs and have lower trade volumes. To estimate these effects, the paper by Hummels et al. (2009) studies freight costs for the United States and a number of Latin American countries. They estimate that shipping prices on Latin American imports are, on average, 30 per cent higher than shipping prices on US imports and that one-third of this difference is explained by the small number of carriers serving Latin American importers. They also calculate that eliminating market power in shipping would increase Latin American import volumes by about 15.2 per cent.

(v) Technological change

Innovations in the transportation sector can have an important role in bringing down transportation costs (see Section C.3 for a discussion about the link between technological change and trade more broadly). Notable examples of innovation include the development of the jet engine and the adoption of containerization in maritime transportation, which also increased the efficiency of multi-modal transport.

As Gordon (1990) observes, the introduction of the jet aircraft in the 1950s created profound quality changes in both performance characteristics and operating efficiency of commercial aircraft. Compared with the piston-driven planes which it displaced, jet aircrafts are faster and have lower maintenance and fuel costs. Adjusting for these improvements in performance, Gordon (1990) estimates that the real price of jet aircrafts fell at a rate of 12.8 per cent to 16.6 per cent per year during 1958-72 when they began to be widely adopted. The reduction in quality-adjusted aircraft prices appears to have been transmitted to air transportation charges. Using the average revenue per ton-kilometre shipped as a measure of air transportation cost, Hummels (2007) estimates that costs fell more than ten times over the 50-year period since the introduction of the jet aircraft (see Figure C.50).

At its simplest, a container is nothing more than a metal box of standardized dimensions. Yet, this box enabled the unprecedented expansion of world trade in the second half of the 20th century and contributed to the rise of just-in-time manufacturing and global supply chains (Levinson, 2006). The value of the container lay not in the product itself but in the system of transportation involving container ships, trucks and

freight trains built to handle container cargo (thus facilitating multi-modal transport) and automated handling that grew around it. Its effect on trade was so profound that it is tempting to assume that maritime transportation costs must have fallen dramatically as a consequence of the widespread adoption of containers.

However, Hummels (2007) finds no strong empirical support for this presumption. As can be seen in Figure C.51, while real tramp prices declined over this 50 year span, real liner prices were almost at the same level in 2003 as they were in 1955 although there have been marked fluctuations.

There are several explanations for this apparent discrepancy. Levinson (2006) observes that most historical data on freight cost cover only the ocean voyage between two ports and do not include the total door-to-door cost of a shipment. These total costs are more likely to have declined with the adoption of containerized trade as large efficiency gains for inland transport and loading and unloading have been realized. Hummels (2007) suggests another explanation is that the available price indices do not adequately capture the quality improvement made possible by containerization. Container ships are faster and quicker in terms of cargo handling. As discussed earlier, this quicker turn-around is absolutely essential to today's just-in-time inventory systems and global supply chains. Thus, even if these prices have not declined, the fact that goods can be moved much more quickly than in the past means there has been in effect a reduction in cost for traders.

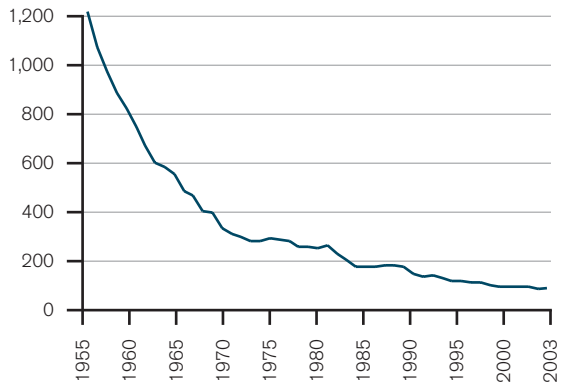
Finally, given that fuels costs are a significant component of the cost of operating ships or airplanes (see discussion below on fuel costs), current R&D efforts are being directed at improving fuel efficiency of these vessels. In the case of a jet aircraft, the three principal areas of concentration are reducing aircraft weight, improving aerodynamic design to lessen lift-dependent and friction drag, and enhancing engine performance to cut fuel burn per unit of delivered thrust.

Aircraft weight is being reduced through greater use of advanced alloys and composite materials and by replacing hydraulic control systems with lightweight electrical ones. Aircrafts are being designed so that effective wing span extension is maximized, laminar or streamline flow is better maintained and wetted areas (areas of the aircraft in contact with the airflow) are minimized. The thermal, transmission and propulsive efficiencies of newer jet engines are superior to those of previous generations. These improvements have made new aircraft such as Boeing's 787 airliner consume about 40 per cent less fuel per passenger than their 1970s counterparts.[143]

(vi) Trade facilitation

Trade facilitation examines how procedures and controls governing the movement of goods across and within national borders can be improved and simplified to reduce delays and costs. While it is not part of transportation *per se*, the growing prominence of time-sensitive trade and global supply chains increases the importance of border or customs-related costs, and hence of trade facilitation. The potential reduction in trade costs from improvements in trade facilitation appears significant. This is why it is a major part of the WTO's Doha Round negotiations, where the subject has made rapid progress (see Box C.11).

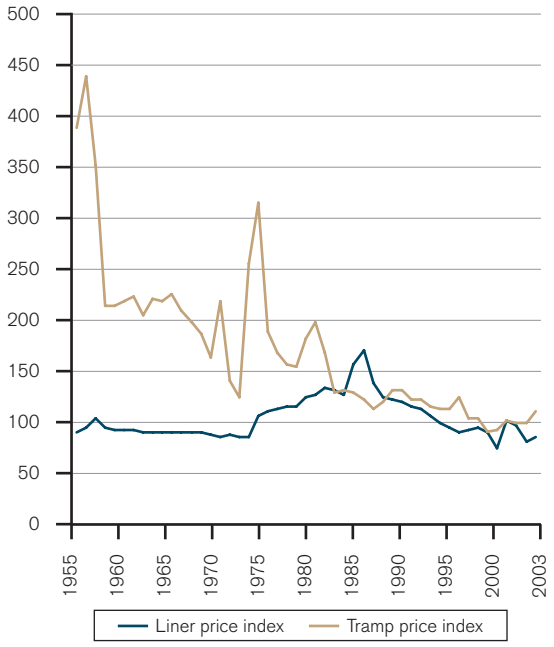
Figure C.50: **Air revenue per ton-kilometre, 1955-2003**



Source: Hummels (2007).

Note: Index is normalized to 100 for the year 2000 and based on revenues expressed in year 2000 US$.

Figure C.51: **Real tramp and liner price indices, 1955-2003**



Source: Hummels (2007).

Note: Indices are deflated using a US GDP deflator for the tramp price and a German GDP deflator for the liner price. Furthermore, indices are normalized to 100 for the year 2000.

Box C.11: **Trade facilitation negotiations in the WTO**

Starting over two years after the launch of the Doha Round,[144] the negotiations on trade facilitation in the WTO have now become one of the most advanced components of the Doha Development Agenda (DDA). Intense discussions among WTO members have brought the talks to a stage where the contents of a new agreement are clearly taking shape.

A first draft of the prospective agreement was tabled in 2009 and has subsequently been refined. Following discussions, members have been able to reduce the number of open questions by more than two-thirds. Structured into two main pillars, the Draft Agreement (TN/TF/W/165 and revisions) proposes a series of trade facilitation measures (Articles 1-15) and a related implementation mechanism (usually referred to as special and differential provisions for developing countries).

The proposed facilitation disciplines are largely based on three existing provisions of the GATT 1994: Article V (freedom of transit), Article VIII (fees and formalities connected with importation and exportation) and Article X (publication and administration of trade regulations). An additional, non-GATT based segment seeks to enhance cooperation between customs and other relevant trade facilitation authorities.

Instructed by the negotiating mandate[145] to "clarify and improve" the above-mentioned GATT disciplines, members have proposed a series of measures to strengthen the current regulatory regime. Common underlying objectives have been the simplification of border crossing procedures, the reduction of related bureaucratic obstacles and the creation of a more transparent and predictable trading environment. With the existing rules not having been revised for more than 65 years, governments agreed on the need to update a legal framework that reflects the trading realities of the 1940s as opposed to those of today's globalized, supply-chain dominated world.

The expected benefits of a new agreement are widely documented and cover various aspects of the cross-border movement of goods. According to a recent OECD study by Moïsé et al. (2011), the trade facilitation measures negotiated in the WTO have the potential to reduce total trade costs by almost 10 per cent for OECD countries alone.[146] It has also been shown that successfully implemented facilitation programmes increase customs productivity, improve tax collection and attract foreign direct investment. There is also a positive impact on government revenue, with several countries having more than doubled their customs proceeds after introducing trade facilitation reforms (OECD, 2009).

The benefits have been shown to be particularly significant for developing economies and least-developed countries (LDCs). Research has found that up to two-thirds of the total gains from trade facilitation are obtained by the developing world (OECD, 2009).

Many developing countries suffer from border procedures that are less efficient than those of their developed counterparts, indicating a great potential for improvement. The costs of importing goods have been found to be about 20 per cent higher for low-income countries than for their middle-income competitors, and another 20 per cent higher when compared with high-income economies (Hoekman and Nicita, 2010).

The recent analysis by Hoekman and Nicita (2010), which is based on the World Bank's Doing Business Indicators, concludes that the WTO discussions on trade facilitation are "perhaps of greatest relevance to low-income countries from a trade expansion perspective …".[147] The study finds that even "taking relatively limited actions to facilitate trade can boost the trade expansion effects of the Doha Round by a factor of two, three or more".[148] It also suggests that "pursuit of trade facilitation is particularly important for lower-income countries, especially LDCs, that otherwise will not benefit from the Doha market access negotiations – because they have duty-free, quota-free access to major markets and will not be asked to reform their own trade policies".[149]

Many studies use measures of trade logistics, such as the World Bank's Doing Business indicators or Logistics Performance Index. The latter is based on a worldwide survey of freight forwarders and express carriers on the logistics performance of the countries in which they operate and those with which they trade. It assesses performance in six major areas: efficiency of the clearance process by border control agencies; quality of trade- and transport-related infrastructure; ease of arranging competitively priced shipments; competence and quality of logistics services; ability to track and trace consignments; and frequency with which shipments reach the consignee within the scheduled delivery time. In 2012, Singapore, Hong Kong (China) and Finland were in the top three places in the index (see Arvis et al., 2012). OECD countries generally ranked high on the index, while countries at the bottom were typically least developed, landlocked or from Sub-Saharan Africa.

With the help of these two indices, Portugal-Perez and Wilson (2009) show that progress in trade logistics can boost the trade volumes of African countries. Even relatively small improvements in these indices that move a country towards the scores of well-performing African countries have large impacts on trade and welfare. This result is consistent with other findings about the huge trade benefits from trade facilitation for different sets of countries (see Wilson et al., 2003; 2005; 2008; Christ and Ferrantino 2011; Márquez-Ramos et al., 2012).

Other authors have investigated the effect of the WTO's Aid for Trade initiative on the costs of trading and found that it has significantly reduced those costs (Königer et al., 2011; Wilson et al., 2006). This indicates how Aid for Trade can be effective in helping developing countries improve their trade logistics capabilities. It shows that even simple reforms, whose implementation is relatively easy and cost-efficient, can have significant effects on international trade. Such reforms include the introduction of a single window, whereby all customs documents have to be submitted to only one governmental authority, or switching from paper-based to electronic submission of documents.

Ahmad (2010) describes the reform efforts in Pakistan and shows that a set of improvements that includes the two aforementioned changes reduced the share of shipments taking longer than one day to clear customs at the port of Karachi from 96 per cent to 7 per cent. As discussed above, the costs related to time delays at customs and the resulting uncertainty can represent a considerable share of the total cost of a product.

The extensive literature on trade facilitation emphasizes the importance of improving the reliability and transparency of customs and other authorities, of increasing competition in service providers in the proximity of borders and of providing advance rulings so as to reduce the uncertainty faced by traders.[150] Furthermore, most studies agree on the interdependency of the reforms, highlighting that an integrated approach magnifies the benefits and yields lasting improvements.[151] Solving one logistical problem within customs or inland transport may not produce major benefits unless other bottlenecks are tackled as well.

(vii) Fuel costs

Higher fuel costs increase transportation costs. Studies by Mirza and Zitouna (2010) and UNCTAD (2010b) find that the elasticity of transport costs with respect to fuel prices is between 0.09 and close to unity depending on the countries, timeframes, modes of transportation and products that are studied. This is quite a wide range since it means that a 1 per cent increase in fuel costs increases transportation costs by between 0.09 per cent and 1 per cent.

There are a number of explanations for this wide range of estimates, including how higher fuel charges affect various modes of transport differently.[152] However, the sensitivity of transportation costs to changes in energy prices appears to have been heightened by long-term improvements in transportation logistics, such as reduced loading times through containerization. As a result of the reduction in these non-energy components of transportation costs, fuel costs now account for almost one half of total freight costs (Rubin and Tal, 2008).

Rising energy prices adversely affect some transport modes more than others. Moreira et al. (2008) show that the increase in energy prices in the last decade raised air transportation costs relative to maritime costs for several Latin American countries and the United States. Over this period, the Chilean and US modal share for air transport decreased or at best remained constant.[153] This is in contrast to the second half of the 20th century where the trend had been for more and more products to be moved by air transport.

Energy costs also influence the composition of traded goods as they are likely to have a more adverse impact on goods with low value-to-weight ratios. For these products, soaring energy costs can quickly wipe out a comparative advantage based on differences in the costs of labour, particularly where margins are narrow. This can put pressure on those global supply chains which depend heavily on differences in labour costs across countries. This difference in value-to-weight ratios is reflected in producers' choice of transport since light and highly valuable goods are more likely to be transported by air (see Box C.12).

An analysis of maritime transportation confirms that goods with low value-to-weight ratios are likely to suffer more from higher energy costs. A study by UNCTAD (2010) estimates the elasticity of maritime freight rates with respect to oil prices to be lower for containerized products (0.19 to 0.36) than for products such as iron ore (up to 1.0), which is a bulky and low value-to-weight good. The study also finds that these elasticities seem to increase at times of sharply rising energy prices, which could be explained by the increased volatility and uncertainty that shipping companies have to deal with under such circumstances.

High oil prices can also prompt trading partners located further away to divert trade towards neighbouring regions (see the discussion on the regionalization of trade in Section B2(d)). In other words, soaring oil prices can act as tariff surcharges differentiated by origin depending on the proximity of the exporter to the importing country.

Mirza and Zitouna (2010) introduce a theoretical model, where transport costs have a fixed and a variable component, with energy prices being part of

Box C.12: **Shares of modes of transport**

The most important modes of transport used for international trade are sea and air transportation. However, rail and road transport are of particular importance for trade with neighbouring countries or within regional clusters, such as the European Union or North America. Martínez-Zarzoso and Suárez-Burguet (2005) find for certain Latin American countries in the late 1990s that air transportation is used for 12 to 25 per cent of total imports in terms of value. In contrast, seaborne transport accounts for 45 to 70 per cent of the value of imports. This pattern can be observed in Table C.17, where modal shares of European, American and Chilean imports are compared.

Depending on the product category and the specific breakdown of a country's imports, the value share of maritime transport lies between 45 and 95 per cent. In terms of its weight, most international trade is carried by maritime transport. UNCTAD (2010a) finds this share to be over 80 per cent. Moreover, Hummels (2007) shows that air transport accounts for less than 1 per cent of world trade in weight.

However, air transport has been gaining in importance as recent growth rates of ton-miles have been significantly higher than for any other mode of transport. Moreover, unlike agricultural goods and fuels and mining products, high-value goods such as manufactured goods – consumer electronics specifically – are transported primarily by air. The share of air transport becomes far more significant if world trade is measured in terms of its value instead of its weight. Table C.17 shows that in terms of value, 29 per cent of the EU's manufactured imports were transported by air but in terms of weight these same goods only account for 1.3 per cent of the EU's manufactured imports.

Table C.17: **Shares of modes of transport for imports in value and weight, 2011** (percentage)

			Shares in terms of value		
EU 2011	**Sea**	**Air**	**Rail**	**Road**	**Other modes of transport**
Total merchandise products	55.62	18.80	1.16	12.95	11.47
Agricultural products	77.32	3.41	1.50	14.71	3.06
Fuels and mining products	71.41	1.37	1.51	2.51	23.20
Manufactured goods	45.29	29.02	0.95	19.05	5.69
			Shares in terms of quantity		
EU 2011	**Sea**	**Air**	**Rail**	**Road**	**Other modes of transport**
Total merchandise products	74.50	0.22	4.23	3.62	17.43
Agricultural products	78.04	0.48	6.50	12.6	2.39
Fuels and mining products	74.00	0.02	3.78	0.88	21.32
Manufactured goods	74.84	1.29	5.12	13.61	5.15
			Shares in terms of value		
Chile 2011	**Sea**	**Air**	**Rail**	**Road**	**Other modes of transport**
Total merchandise products	78.24	13.03	0.00	8.63	0.10
Agricultural products	53.87	1.99	0.00	44.15	0.00
Fuels and mining products	95.94	0.21	0.00	2.27	1.58
Manufactured goods	72.89	19.44	0.00	7.65	0.03
			Shares in terms of value		
US 2011	**Sea**	**Air**	**Rail**	**Road**	**Other modes of transport**
Total merchandise products	52.51	22.41	-	-	25.08
Agricultural products	62.11	3.56	-	-	34.33
Fuels and mining products	77.25	1.58	-	-	21.18
Manufactured goods	45.69	29.64	-	-	24.67

Source: *Global Trade Atlas*, maintained by GTIS (Global Trade Information Services).

Note: Modal shares (in per cent) are constructed by using data on imports. For the EU, only external imports (from outside the EU) are used. Due to data limitations, "Other modes of transport" for US includes rail, road and other modes of transport. For EU and Chile "Other modes of transport" is an aggregation over all remaining modes such as inland waterways, pipelines or mail deliveries.

the latter component. One prediction of their theoretical model is that with increasing fuel costs, international trade will become more regionalized and products will be sourced more locally. Rather than through trade, distant markets may then be served by way of foreign affiliates or licensing arrangements. However, the empirical evidence is far from conclusive.

Contrary to the model prediction, Mirza and Zitouna (2010) find that the difference in the elasticity of transport costs with respect to energy prices between countries close to the importer compared with ones that are located far away from the importing market is only very small.[154] They show that in the US market, Mexican and Canadian exporters do not seem to have outperformed other exporters when the price for oil and other energy sources increased before the financial crisis. Rubin and Tal (2008) find the opposite result to Mirza and Zitouna, showing that during past oil crises the share of US non-oil imports from Europe and Asia dropped while the share of imports from the Americas went up. They calculate that at an oil price of US$ 200, imports from East Asia would be equivalent to an additional 15 per cent tariff on comparable imports from Mexico.

(c) Conclusions

The future scenario of transportation costs will depend on how different determinants – distance to markets and transportation routes, infrastructure, trade facilitation, competition and regulation, transportation technology, and fuel costs – are likely to develop.

Section C.4 notes the IEA's baseline prediction of a long-term increase in the real price of energy of about 16 per cent. Although no similarly precise projections for the other determinants of transportation costs are available, it is possible, based on the extensive literature, to arrive at estimates of how improvements in these areas could reduce transport costs (see Table C.18). These estimates are used to perform a series of "thought experiments" to assess whether such cost reductions are likely to offset the expected rise in energy prices.

The estimates referred to in Table C.18 come from different studies and employ different countries and time periods. While the estimates are statistically significant, they are still subject to estimation error. Moreover, they do not distinguish which mode of transport is involved. Nor do they include the impact of technological change. Although technological advances can be key to reducing transportation cost, there are no available estimates of how additional investments in R&D will translate into reductions in transportation costs. Despite these caveats, the exercise can be revealing.

Based on the work by Mirza and Zitouna (2010) and UNCTAD (2010b), there is a lot of variation in the estimated elasticities of transportation costs with respect to fuel prices. If we take the maximum of their estimates – an elasticity of one – a 16 per cent rise in energy prices will translate to a 16 per cent rise in transportation costs. Rubin and Tal (2008) estimate that fuel costs represent about half of transportation

Table C.18: **Estimates of potential changes to transportation costs**

Determinants	Estimated impact on transportation cost	Sources	Remarks
Fuel cost	Increase transportation cost by between 8% and 16%	Mirza and Zitouna (2010)	*Future scenario*:
		UNCTAD (2010), Rubin and Tal (2008)	Energy costs rise by 16%
Infrastructure	Decrease transportation cost by up to 12%	Limao and Venables (2001)	*Assumed improvement in infrastructure*:
		Blyde (2010)	Countries make investments in transportation infrastructure that improve their ranking from the 75th to the 25th percentile.
Trade facilitation	Decrease transportation cost by 10%	Moïsé et al. (2011)	*Assumed improvement in trade facilitation*:
			Implement trade facilitation measures being negotiated in the Doha Round.
	Decrease low income countries' trade costs by 20%	Hoekman and Nicita (2010)	Improve low-income countries' trade facilitation score to the level of middle-income countries.
Competition	Decrease transportation cost by up to 10%	Hummels et al. (2009)	*Assumed increase in degree of competition*:
			Increase number of carriers serving developing country markets.

costs. If we take Rubin and Tal's estimate as the lower most projection, transportation costs will go up by 8 per cent as a result of a 16 per cent rise in energy prices.

The estimates in Table C.18 suggest that there is ample scope for improvements in trade facilitation, investments in transportation infrastructure, and introducing more competition in transportation services to offset higher energy prices in the future.

The estimates from Limao and Venables (2001) and Blyde (2010) suggest that poor countries which improve their transportation infrastructure sufficiently to raise them from the 75th percentile to the 25th percentile can expect to lower transportation costs by about 12 per cent. The Moïsé et al. (2011) study gives an estimated reduction in trade costs of about 10 per cent if the trade facilitation measures being negotiated in the Doha Round come to fruition. The study by Hoekman and Nicita (2010) suggests that the cost of importing for low-income countries could be reduced by 20 per cent if their border procedures were at a comparable level to that of middle-income countries. Based on the study by Hummels et al. (2009), there is also a large potential to be tapped from increasing competition in transportation routes serving developing countries. Their transportation costs can be cut by as much as 10 per cent, which can either wholly or significantly offset the effect of higher fuel costs.

These "thought experiments" underscore the importance of pursuing a number of policy initiatives at both the national and multilateral levels. They include improving the quantity and quality of transportation infrastructure, successfully concluding the Doha Round of negotiations and introducing more competition in routes that serve poor countries. Although the predicted cost impact of technological change is not included in the table, given the inherent difficulty of predicting future innovation, it is likely to be a powerful force for cost reduction.

If no significant progress is made on these fronts, the expected rise in energy prices may well translate into a long-run rise in transportation costs. The consequence will be slower trade growth. There may be more regionalization of trade as higher transportation costs penalize trade with more distant countries. There will be a shift in the composition of trade, which will favour high-quality goods and goods with higher value-to-weight ratios. The share of time-sensitive goods in trade will fall. The extensive margin of international trade – the quantity of goods traded – will be affected adversely. Furthermore, there might be a move away from trade in merchandise goods towards trade in services, technology and ideas since this would entail far less transportation costs (Hummels, 2009).

Among the major trends identified in Section B was the emergence of new players in international trade and the rise of global supply chains. While not the only explanation, a reduction in trade costs has been a key driver of these trends.

On the basis of various measures of transportation costs and logistics performance, least-developed countries and countries in Sub-Saharan Africa tend to fare worst, while poor, landlocked countries face unique obstacles. Not only do higher transportation costs and longer delivery time reduce these countries' overall volume of trade, they make it difficult for them to break into new markets and participate in global supply chains.

Their situation can be alleviated through improved trade facilitation, introducing greater competition and by making sizeable investments in transportation infrastructure. Given the likelihood of rising fuel costs in the future, there is some urgency in reforming and modernizing these countries' transportation infrastructure and regulatory systems. The pay-offs from infrastructure investments appear large and should justify commitment of more resources on a cost-benefit basis. Because the trade partners of these countries will also see benefits from lower trade costs, it is in their interest to provide assistance through the Aid for Trade initiative, for example. Beyond this, there may be a good reason to re-examine the subject of competition policy in the future as the available evidence suggests market power in transportation services has been particularly burdensome to a number of developing countries.

6. Institutions

This section studies the relationship between international trade and the institutional framework. Two broad questions are addressed: How do institutions shape international trade relations? And how does trade affect institutions? The key observation in this section is that, in the long run, there exists a dual relationship between these two variables (in the language of economists, they are endogenous). Put simply, institutions shape and are shaped by international commerce. Understanding this relationship can help shed some light on the future of international trade and the multilateral trading system.

What are institutions? Economists have developed a notion of institutions that incorporates practices and relationships as well as organizations. As North (1990) explains, "institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction" (North, 1990). In economics, therefore, institutions are the deep frameworks, such as social norms, ordinary laws, political regimes or international treaties, within which policies – including trade policies – are determined and economic exchanges are structured.

Institutions can be formal or informal. Formal institutions are those that are consciously created by agents and that impose clear and visible constraints. Informal institutions are conventions and codes of behaviour. Formal institutions can be further sub-divided into political and economic institutions. The former impose constraints on government activities whereas the latter set rules that directly affect the relationship between economic agents. This section examines the two types of formal institutions, political and economic, and then focuses on informal institutions, broadly defined as culture.

Formal and informal institutions shape and are shaped by international trade. Institutional differences create transaction costs that make it more difficult to trade but they can also form the basis of comparative advantage in certain sectors or production tasks. More directly, institutions determine how trade and trade-related policies are set and negotiated, leading to a more or to a less open trading environment. In this sense, institutions are clearly a shaping factor of trade. At the same time, economic integration is an important determinant of institutional development, in the political, economic and cultural spheres. While these dynamic effects are likely to be slow to materialize, they feed back into trade relations over the longer term.

Part (a) looks at political institutions, such as the form of government. Part (b) focuses on economic institutions, such as the quality of the regulatory system. Part (c) examines cultural norms, such as those embedded in social values. Trade agreements are both political and economic institutions, in that they commit national policy makers and affect economic actors. For this reason, trade agreements are discussed throughout the entire section. Each sub-section begins with some evidence on the relationship between trade and institutions. The goal is not to have a thorough empirical analysis but rather to highlight some facts and correlations that can then be analysed in light of economic theory.

(a) Political institutions

Political institutions shape economic interactions in two ways: first, they impose constraints on government activities; secondly, they influence the set of economic institutions that societies adopt. The economic literature has tended to focus, in particular, on the impact of the form of government and political borders on international trade. Form of government, defined by the extent of accountability, legitimacy, transparency and choice in a political system, may impact trade indirectly through economic development or directly by altering policy-makers' incentives to set trade policy. Similarly, political borders impact trade flows directly by increasing trade costs and indirectly by fragmenting the international political system.

(i) Form of government

Democratic forms of government have been on the rise over the last half-century (Murtin and Wacziarg, 2012; Acemoglu, 2012), as has world trade. Much of this research uses data from the Polity IV Project to define and measure the form of government. The Polity scheme captures key qualities of political institutions and processes, including executive recruitment, constraints on executive action, and political competition. Individual ratings are combined into a single measure of regime governance – the "Polity score" – on a 21-point scale ranging from -10 (fully institutionalized autocracy) to +10 (fully institutionalized democracy). The measure examines concomitant qualities of democratic and autocratic authority in governing institutions, rather than discreet and mutually exclusive forms of governance. This perspective results in a spectrum of governing authority that spans "autocracies" (-10 to -6), mixed authority regimes or "anocracies" (-5 to +5), and "democracies" (+6 to +10).[155]

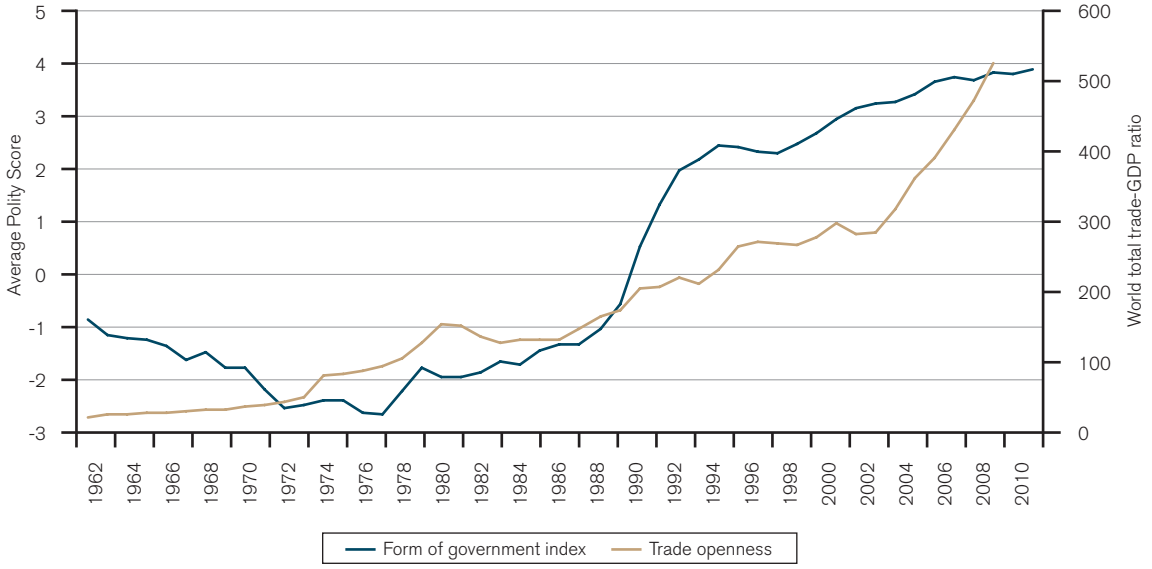
Figure C.52 shows that the correlation between more democratic forms of government, as measured by the "Polity score", and trade (measured as the total trade to GDP ratio) is strong and positive between 1962 and 2010.

A positive correlation between the value of imports and exports and a more democratic form of government can also be seen using a cross-section of countries in 2010 (see Figure C.53). While not shown in this report, a similar picture is evident for different years from 1962 onwards. However, if the ratio between total trade and GDP is used, rather than the value of imports and exports, the correlation (while still positive) appears to be weaker; possibly suggesting that richer countries are both more democratic and more open to trade.

The main conclusion from these figures is that countries which trade more tend to be more democratic on average, but this relationship is weak and not supported by a considerable number of individual country observations. These correlations also do not show that particular forms of government are a shaping factor of trade as the opposite could also be true – trade is a shaping factor of the choice of political systems. Moreover, both trade openness and the choice of a particular form of government could be driven by a third common factor, such as development levels. Economic analysis sheds some light on the determinants of this relationship.

A number of studies argue that more democratic regimes tend to have more liberal trade policies. The mechanism occurs through several channels. One argument is that less democratic governments are more easily "captured" by special interest groups that benefit from the economic rents associated with trade

Figure C.52: **Form of government and trade openness, 1962-2010**



Sources: Authors' calculation based on data from the Polity IV Project (http://www.systemicpeace.org/polity/polity4.htm), IMF and COMTRADE.

Note: Form of government as proxied by the Polity Score index. It ranges from -10 to 10. See text for more details.

barriers. Another argument is that democratic governments are more likely to enter into trade agreements to signal to voters their commitment to open and stable trade policies.

Mansfield and Milner (2010) provide empirical evidence that the probability of a country signing a free trade agreement increases with its level of democracy. In addition, Mansfield et al. (2000) show that pairs of democratic countries establish lower trade barriers compared with pairs of countries that include an autocracy. Yu (2010) considers democracy in a standard gravity model and finds evidence consistent with the hypothesis that, on average, more democracy is associated with increased trade. Finally, the empirical results in Eichengreen and Leblang (2008) confirm that the relationship between trade and the form of government runs in both directions.

A related issue is how the transition from one form of government to another affects trade policy. From Figure C.54, it appears that the empirical relationship between trade policy and the form of government is not linear: the countries with the lowest and highest polity scores on average apply lower tariffs compared to countries with an intermediate polity score.[156] This fact may suggest that the transition towards more democratic regimes could lead to an initial surge in protectionism.

O'Rourke (2007) argues that the transition from more autocratic to more democratic regimes implies a transfer of power from a small ruling elite to the wider population. As a consequence, trade policies will change according to the preferences of the majority. In a standard Heckscher-Ohlin framework, one would expect that more open trade policies should be observed in countries where the majority of workers gain from trade opening. Conversely, in countries where workers stand to lose from trade opening, a democratic transition might be expected to lead to an increase in trade barriers. The evidence from a sample of developed and developing countries between 1870 and 1914 confirms this basic theoretical insight. While this finding might help to explain why an intermediate level of democracy generates higher protectionism (see Figure C.54), it does not explain why further moves towards democracy result in lower protectionism. The transition to democracy has been the subject of a heated debate among social scientists in recent years. There is some anecdotal evidence that democratic reforms lead to an initial deterioration of economic policy and result in poor economic outcomes and instability (at least in the short run). The evidence in Rodrik and Wacziarg (2005), however, appears to reject the notion that nascent democracies systematically under-perform more autocratic regimes and more established democracies.[157]

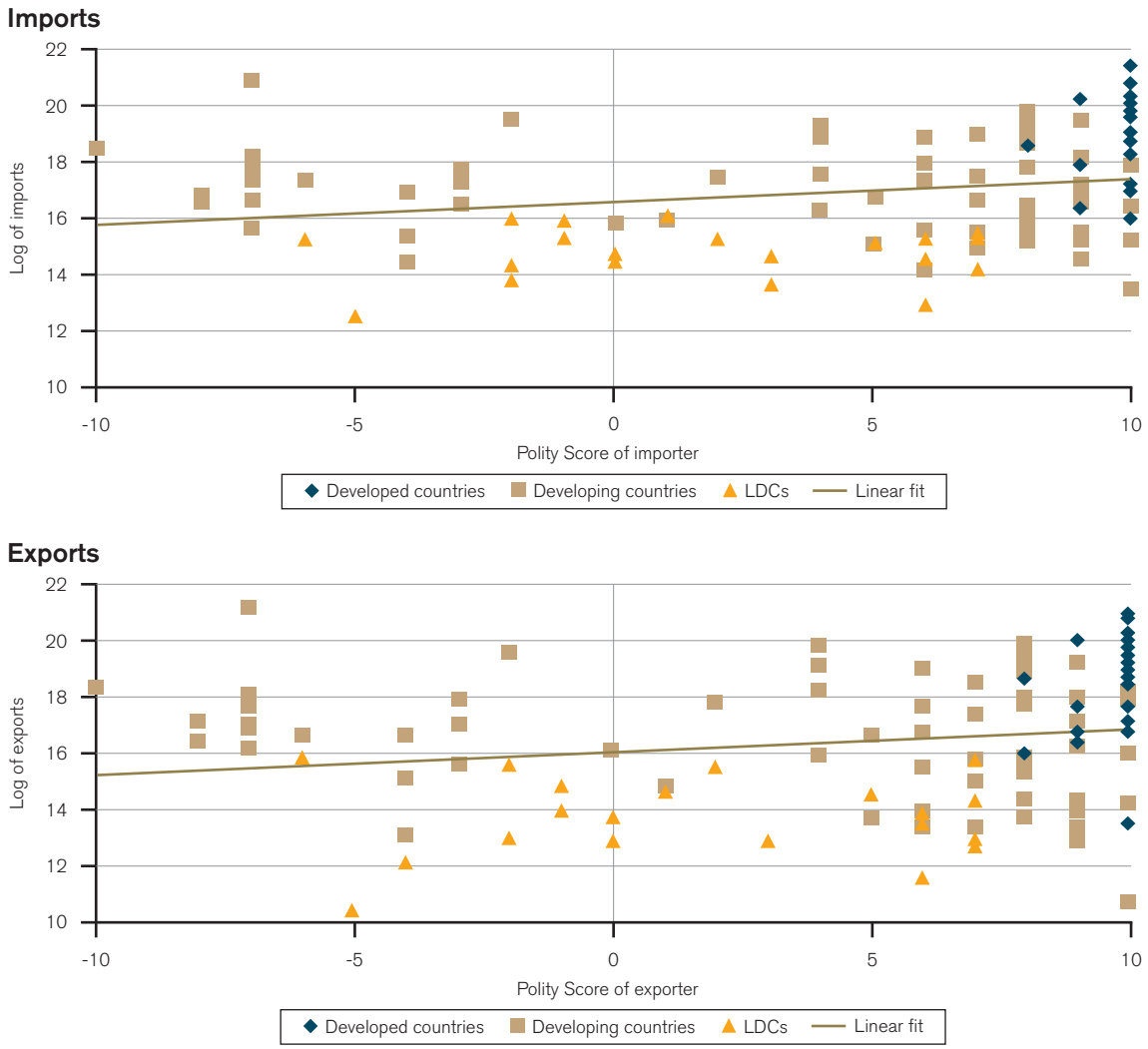
Another possible explanation for the weak positive correlation between trade and more democratic forms of governments observed in Figures C.52 and C.53 runs in the opposite direction. A number of studies show that the effect of trade on the form of government is influenced by the changes in relative wealth and power among social groups. Acemoglu and Robinson (2006) provide a theory that explains how globalization affects the transition to and consolidation of more democratic regimes. The mechanism through which trade influences the political regime is a change in factor prices triggered by trade opening. They observe that poorer countries are typically less democratic (or

more easily subject to authoritarian coups) and relatively more abundant in labour. Trade opening leads to an increase in wages in poorer countries, leading to convergence in incomes and a decline in "class conflict". This, in turn, acts on the political structure because a smaller income gap between rich and poor decreases the demand for highly redistributive policies, thus making more participatory forms of government less costly for the elites.

Puga and Trefler (2012) analyse the effects of increasing trade in medieval Venice. They argue that long-distance trade allowed merchants to accumulate wealth and to impose constraints on the executive, eventually triggering a switch from a monarchy to a more liberal political system. Both studies, however, point out that the causal relationship between trade and forms of government is ultimately a question of degree. In the case of medieval Venice, the class of merchants that imposed constraints on the absolute power of the executive later used their resources to block political competition by demanding hereditary parliamentary participation. The cross-country evidence on the impact of trade openness on the form of government is not conclusive. Rigobon and Rodrik (2005) and Milner and Mukherjee (2009) find that the relationship between trade openness and more democratic forms of government is either negative or weak, in particular for developing countries. However, López-Córdova and Meissner (2008) find that, while no relationship exists in the short run, a positive impact of trade on more representative forms of government can be detected in the long run.

A separate argument is that trade-related institutions may decrease the opportunity for rent seeking. Liu and Ornelas (2012) analyse the role played by preferential trade agreements (PTAs) in shaping domestic political

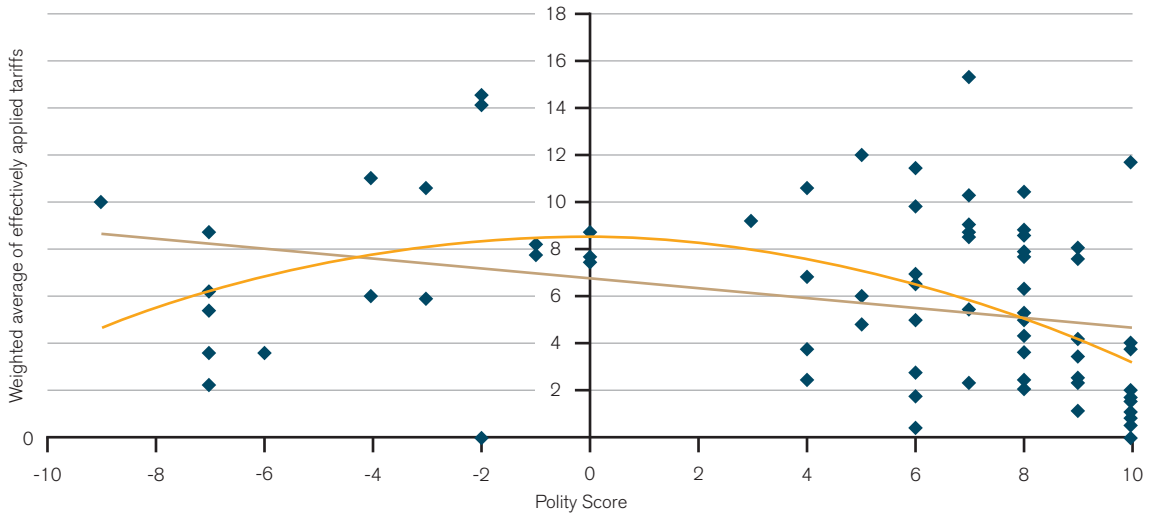
Figure C.53: **Form of government and imports/exports, 2010**



Source: Authors' calculation based on data from the Polity IV Project (http://www.systemicpeace.org/polity/polity4.htm) and COMTRADE.

Note: Imports and exports measured as the natural logarithm of the value of trade in thousand US$. Form of government as proxied by the Polity Score index. It ranges from -10 to 10. See text for more details.

Figure C.54: **Form of government and average tariffs, 2010**



Source: Authors' calculation based on data from the Polity IV Project (http://www.systemicpeace.org/polity/polity4.htm) and TRAINS.

Note: Form of government as proxied by the Polity Score index. It ranges from -10 to 10. See text for more details.

institutions through this mechanism. In particular, they show that participation in PTAs works as a commitment which helps governments to resist future pressures for protectionism from lobby groups. Therefore, organized groups seeking political power for economic gain have a lower incentive to do so if a country is "tied" by a PTA. In unstable democracies, the government has a particularly strong incentive to sign PTAs and thus weaken the position of organized groups trying to displace the incumbent. The authors find empirical support for a positive correlation between participation in PTAs and the longevity of more representative regimes.

(ii) Political borders

International politics can have an impact on trade in a number of ways. The breakdown of international relations between the two world wars, for example, was associated with a dramatic fall in trade flows during this period. Likewise, trade flows and commercial interests can help to shape the evolution of the world's political map, as shown by the age of European colonialism beginning in the 1500s (O'Rourke and Findlay, 2007). The following sub-section focuses on how trade interacts with the Westphalian system, the political order that was born in Europe with the Treaty of Westphalia in 1648 and that gradually extended to encompass most of the world. At the core of the Westphalian system is the sovereign nation state delimited by clearly defined political borders. The question addressed here is "how does international trade and national sovereignty interact?"

The number of sovereign countries has dramatically increased over the last century, from 58 in 1904 to 196 today, with most of this increase taking place since the Second World War. One line of research argues that political fragmentation and a significant expansion in political borders increase transaction costs, and this negatively affects trade. The bulk of the literature focuses on measurements of the "border effect", which is found to be sizeable.

In a ground-breaking paper, McCallum (1995) investigates the trade effect of the border between Canada and the United States using standard gravity equation techniques. Even though the two countries share a common language, similar legal systems and other characteristics that might render the border separating them as inconsequential, McCallum (1995) finds that the border reduces trade by a factor of 22. That is, trade between Canadian provinces is estimated to be 2,200 per cent higher than trade between Canadian provinces and US states.

Subsequent work by Anderson and van Wincoop (2003) finds that the trade effect of political borders is smaller than the finding of McCallum (1995) but still sizeable. Specifically, their estimates suggest that the border separating Canada and the United States reduces trade by 44 per cent, while borders among industrialized countries more broadly have a negative impact on trade of about 30 per cent. Finally, a recent paper by Redding and Sturm (2008) examines Germany's separation into two states after the Second World War and its reunification in the 1990s to determine the trade and development impact of changing borders. They find that the imposition of the East-West border had a large negative impact on economic activity (for instance, as measured by population growth) in towns closest to the new border by reducing market access.

While borders have a negative impact on trade, Figure C.55 shows a positive correlation between trade openness and the number of sovereign countries over time (and, hence, the number of borders). Clearly, the statistical volume of international trade increases by definition when a new sovereign nation is created (a fraction of what was measured as internal trade becomes international as a result of the creation of a new border, as discussed in Section B.2(a)). However, the relationship between the number of countries and trade openness is still positive when the latter is measured by the level of the average tariff (Alesina et al., 2000). This positive correlation suggests that an increase in trade itself may have an impact on political borders and the number of sovereign countries.

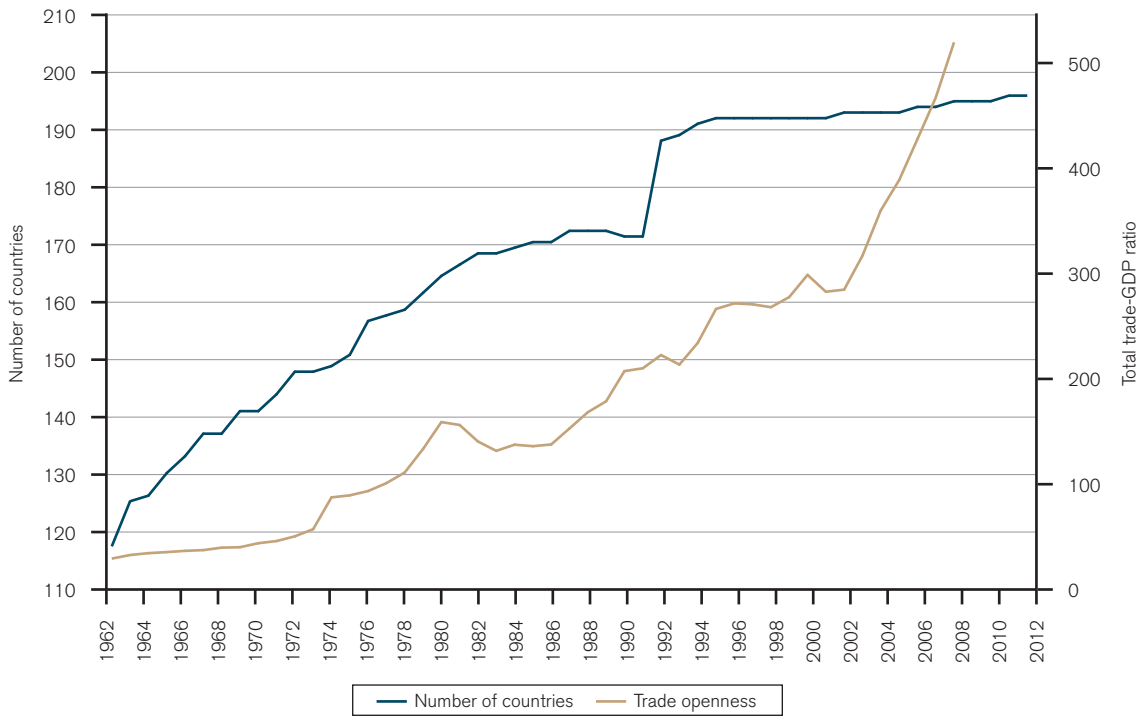
Trade openness often involves a reshaping of sovereignty, while political borders may also change in nature as well as in number. The increasing role of regional organizations, such as the European Union or the Association of Southeast Asian Nations (ASEAN), is one example. Expanding membership in the WTO, and its enhanced role in international trade dispute settlement, is another example. Figures C.56 and C.57 provide some insights into this.

Figure C.56 shows a strong positive correlation between the number of sovereign countries and the number of preferential trade agreements (PTAs). The large surge in the number of sovereign countries in the past 50 years appears to precede the formation of new PTAs. Furthermore, Figure C.57 indicates that the nature of these agreements has changed over time, with deeper forms of agreements becoming more prominent, particularly when countries engage in shared, cross-border production.[158]

A limited economic literature helps to explain these apparently conflicting facts (Alesina and Spolaore, 2003; Ruta, 2005). The studies find that economic integration changes the costs and benefits of national sovereignty, releasing centrifugal and centripetal forces. On the one hand, trade openness promotes political fragmentation. In a world of trade restrictions (at their maximum in a world where countries do not trade), large nations enjoy economic benefits because political borders determine the size of the market and the extent of economies of scale. Economic gains create incentives for political integration. However, with more open trade, the extent of the market is no longer restricted by political borders. The economic incentive for political integration wanes, and cultural, linguistic and ethnic groups within countries may choose to form smaller more homogenous sovereign states (Alesina et al., 2000).

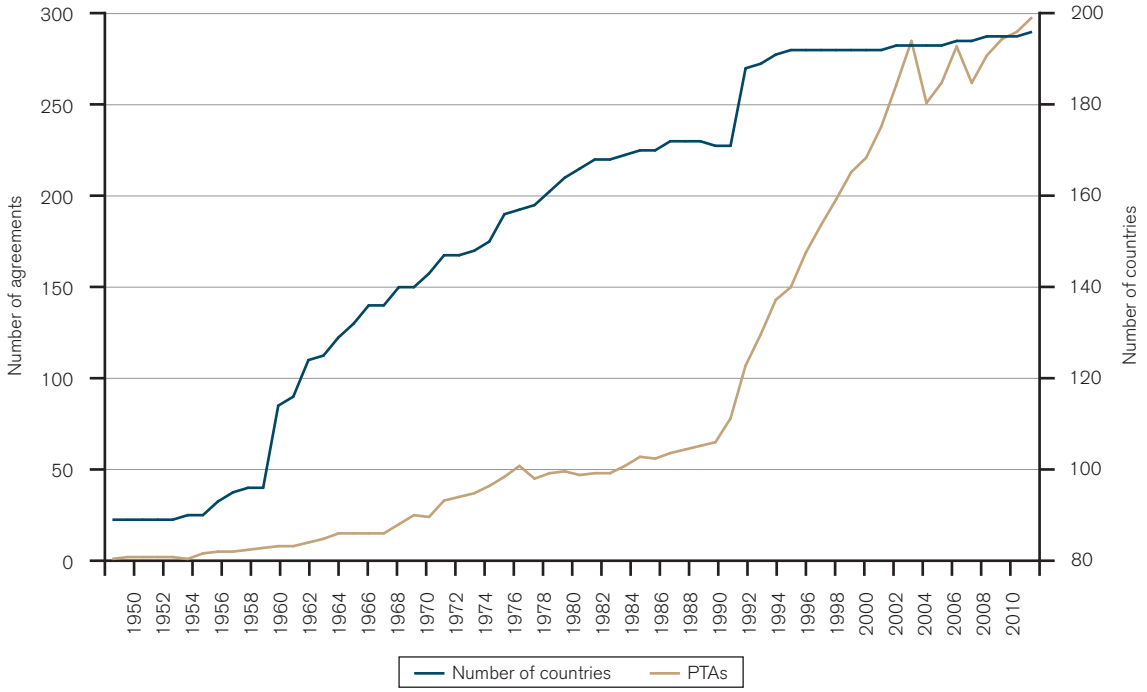
On the other hand, trade openness requires deeper forms of institutional integration which create centripetal forces. Economic theory makes two compelling arguments that substantiate this point. First, a number of authors argue that markets need non-market institutions (political, legal and social) for their proper functioning (Casella, 1996; Padoa-Schioppa, 2001; Rodrik, 2000). These non-market

Figure C.55: **Number of countries and trade, 1962-2012**



Sources: Authors' calculation based on data from COMTRADE and Alesina et al. (2000).

Figure C.56: **Preferential trade agreements (PTAs) and number of sovereign countries, 1950-2011**



Sources: Authors' calculation based on data from Alesina et al. (2000) and WTO Secretariat.

institutions are essentially public goods that markets fail to provide. Others make the point that trade openness increases the impact of trade policy on other countries, rendering unilateral decision-making inefficient compared with cooperative decision-making (Broner and Ventura, 2011; Epifani and Gancia, 2007; Brou and Ruta, 2011). The coexistence of competing centripetal and centrifugal economic forces contributes to explaining the reshaping of sovereignty/political borders described above.

An example of the dual relationship between trade and sovereignty is the new momentum that deep economic agreements have gained since 1990. As the 2011 World Trade Report (WTO, 2011a) notes, the changing nature of international trade (and, specifically, the rising importance of global supply chains) is related to the rise of deeper forms of integration. The first is both a cause and a consequence of the latter. The expansion of production networks is driving the proliferation of deep agreements that aim at filling a governance gap in areas, such as competition policy, investment and product regulation, which are essential for the smooth functioning of these networks. For these same reasons, governments undertake commitments in these policy domains that often impose constraints on national sovereignty and effectively make the political borders more porous. At the same time, deep agreements are a shaping factor of foreign investments flows and outsourcing as the institutional environment is a determinant of firms' economic decisions. This issue is discussed in more detail in the next sub-section.

(b) Economic institutions

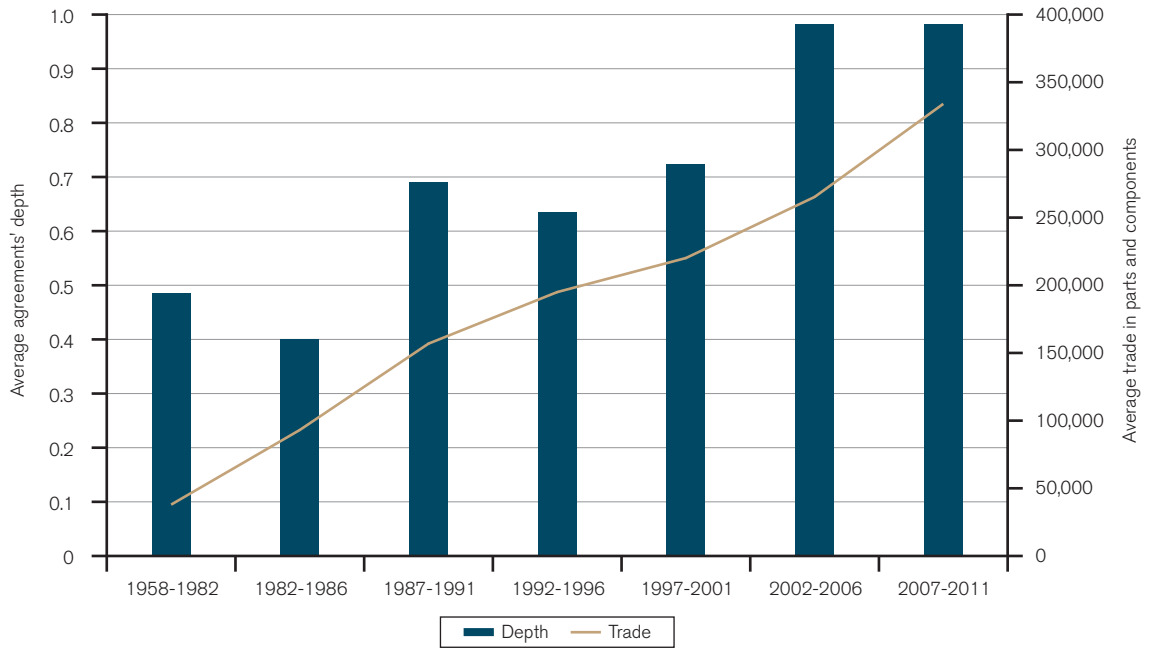
Economic institutions – especially the quality of regulations and the rule of law – provide a critical structure for economic interaction. According to the Worldwide Governance Indicators (2011), regulatory quality "reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development". In the same way, the rule of law index "reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence".

Clear, stable and enforceable rules are fundamental to international trade relations as they limit uncertainty by creating a framework within which economic exchange takes place. Moreover, economic institutions may shape trade flows by influencing the comparative advantage of countries. The following sub-section attempts to uncover the determinants of the relationship between trade and economic institutions.

(i) Stronger institutions promote trade

How do economic institutions relate to international trade? The evolution of the average levels of the rule of law and regulatory quality across all countries does not show a clear pattern. Both measures of institutional quality decreased in the last half of the 1990s and improved in the following decade, returning

Figure C.57: **Trade in intermediate goods and "depth" of preferential trade agreements, 1958-2011** (thousands of US$)



Sources: WTO Secretariat and Orefice and Rocha (2011).

Note: The depth of PTAs is constructed considering the ten most important provisions using principal component analysis. See Orefice and Rocha (2011) for more details.

approximately to the 1990 level by 2010. Over the same time period, however, world trade increased, with the exception of the 2008-09 fall after the global financial crisis. However, this lack of any obvious positive relationship at the aggregate level can be deceiving. Figure C.58 shows the pattern of exports, rule of law and regulatory quality for best-performing exporters, i.e. for the sample of countries that registered the highest increase in exports between 1996 and 2010.[159] The growth of exports in these countries was accompanied, on average, by significant improvements in economic institutions, as measured by the two indices. Cross-country evidence for 2010 reported in Figure C.59 also confirms this positive relationship between trade openness, regulatory quality and rule of law.

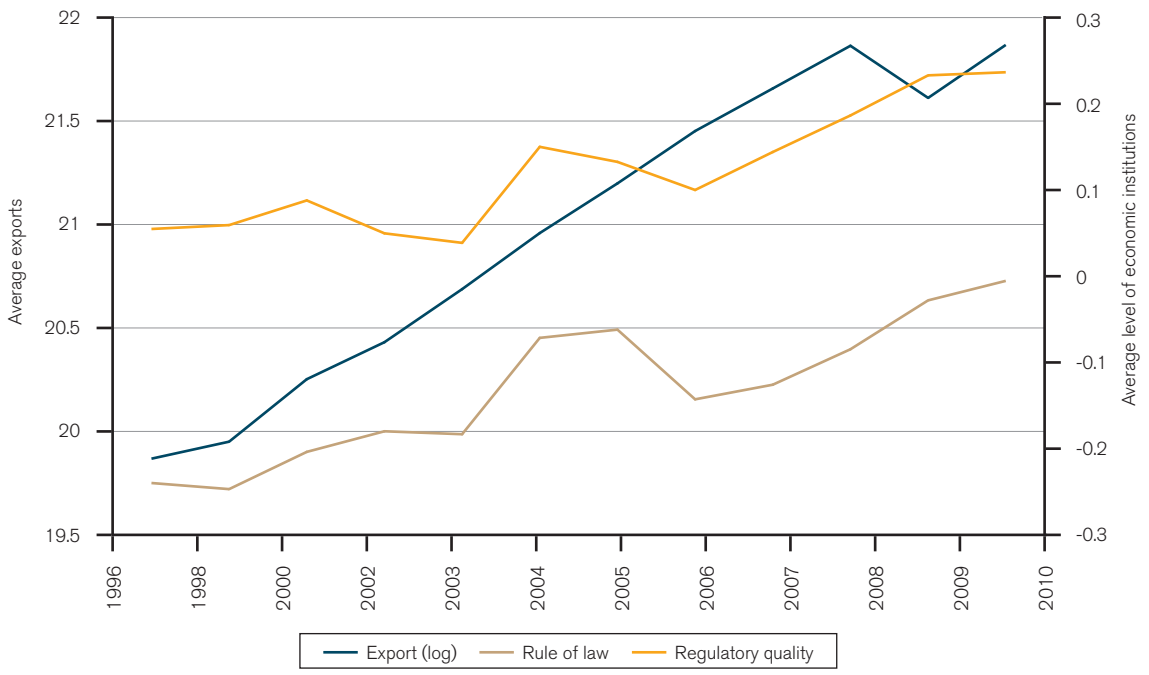
Why are the quality of economic institutions and trade positively related? As already observed for political institutions and trade, the relationship runs in both directions. Property rights, efficient regulations and the rule of law allow economic actors to establish a trade relationship in which rules and individual positions are clearly understood. These institutions create incentives to exchange goods and services as they reduce transaction costs associated with uncertainty and lack of transparency. Available empirical evidence confirms the importance of this channel.

Examining the effect of corruption and imperfect contract enforcement on trade, Anderson and Marcouiller (2002) find that improvements in the quality of institutions lowers the price of traded goods and increases trade flows. They also find that institutional quality can be an alternative explanation for why high-income, capital-abundant countries trade disproportionately with each other rather than with low-income, labour-abundant countries. Indeed, they argue that efficient economic institutions in high-income countries lower the transactions costs of trading with each other relative to trade with developing countries.

At the same time, trade openness can have an impact on economic institutions in various and sometimes conflicting ways. A number of studies point out that economic institutions are inter-linked with changes in the economy. Contract enforcement and the protection of property rights, for example, can depend on a variety of factors, such as governments' incentives to act and economic actors' incentives to respect the rules. Changes in relative prices brought about by international trade are likely to influence these incentives and hence shape institutions (Copeland and Taylor, 2009; Anderson, 2008).

Consider a country with weak protection of property rights that is relatively abundant in forestry resources. As the price of forestry products increases with trade openness, poachers may be tempted to extract more forest products but the government also has an incentive to better monitor and manage an increasingly valuable resource. Copeland and Taylor (2009) offer various examples of how trade opening had either a

Figure C.58: **Exports and the quality of economic institutions in the best-performing exporters, 1996-2010**



Sources: Authors' calculation based on data from WGI and COMTRADE.

Note: Average exports are measured as the natural logarithm of the value of exports in thousands of US$. Rule of law and regulatory quality are indices ranging from -2.5 to 2.5.

positive or negative impact on the effective protection of property rights.

Trade can also have an impact on economic institutions through more indirect channels. In the previous sub-section, it was shown how trade opening can influence the relative economic power of different social groups and thus formal political institutions that evolve. As economic institutions are established and reformed through political processes, changes in political institutions and organizations will clearly matter (Greif, 2006).[160]

Acemoglu et al. (2005) suggest that the effect of trade on economic institutions depends, especially, on initial political conditions. They argue that the varying growth patterns among European countries after 1500 are explained by how the increase in transatlantic trade affected economic reforms. In countries with more open political systems, such as Great Britain and the Netherlands, the increase in Atlantic trade strengthened and enriched merchant groups who obtained important reforms, including better protection of property rights. This, in turn, paved the way for sustained economic growth. Similar changes in economic institutions did not take place in countries that had weaker checks and balances on the monarchy, such as Spain and Portugal. This finding suggests an important and complex interaction between trade openness, political institutions and economic reforms.[161]

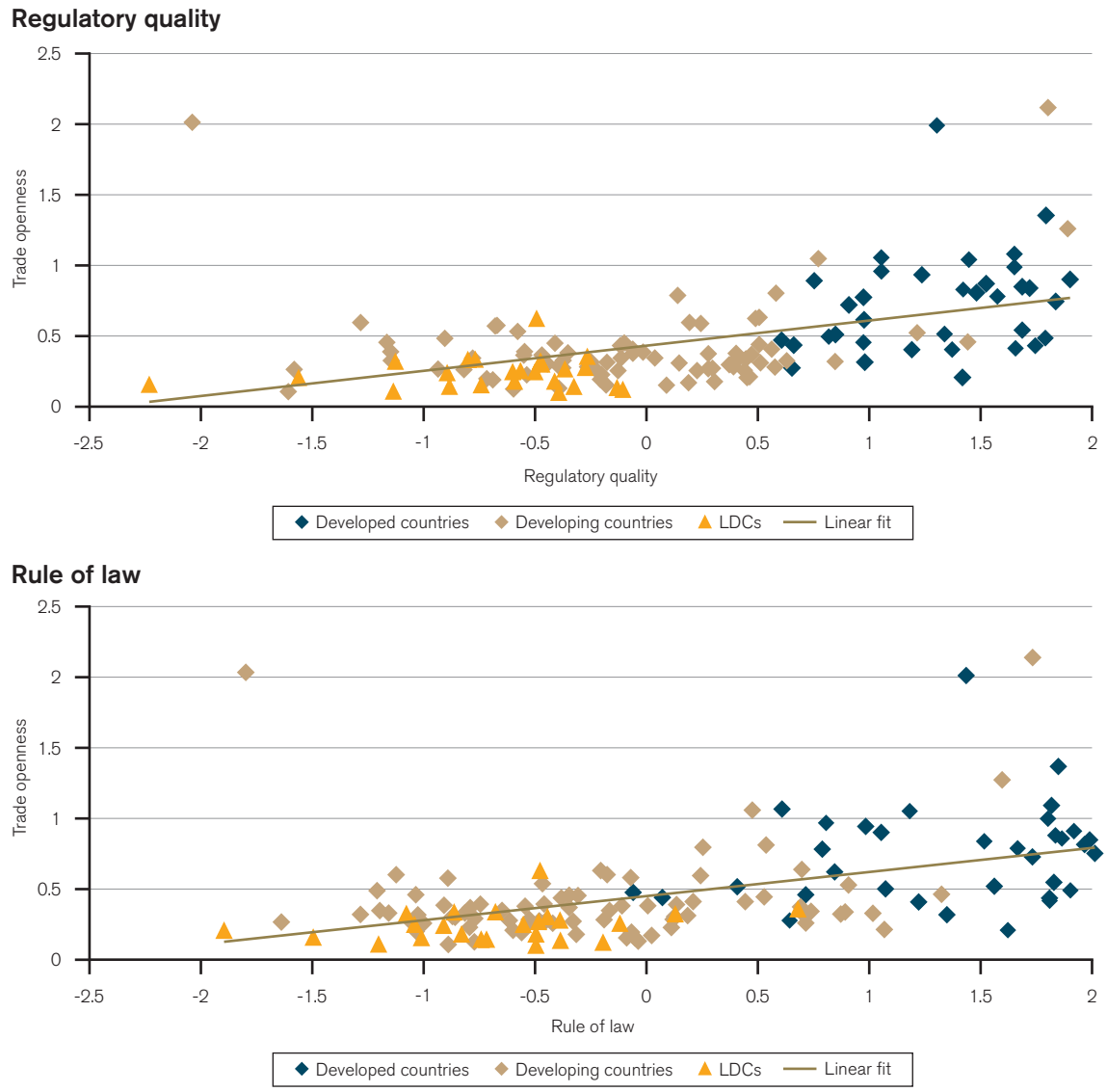
(ii) Institutions create comparative advantage

Economic institutions can also be a source of comparative advantage. Countries with better institutions specialize in industries for which the existence of stable and reliable institutions is more important. Figure C.60 shows a positive cross-country correlation between the rule of law and the share of exports in sectors with high institution-intensity. As discussed in more detail below, the indicator for institutional intensity measures the proportion of intermediate inputs that require relation-specific investments for each industry (Nunn, 2007): the more complex the production process required to use these intermediate inputs, the more it is reliant on strong institutions.

Economic theory and empirical evidence confirm that a country's institutional framework, in addition to its technological level or relative factor abundance, is a source of comparative advantage. Recent literature emphasizes in particular the role of cross-country differences in contract enforcement – and therefore in the degree of contract incompleteness – in shaping trade patterns (Levchenko, 2007; Nunn, 2007).

The relative need for contract-dependent inputs varies widely across sectors. For example, the automotive industry is more institution-dependent than flour milling. In fact, most of the intermediate inputs involved in automotive production are designed for a particular model and cannot be used by different car producers.

Figure C.59: **Trade openness and institutional quality, 2010**



Sources: Authors' calculation based on data from WGI and COMTRADE.

Note: Rule of law and regulatory quality are indices ranging from -2.5 to 2.5.

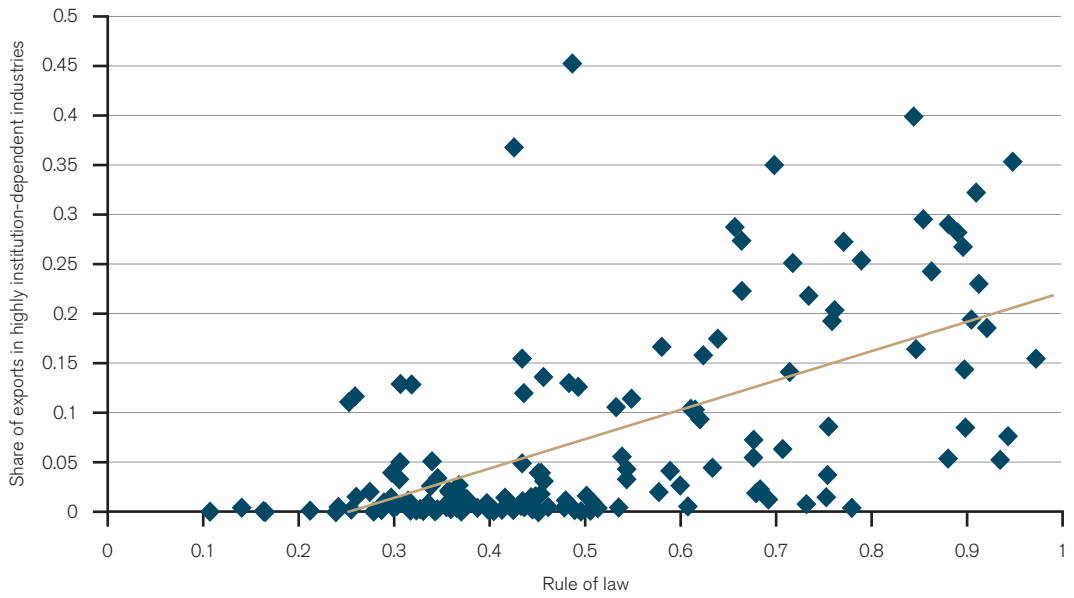
In contrast, flour production requires mainly cereals that are exchanged and priced in uniform markets. Better economic institutions reduce the inefficiencies associated with contract incompleteness, which in turn will have a disproportionate impact on costs in sectors that require more contract-dependent inputs, such as the car industry. One implication is that countries with better economic institutions are more likely to have a comparative advantage in these sectors.[162]

A study by Nunn (2007) offers a convincing test of whether countries with stronger contract enforcement specialize in the production of goods for which relation-specific investments are most important.[163] He shows that the average contract intensity of exports at the country level is positively correlated with different measures of the quality of economic institutions, including judicial efficiency and contract enforcement. At the country-industry level, countries with better contract enforcement specialize in industries where relationship-specific investments are most important.

The development of financial institutions also helps to determine trade patterns. Beck (2002) shows that economies with more developed financial sectors have a comparative advantage in manufacturing industries. Examining 65 countries over a 30-year period, he shows that financial development exerts a large impact on the level of both exports and the trade balance of manufactured goods.

Svaleryd and Vlachos (2005) find that the financial sector is a source of comparative advantage consistent with the Heckscher-Ohlin-Vanek model. Countries with well-functioning financial systems tend to specialize in industries that are highly dependent on external financing. They find that differences in financial systems are more important determinants of

Figure C.60: **Rule of law and comparative advantage, 2010** (share)



Source: Authors' calculation based on data from WGI and Nunn (2007).

Note: Rule of law is an index ranging from -2.5 to 2.5.

specialization among OECD countries than differences in human capital. Weak financial institutions result in larger transaction costs and other "financial frictions". These frictions also affect the volumes of trade by distorting firms' production decisions and entry into international markets.

Manova (2008b) shows that countries with weak financial institutions export fewer varieties to fewer destination markets, thus registering lower aggregate trade volumes. These distortions are amplified in financially vulnerable sectors that need more outside capital and that have fewer assets that can be collateralized. Ferguson and Formai (2011) show that countries with more developed financial systems export disproportionately more in sectors that produce complex goods and that have a high propensity for vertical integration.[164]

(iii) Institutions and the changing nature of trade

Another important issue is the association between countries' economic institutions and trade policies (including regulations, protection of intellectual property rights, and investment). Figure C.61 plots the correlation between the rule of law and average tariffs across countries in 2010. The relationship is negative, suggesting that countries that have better contract enforcement also tend to have lower tariffs. A similar negative correlation can be found between the quality of the regulatory system and tariffs.

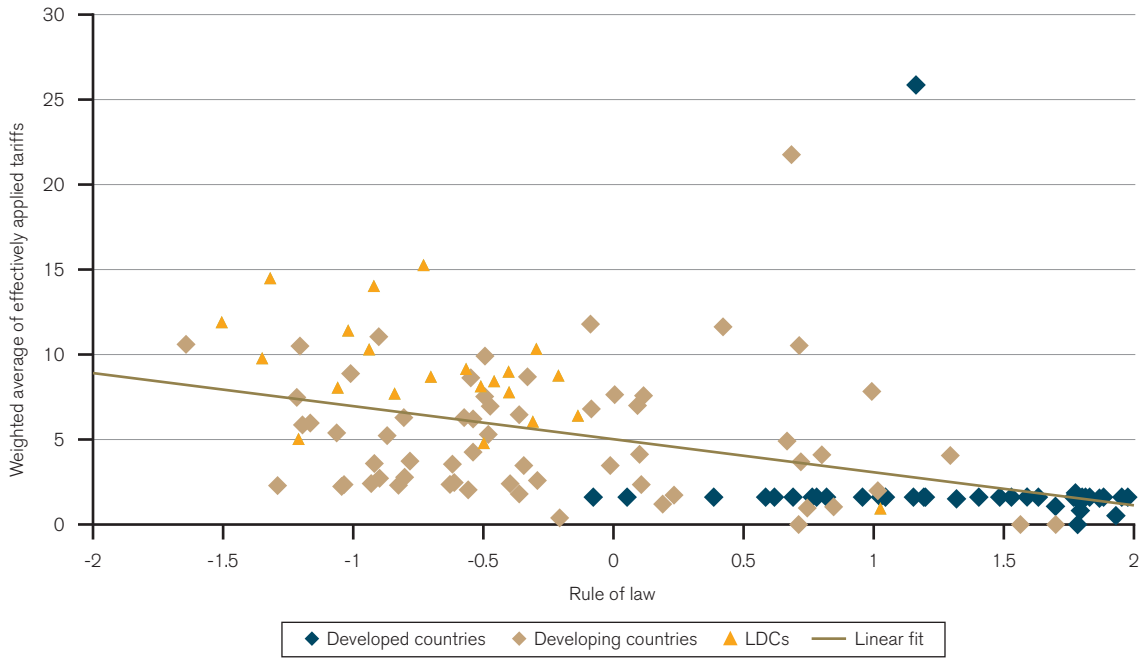
Figure C.62 shows the relationship between economic institutions and deep preferential trade agreements. The relationship appears to be less pronounced than the correlation between rule of law and average tariffs but the figure still shows a positive association between countries' international commitments and their domestic enforcement capacity.

What factors could explain this relationship between trade policies and economic institutions? One compelling argument is that it is shaped by the changing nature of trade and the growing importance of cross-border production (see Section B.2(e)).

The emergence of opportunities to participate in global supply chains lowers incentives to impose trade barriers. As noted by Baldwin (2010b), rather than building their own supply chains behind tariff walls over several decades, the ICT revolution allows developing economies to set up manufacturing facilities in a matter of months by joining in supply chains. In this context, tariffs and other trade-related policies that were conceived to promote import substitution become outdated. Domestic economic institutions, however, interact with the changing nature of trade in complex ways.

First, whether joining supply chains can be a successful strategy for developing countries crucially depends on the strength of domestic economic institutions. The reason is that the quality of domestic institutions determines in which country firms choose to offshore (Grossman and Helpman, 2005). In developing countries with stronger contract enforcement, there will be more investment and the costs of producing intermediate inputs will be lower than in countries with poor institutions. Hence, tariff cutting and participation in deep preferential trade agreements is more likely to

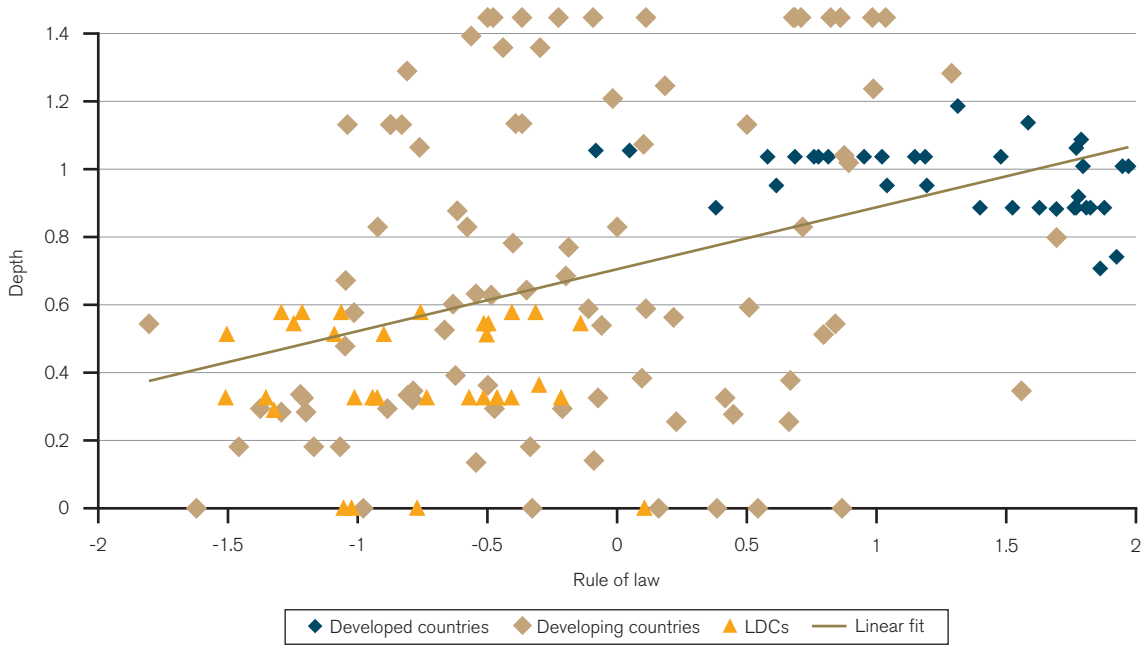
Figure C.61: **Rule of law and average tariffs, 2010**
(percentage)



Sources: Authors' calculation based on data from WGI and TRAINS.

Note: Rule of law is an index ranging from -2.5 to 2.5.

Figure C.62: **Rule of law and "deep" preferential trade agreements, 2010**



Sources: Authors' calculation based on data from WGI and WTO Secretariat.

Note: Rule of law is an index ranging from -2.5 to 2.5. The depth of PTAs is constructed considering the ten most important provisions using principal component analysis. See Orefice and Rocha (2011) for more details.

characterize the first rather than the latter group of countries, in line with the discussion above.

Secondly, the quality of the institutional framework is an important determinant of firms' choice to integrate a particular production stage or to outsource it. Consider the case where a firm in an advanced economy has to decide whether to outsource or to integrate the production of an intermediate input in a developing country. If economic institutions in the developing

country are strong, contracts between suppliers of intermediate goods and the final good producer are more likely to be enforced. In addition to increasing the likelihood of offshoring, this implies that the strength of economic institutions affects the relative prevalence of FDI or foreign outsourcing (Antras and Helpman, 2004).

As recent evidence by Bernard et al. (2010) shows, better quality economic institutions are associated with a higher probability of offshoring. However, further strengthening of the institutional environment is associated with a relative decrease in FDI. As the authors argue, this is presumably related to the greater ease with which arm's length contracts can be written and enforced.

(c) Culture

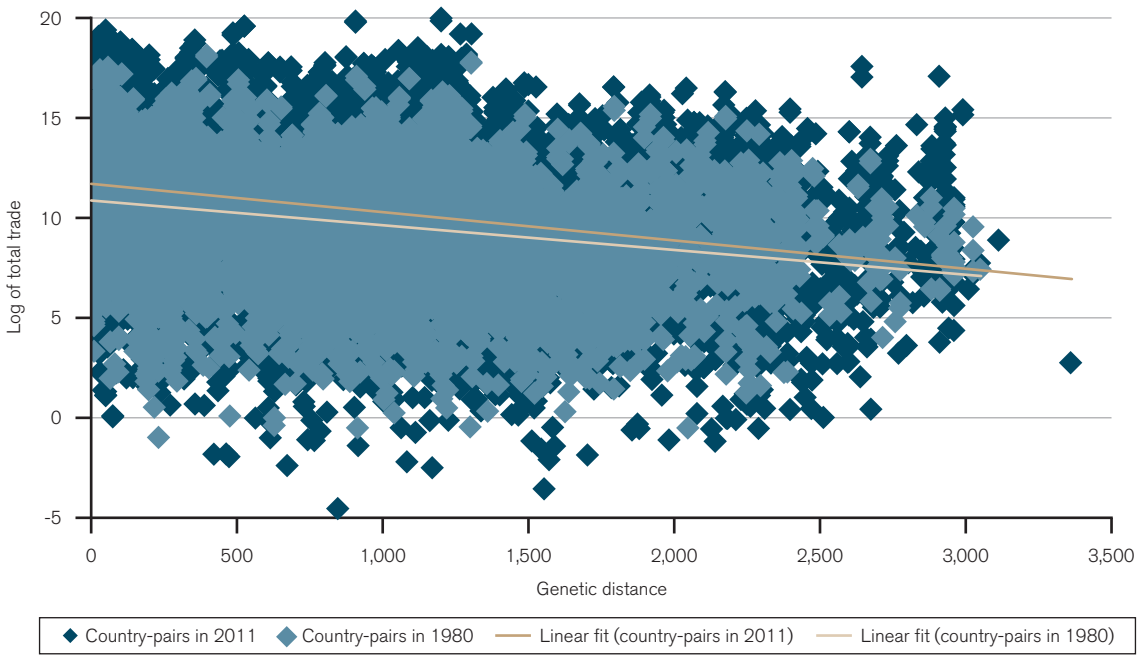
In addition to the formal institutions discussed above, informal institutions, such as social norms and conventions, impose constraints on and therefore influence human interactions. The multiple forms of codes of behaviour are often captured in a single word: culture. This sub-section highlights some basic facts about how differences in culture across countries are relevant to international trade. Simply put, it asks if cultural differences are a shaping factor of international trade.

The question of how international trade patterns relate to cultural differences and how this relationship evolves over time has not been of interest to economists only. In his well-known study *The Clash of Civilization and the Remaking of World Order*, political scientist Samuel P. Huntington writes: "In the emerging world, patterns of trade will be decisively influenced by the patterns of culture. Businessmen make deals with people they can understand and trust; states surrender sovereignty to international associations composed of like-minded states they understand and trust. The roots of economic cooperation are in cultural commonality" (Huntington, 1996). The key hypothesis is that cultural identities will be a more prominent determinant of the pattern of trade and of trade agreements in the post-Cold War world.

Defining and measuring culture is not easy. Religion and language have often been used as a proxy for culture. However, each of these measures has some drawbacks. For instance, differences in religion as a measure of cultural differences has been criticized because religion has relatively more recent roots than the latter (Guiso et al., 2009). As a result, countries that have substantial cultural differences may share the same religion. For this reason, a number of recent economic studies use genetic distance as a proxy for differences in culture among countries.[165] Genetic distance measures the time since two populations have shared common ancestors. The assumption is that populations that share more recent common ancestors have had less time to diverge in a wide range of traits and characteristics, such as implicit beliefs, customs, habits, biases and conventions, which are transmitted across generations (Spolaore and Wacziarg, 2009a; 2009b).

Figure C.63 shows the correlation between total trade and cultural differences, as measured by genetic

Figure C.63: **Total trade and cultural differences, 1980-2011**



Sources: Authors' calculation based on data from Spolaore and Wacziarg (2009a) and COMTRADE.

Note: Genetic distance is used as a proxy for cultural differences. It measures how two populations are generally related to each other. The variable is an index between 0 and 10,000. It is constructed as a weighted average of a probability (between 0 and 1), weighted by the product of the shares of the population in percentage points (between 0 and 100) in any two countries. See text for more details.

distance. Each point in the figure represents a country-pair. The unconditional correlation is negative, meaning that on average countries that are more distant culturally trade less with each other compared with countries that share more similar cultural traits. Perhaps more surprisingly, it also shows that the relationship between trade and culture does not vary much over time. To the extent that a slight difference exists between international trade in 2011 and in 1980, cultural differences appear more relevant today than 30 years ago.

While Figure C.63 focuses on trade in final goods, Figure C.64 correlates cultural differences across countries (measured by genetic distance) and trade in intermediate goods. Trade in intermediate goods is a simple (if not fully accurate) proxy for the relevance of cross-border production networks. Also in this case, the correlation is negative and relatively constant across time, suggesting that cultural differences represent a cost in the development of global supply chains.

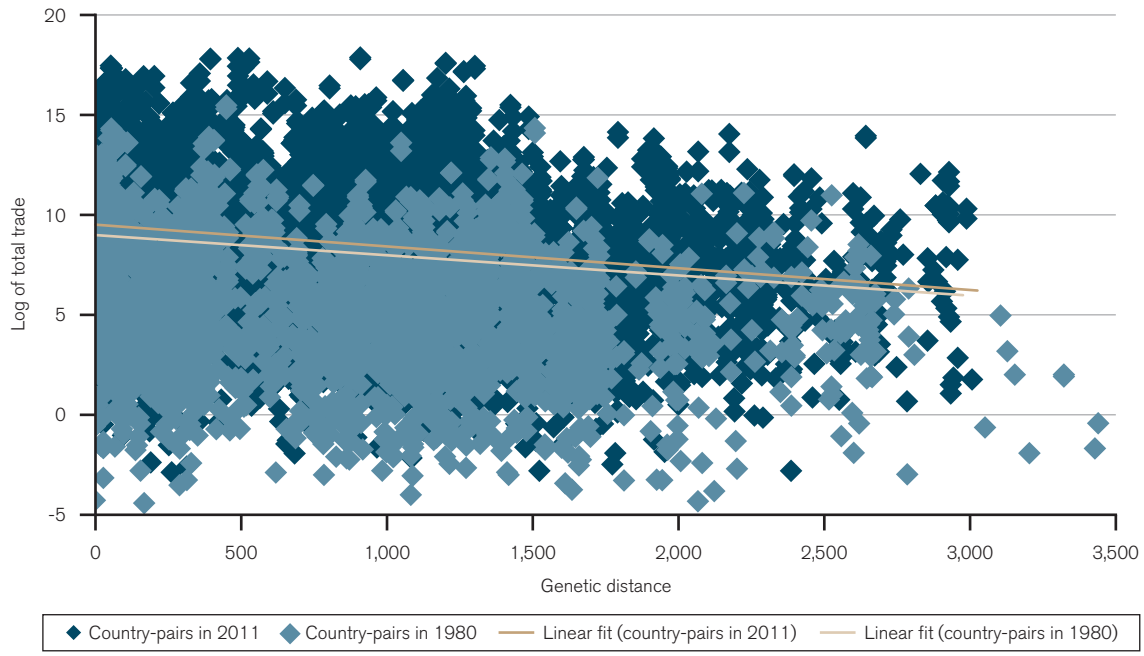
Why do cultural differences appear to negatively affect trade? Economics provides two overlapping answers. The first is that differences in informal institutions, such as cultural traits, are an implicit barrier to trade as they create transaction and information costs. The logical implication is that deeper cultural differences have a negative impact on trade. If this argument is correct, however, one should also expect that networks of people with similar cultural traits, but located in different countries, should trade more. The available evidence supports this conclusion.

In particular, Rauch and Trindade (2002) examine how ethnic networks influence trade volumes. The study focuses on international transactions involving Chinese networks, the largest transnational network in the world. The authors find that the effect of Chinese networks is positive for all goods, and that it is stronger for bilateral trade in differentiated products, for which information frictions are likely to represent a more important barrier relative to undifferentiated goods.[166]

The second, and related, reason why cultural differences negatively affect international trade is trust. Trust is a crucial component in determining economic relationships, including trade relationships. Trust is particularly important in those societies where informal institutions, such as social norms, regulate economic exchanges between individuals. Guiso et al. (2009) provide evidence that trust is an important component in trade relationships. They show that cultural aspects, measured by religious, genetic and physical similarities, and by the history of conflicts, affect bilateral trust (and, hence, trade) between European countries.

However, the relationship between culture and trade is probably more complex than simple cross-country regressions may suggest. One reason is that over a long period of time, trade may shape cultural differences. For example, trade may act as a vehicle to increase or establish trust between culturally diverse

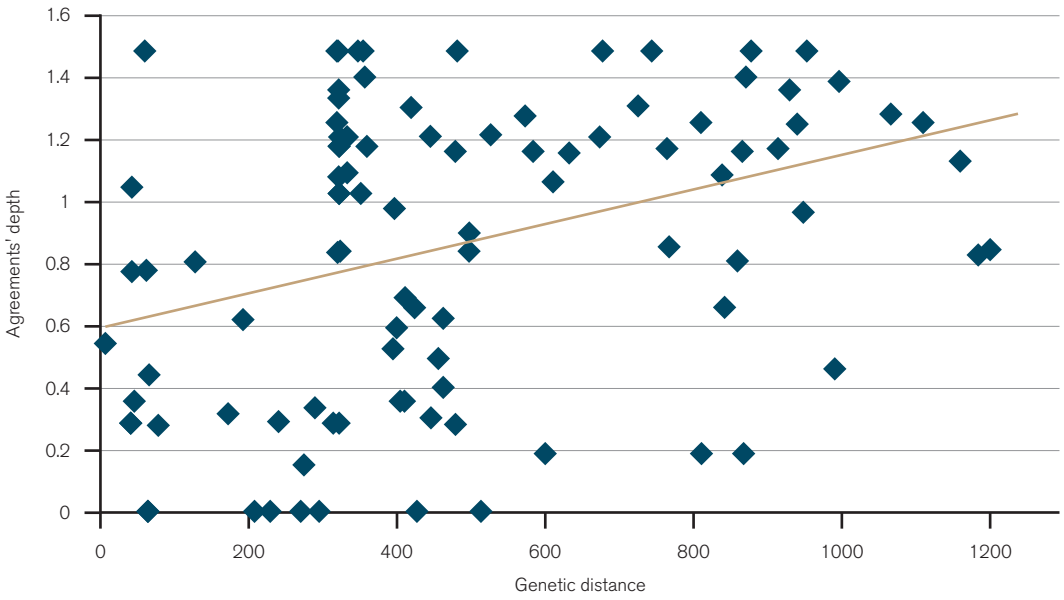
Figure C.64: **Trade in intermediate goods and cultural differences, 1980-2011**



Sources: Authors' calculation based on data from Spolaore and Wacziarg (2009a) and COMTRADE.

Note: Genetic distance is used as a proxy for cultural differences. It measures how two populations are generally related to each other. The variable is an index between 0 and 10,000. It is constructed as a weighted average of a probability (between 0 and 1), weighted by the product of the shares of the population in percentage points (between 0 and 100) in any two countries. See text for more details.

Figure C.65: **Cultural differences and "deep" preferential trade agreements, 1958-2011**



Sources: Author's calculation based on data from Spolaore and Wacziarg (2009a) and WTO Secretariat.

Note: Genetic distance is used as a proxy for cultural differences. It measures how two populations are generally related to each other. The variable is an index between 0 and 10,000. It is constructed as a weighted average of a probability (between 0 and 1), weighted by the product of the shares of the population in percentage points (between 0 and 100) in any two countries. See text for more details. The depth of PTAs is constructed considering the ten most important provisions using principal component analysis. See Orefice and Rocha (2011) for more details.

agents (Tabellini, 2008).[167] Moreover, cultural differences may not only work as a trading cost but also as a trading advantage. Like formal institutions, they can be a source of comparative advantage.

Greif (1994) offers a theoretical framework in which cultural factors determine institutional structures, which in turn have an impact on the economic development and trade patterns of different societies. By comparing the Maghrebis and the Genoese roles in Mediterranean trade during the 11th and 12th centuries, the author argues that collectivist and individualist cultural beliefs shaped the institutional background in which the two traders' groups operated, leading to different patterns of trade and economic success.

One puzzling aspect of Figures C.63 and C.64 is the comparison of the relationship between cultural differences and trade in final and intermediate goods, respectively. To the extent that trade in intermediate goods captures trade in parts and components and, more generally, the importance of cross-border production between pairs of countries, one would expect that cultural differences matter more than in trade in final goods. Cultural differences are likely to be associated with different formal institutions and, other things being equal, to discourage offshoring. However, while in both charts the relationship is negative, trade in intermediate goods appears to be less – rather than more – affected by cultural differences. At first sight, this finding is at odds with basic economic intuition.

A possible explanation for why cultural differences do not appear to provide a formidable barrier to trade in intermediate goods is that states often cooperate to overcome these barriers. Put differently, formal institutions such as deep preferential trade agreements may "compensate" for the implicit trade costs created by cultural distance and divergent domestic institutions. Some evidence supporting this possibility is provided in Figure C.65.

It indicates that deeper agreements are entered into by countries that, on average, have different cultures. One explanation is that culturally distant countries are less likely to have similar formal institutions in areas such as intellectual property rights or investment that are essential to the successful development of cross-border value chains. For these countries, deeper trade agreements serve as a substitute for poor or divergent domestic institutions and may be a necessary prerequisite for taking advantage of the gains from international production.

An intriguing question is whether the Huntington hypothesis – which predicts that cultural diversity would matter more in the post-Cold War era compared with the Cold War period – is supported by the data. A recent study offers an affirmative response. Gokmen (2012), using different measures of culture, including religion, ethnicity, language, civilization and genetic distance, finds that culture affected trade more following the end of the Cold War. However, the observation that the depth of economic agreements between countries is

positively correlated with their cultural distance counters Huntington's view that a shared culture is a prerequisite for economic cooperation.

(d) Conclusion

This section makes two key points. First, the institutional framework is an important shaping factor of trade, along with traditional factors such as technology and endowments. Secondly, the relationship between institutions and trade is complex because of the two-way nature of how one influences the other.

Institutions are a shaping factor of trade. Domestic political institutions and the international political map affect how trade and trade-related policies are set and negotiated. Stronger economic institutions facilitate international commerce and influence trade patterns, as they represent a source of comparative advantage and a determinant of firms' offshoring decisions. In addition, differences in culture can create transaction costs that may limit commercial relationships. In the coming years, institutions will continue to be an important shaping factor of trade. This is because institutions are likely to affect the flows of intermediate goods in global supply chains even more than flows of final goods. In light of this, governments are likely to pay even more attention to reforming domestic and international institutions in the near future as a way of reducing transaction costs, gaining comparative advantage in sectors with higher value-added, and linking to international production networks

Institutions, however, are also shaped by international trade. Economic integration is associated with changes in domestic political institutions and with the reshaping of sovereignty. Trade also creates incentives to improve the quality of economic institutions. The increasing importance of cross-border supply chains is a driver of deep preferential trade agreements, in part because governments need to address the new cross-border policy spillovers created by the internationalization of production. Finally, trading relationships contribute to building trust between diverse communities and are vectors for cultural influence. Institutions that shape human interactions tend to be more persistent than economic forces, such as international trade. This inconsistency between the reach of markets and the reach of regulators must be a fundamental policy concern in coming years.

What does this complex relationship between trade and institutions imply for the WTO? On the one hand, certain aspects of this relationship reinforce the multilateral trading system. As stronger commercial ties create incentives to adopt more efficient economic institutions and reinforce trust and cooperation across countries, global trade policy-making may flourish. On the other hand, there are important reasons for concern.

First, while trade openness can encourage domestic political and institutional reform, the transition may initially lead to a surge in protectionist incentives. Long-term policy commitments are needed to keep these self-defeating temptations in check. Secondly, economic integration is reshaping sovereignty but the central actors in existing global organizations remain nation states. The growing number of countries in the international system makes it more difficult to cooperate and to reach meaningful agreements. The WTO already provides a role for regional organizations (notably the European Union as a WTO member) but this role could be further promoted.

Thirdly, weak economic institutions can be a reason for inefficient specialization and the inability to join global supply chains, especially for developing countries. Deep preferential trade agreements can be an instrument to help overcome these barriers. In addition, aid programmes aimed at promoting trade should continue to focus on building institutional infrastructure. Finally, the proliferation of deep preferential trade agreements is in part an efficient response to the changing nature of trade. However, the risk of segmenting markets can be an unintended consequence of these arrangements. Improving coherence between multilateral and preferential trade systems is necessary to avoid discrimination among trading partners. These issues will be further taken up in Section E.

7. Conclusions

This section has looked at a number of factors – demography, investment, technology, natural resources, transportation and institutions – and asked how each one is likely to shape the future of international trade. These concluding reflections will examine what implications they hold for individual countries or country groups.

Developing countries

One of the biggest stories of the past 20 years has been the successful integration of many developing countries into the global economy and their emergence as key players in international trade. Developing countries are diverse in the quality of their political and economic institutions but there are strong reasons to believe that "better" institutions give countries a competitive advantage and produce better trade outcomes. It is not clear, however, whether developing country growth will continue at the same rapid pace or taper off. Improving the quality of institutions would provide developing countries with a way of ensuring that growth continues.

A rapidly ageing population means that a key source of China's comparative advantage – its workforce – which fuelled its rapid economic rise could diminish.

At the same time, China is undergoing a process of rapid capital accumulation. If this momentum continues, China could shift the source of its comparative advantage in the direction of more capital-intensive exports. A similar process is under way in other developing countries, such as Chile and Turkey, which have seen rapid capital accumulation in recent years and rising aggregate capital-labour ratios. It is not clear whether the impetus behind China's demand for natural resources will recede or intensify. Given the likely moderation in China's future growth, there is reason to think that the need for natural resources will dissipate. At the same time, however, China faces a growing scarcity of certain key resources, especially water, that is unlikely to abate any time soon.

India and countries in the Middle East and Sub-Saharan Africa will continue to see their populations grow. Not only will median ages be low but dependency ratios will decline over the next decades. If these countries can strengthen public institutions and keep economic policies outward-looking, they could become the world's fastest-growing economies. The high rates of population growth in the Middle East and Sub-Saharan Africa also offer these countries the possibility of reducing their dependence on natural resource exports. However, this in turn depends on successfully providing their growing populations with the necessary skills.

In the case of many countries in Sub-Saharan Africa, it also requires efforts to reduce the "distance" to markets. Countries in Sub-Saharan Africa tend to fare worst on various measures of transportation costs. Since reducing transportation costs and delivery times are preconditions for successfully integrating into the global economy and global supply chains, increasing investment in transportation-related infrastructure is critical. This will involve harnessing domestic resources (public and private) and using the Aid for Trade initiative as the lynchpin to mobilize international assistance. There may be some scope to use current regional integration efforts to identify and prioritize regional infrastructure projects that can reduce trade costs and to use the current Doha Round negotiations on trade facilitation as a way of improving customs procedures and other regulations. African countries continue to lag behind in innovation and in absorbing technology transfers. These too can be addressed by improving the quality of education and training.

Developed countries

In recent decades, developed countries have grown more slowly than developing countries and have seen their share of world trade shrink. The ongoing Great Recession is likely to produce a lost decade for many advanced countries, particularly those in Europe.

Demographics in the form of an ageing and declining population will confront Japan and a number of European countries with strong headwinds to growth. This will have adverse effects on their future share of global trade exacerbating the trends outlined in Section B. Greater openness to migration may help alleviate these demographic challenges. These countries will need to maintain a highly skilled workforce, invest a high share of GDP on research and development and promote innovation. New technologies such as robotics and 3D printing may become more widespread. Their adoption is likely to vary significantly across sectors: currently they are used, for instance, in construction, aerospace, jewellery and healthcare. More importantly, these technologies are likely to prove disruptive by reducing the importance of low labour costs (provided by developing countries). This can lead manufacturing and its associated supply chains to return ("in-sourcing") to developed countries.

Compared to Japan and Europe, the United States does not face as serious a set of demographic challenges. Its population is expected to continue to grow (although at a slower rate) and it remains more open to immigrants, who now make up about a sixth of its work force. Immigrants are particularly important in agriculture and information technology, sectors where the United States is an export powerhouse. Nevertheless, the United States will need to upgrade its infrastructure and invest in its workers so they can continue to provide innovation and entrepreneurship. Dependent on oil imports for decades, technological improvements in natural gas extraction now promise the United States energy self-sufficiency in the future. Since this will lead to lower energy costs, it is likely to could give a substantial competitive boost to United States' manufacturing exports.

From "fundamentals" to other shaping factors

This assessment of the key factors shaping trade – and how they will play out among various countries and regions – is incomplete. It does not take into account how trade affects income distribution, alters the relative power of nations or creates spillovers (e.g. environmental degradation) that certain countries may find unacceptable. These effects can weaken public support for trade openness or prompt governments to adopt policies that directly or indirectly have an adverse impact on trade. We turn to these issues in Section D of this report.

Endnotes

1 There are various causes for the fall in fertility. Technological progress and the accumulation of human and physical capital make labour more productive and increase the opportunity costs of raising children (Galor and Weil, 1996). Moreover, raising income shifts the composition of demand towards non-agricultural goods and services, which are relatively more intensive in skilled labour. The related rise in the return to education leads to increased investment in education, further increasing the opportunity cost of raising children. Furthermore, parents with higher income devote more resources to each child. Since this raises the cost of each child, it also leads to fewer children (Becker, 1981).

2 The young-age (old-age) dependency ratio is defined as the ratio of individuals below 15 (above 65) to working age population (15-65). The overall dependency ratio is the sum of the young- and old-age dependency ratios.

3 The slow-down in population growth in China is partly due to the one-child policy, introduced in 1979. This policy has also contributed, in varying degrees, to a decline in fertility, an increase in the sex ratio (defined as the proportion of male to female live births) from 1.06 in 1979 to 1.19 in 2010 (World Bank Data, Gender Statistics) and an increase in the old-age dependency ratio (Hesketh et al., 2005).

4 The World Bank (2012) estimates that close to 42 million jobs will have to be generated globally by 2020 to cope with the growth in the number of older people. One-quarter of these will have to be generated in China, but by then the size of the Chinese labour force will have started to decline in absolute terms.

5 See Section C.1(b) for an account of current and projected education trends in selected countries and regions.

6 The autarky relative price is the price of the capital-intensive good relative to the price of the labour-intensive good that would be observed in a counterfactual situation of no trade.

7 See Section B.2 for an explanation of the Heckscher-Ohlin trade model. The studies by Sayan (2005) and Naito and Zhao (2009) also look at the distribution of gains across generations. In Sayan's (2005) model, trade based on differences due to unequal population dynamics does not necessarily lead to welfare gains for both countries. Naito and Zhao (2009) show that the old generation in the ageing country (a country with declining fertility rate) gains from trade, but subsequent generations lose during the transition phase. A compensation scheme consisting of country-specific lump-sum taxes (transfers) and savings subsidies (taxes) can, however, make free trade Pareto superior to autarky. Another paper on the differential effects of trade liberalization on old and young written by Gokcekus and Tower (1998) argues that retirees are capital owners. According to the Stolper-Samuelson theorem they will favour trade opening if the country has a comparative advantage in capital-intensive goods (such as the United States).

8 Standard national accounting shows that capital flows and the trade balance are closely related. The current account deficit – the excess of payments (M) to the rest of the world for goods, services, investment income, and unilateral transfers over receipts (X) from the rest of the world for similar items – equals (apart from measurement errors, which may be substantial) the excess of aggregate expenditure (E) for goods and services over national output (Y). The latter, in turn, equals the excess of investment (I) over aggregate savings S (the sum of public savings $S_G = T - G$ and private savings S_P). In symbols: $M - X = E - Y = I - S$. Thus, a current account deficit implies an excess of investment over savings. For a textbook treatment, see Mankiw (2010). On the influence of demographic factors on large and persistent United States' trade deficits, see Cooper (2008) and Ferrero (2010).

9 Another mechanism at work is that in ageing countries, due to "capital deepening" (higher capital-labour ratios), capital becomes more productive, producing capital inflows.

10 Helliwell (2004) argues that, although there is some evidence that countries with high dependency ratios tend to import more capital and run current account deficits, these effects are stronger for non-OECD than for OECD countries. In the latter, he argues that the share of the population aged 65 or more has no statistically significant effect on the current account balance.

11 The life-cycle hypothesis was first advanced by Modigliani and Brumberg (1954). It is closely related to the permanent income hypothesis of Friedman (1957), which posits that transitory income fluctuations do not affect consumption, because the latter is only influenced by changes in permanent income. In the Hall (1978) formulation of the life-cycle permanent income theory, individuals choose their consumption pattern so as to keep the expected (discounted) marginal utility of consumption constant over time.

12 As underlined by Attanasio (1999), the importance of the precautionary motive is ultimately an empirical question, depending, among other factors, on the availability of safety nets and on the characteristics of individuals' preferences and income.

13 The importance of liquidity/borrowing constraints is mainly documented in developing countries.

14 In the case of France, Desvaux et al. (2010) estimate that by 2030 mature households (aged 65 or above) and prime-earning households (aged 40 to 59) will account for about 70 per cent of total consumption. Family fragmentation is also projected to increase: average household size, equal to 2.8 in 1980, will decline to 2 by 2030.

15 The drop in consumption following retirement is a "puzzle" because it seems to contradict the consumption-smoothing prediction of the life cycle-permanent income hypothesis. The empirical evidence, however, is mixed. Using United States panel data over the period 1980-2000, Aguila at al. (2011), for instance, find no evidence of a decline in overall consumption at retirement. In the case of Italy, Miniaci et al. (2003) present evidence that work-related expenses fall after retirement, but non-durable consumption does not fall. They conclude that the retirement consumption puzzle is absent in the Italian context. Hurst (2008) argues that the observed evidence is not inconsistent with the life cycle model, once this is extended to allow for home production (see also Lührmann, 2010) and health shocks (see also Banks et al., 1998).

16 Following Milanovic and Yitzhaki (2002), World Bank (2007) uses an absolute definition of middle class, which includes individuals earning an annual per capita income between the average of Brazil and that of Italy (i.e. between about US$ 4,000 and about US$ 17,000 per year, in 2000 PPP). Other studies use wider income intervals to define the global middle class, obtaining higher projections for its size, both in absolute numbers and as a share of the global population (Kharas and Gertz, 2010; Wilson and Dragusanu, 2008).

17 China is already the world's largest auto market, with 13.6 million vehicles sold in 2009, compared with the 10.4 million sold in the United States. Moreover, the country is also the world's first cell phone market, with approximately 700 million subscribers in 2010 (Kharas and Gertz, 2010).

18 Kharas and Gertz (2010) estimate that in 2010 Chinese households' final consumption accounted for 37 per cent of total output, below the global average (61 per cent) and the percentage observed for other emerging economies such as Viet Nam (66 per cent), Indonesia (63 per cent), India (53 per cent) and Thailand (51 per cent). However, Atsmon et al. (2012) highlight that in recent years Chinese households' consumption increased, also thanks to the measures included in the country's latest five-year plan, which enhanced social security and financial integration.

19 As will be detailed in Section D.1, another recent trend which characterizes both more developed and less developed areas is the increase in inequality within countries. This trend is also influencing demand patterns, contributing to the luxury market's growth in many economies, including China (Atsmon et al., 2012; Kharas and Gertz, 2010).

20 There are, however, a number of policy barriers to trade in education, in the form both of quantitative restrictions on the number of foreign suppliers and of procedural requirements related to recognition of qualifications (Lim and Saner, 2011).

21 As can be seen in Figure C.7, for developing countries the increase in education levels was mainly achieved thorough increases in primary enrolment rates, while for developed countries it was achieved mainly through increases at the secondary and tertiary levels.

22 KC et al. (2010) provide population projections by level of education, age and sex for 120 countries, for the period 2005-50. Starting from baseline country-level survey data for the year 2000, they produce education projections for four different scenarios, among which the most realistic one assumes that countries' education will evolve according to a global upward trend.

23 In particular, Romalis (2004) argues that countries that are abundant in skilled labour and capital do capture larger shares of US imports in industries that intensively use those factors. In a similar vein, Chor (2010) shows that countries which are more skill abundant exhibit higher volumes of bilateral exports in more skill-intensive industries. Finally, Kowalski (2011) finds that, together with physical capital endowments, the length of schooling (a proxy for human capital endowment) is among the most important variables explaining industry patterns of trade flows. According to Kowalski's estimates, a standard deviation increase in years of schooling results on average in about 14-17 per cent increase in exports. He also claims that secondary and tertiary education have different impacts on trade patterns, with cross-country differences in secondary schooling being a more important explanation of industry trade flows.

24 In Costinot's (2009) model, the quality of institutions complements human capital in determining comparative advantage. Due to this complementarity, improvements in institutions have larger effects in countries with more educated workers. Similarly, improvements in education have larger effects in countries with better institutions. See Section C.6 for further discussion.

25 This is because in the former country efficient organization of production requires the matching of workers with similar talent. Conversely, in the latter country it requires hiring one, or few very talented individuals, who are complemented by several lesser talented individuals.

26 Other papers that develop the idea that worker heterogeneity matters for comparative advantage are Grossman (2004) and Ohnsorge and Trefler (2007). See also the discussion on "lumpiness" in Section C.1(c).

27 Amiti and Freund (2010), for instance, document that since 1992 China's exports were substantially reallocated away from apparel, textiles, footwear, and miscellaneous manufacturing (including toys) and toward electrical machinery, office machines (which includes computers), and telecommunications. These are precisely the sectors that rely most heavily on processing trade.

28 The labour force participation rate is defined as the ratio between labour force (employed and unemployed actively looking for a job) and population aged over 15 years.

29 The fraction of the labour force composed of women increased in every country where significant reductions in fertility were observed (Soares and Falcão, 2008).

30 In the standard model of labour supply, a higher wage rate induces two effects on labour market participation: a substitution effect (the opportunity cost of leisure increases, therefore individuals work more and reduce leisure) and an income effect (higher income opportunities increase the demand for leisure, inducing individuals to work less). See Blundell and MaCurdy (1999) for a review of the labour supply literature.

31 However, as underlined by Klasen and Pieters (2012), the U-shaped hypothesis has been documented mainly by cross-sectional analyses, while studies using panel data find more mixed results (see for instance Gaddis and Klasen, 2011). It should also be mentioned that in many developing countries, especially in Asian ones, women increase their participation in the labour market in response to adverse economic shocks. This form of women's labour force participation may create poverty traps (Bhalotra and Umaña-Aponte, 2010).

32 The United States (not shown in Figure C.9) follows a similar pattern to the European Union.

33 Klasen and Pieters (2012) for instance, show that husbands' higher income reduces female LFPRs in India.

34 The Middle East is characterized by low levels of LFPRs also for males. Indeed, increasing labour force participation is recognized as a priority by many governments in the region (ILO, 2012).

35 There is also some evidence of a positive correlation between women's share in employment and aggregate exports for developing countries such as Mauritius, Mexico, Peru, the Philippines and Sri Lanka (Nordås, 2003).

36 Comparative advantage is measured with revealed comparative advantage indices.

37 See Morrisson and Jütting (2005) for an empirical contribution using measures of discrimination based on institutional constraints.

38 In particular, the United States hosted 42.8 million migrants (20 per cent), followed by the Russian Federation (12.3 million, 5.7 per cent), Germany (10.8 million, 5 per cent), the Kingdom of Saudi Arabia and Canada (3.4 per cent each), France, the United Kingdom and Spain (3 per cent each), India and Ukraine (2.5 per cent each).

39 The average share of international migrants in the population of the ten largest hosts was 13.2 per cent in 2010. In the same year, among those with more than 1 million inhabitants, the highest proportion of international migrants were found in Qatar (87 per cent of the population), the United Arab Emirates and the State of Kuwait (about 70 per cent), Jordan and Palestine (about 45 per cent), Singapore, Israel and Hong Kong, China (about 40 per cent).

40 In Australia, the yearly average inflow of migrants increased from 154,000 between 1980 and 1989 to 318,000 between 2000 and 2008. In Canada, it increased from 126,000 between 1980 and 1989 to 241,000 between 2000 and 2009. In the United States, it increased from 633,000 between 1980 and 1989 to 1 million between 2000 and 2010. These data, as well as other data on migrant inflows reported in this section, are from the United Nations Population Division, International Migration Flows to and from Selected Countries: The 2010 Revision, database.

41 For instance, the United States' Immigration Reform and Control Act (IRCA) of 1986 accelerated the country's immigration flows, regularizing 2.7 million immigrants between 1989 and 1994 (United Nations, 2011a).

42 For instance, between 2005 and 2007, inflows from Poland to Germany registered annual net gains of 43,000 arrivals, amounting to an annual average of 146,000.

43 The World Bank Global Bilateral Migration Database (GBMD) only includes data up to 2000. Bilateral migrant stocks in 2010 are used by World Bank (2011c). However, these data, as in an update of Ratha and Shaw (2007), include a smaller set of country-pairs with respect to the GBMD data, and therefore are not precisely comparable to the latter. Nonetheless, the calculation of intra-regional shares of migrant stocks for 2010 indicates that the share of intra-regional migrants declined from 2000 to 2010 in Asia, Europe and the Middle East while it increased in the other regions.

44 Other determinants of cross-border migration are seasonal weather patterns, conflicts and natural disasters (Ratha and Shaw, 2007). Concerning the determinants of internal migration, earlier studies focused on the role of geographical income differentials in determining internal migration (Harris and Todaro, 1970; Todaro, 1969). Differently, the so-called "New Economics of Labor Migration" (NELM) underlined the role of migration as a strategy undertaken by households in poor countries to diversify and thus reduce risk (Katz and Stark, 1986; Lucas and Stark, 1985; Rosenzweig and Stark, 1989; Stark and Levhari, 1982). Hoddinott (1994) generalizes the Todaro and NELM approaches and provides evidence on the importance of both individual- and household-level determinants. For a comprehensive review of the internal migration literature, see Taylor and Martin (2001).

45 On RCPs in Africa, see IOM (2011).

46 In particular, Africa is the main source region for France (with a share of 43 per cent of the total inflow of immigrants in 2008) and the Commonwealth is the main source region for the United Kingdom (with a share of 34 per cent of the total inflow of immigrants in 2009).

47 Figure C.11 shows the average for developed countries. In the period 2005-10, net migration in countries like Italy, Portugal and Japan more than doubled the contribution of natural increase (births minus deaths) to population growth. In a further 29 countries or areas, net migration counterbalanced totally the excess of deaths over births (United Nations, 2011b).

48 The literature on migration and fertility offers four broad hypotheses to explain the observed patterns. The socialization hypothesis, emphasizing the differences in fertility between migrants and natives at destination, posits that, once at destination, migrants maintain the fertility norms to which they were "socialized" during their childhood. Studies maintaining the adaptation hypothesis stress that migrants' fertility, even though it can differ from the one of natives at destination, tends to converge to that of natives over time. According to other analyses, however, the similarities between migrants' and natives' fertility levels observed in some contexts are not due to adaptation, but instead they are related to the selection of migrants, i.e. to the fact that migrants are a non-random sample of the population at origin, characterized by fertility levels different than those of other natives at origin. Finally, according to the disruption hypothesis, the reduction in fertility observed for some migrants at destination is mainly due to the economic and psychological costs associated with relocation. Depending on the context of analysis and on the methodology used, each of these hypotheses finds some support in the literature, with more recent analyses providing relatively more support to the adaptation hypothesis. For a comprehensive review, see Kulu (2005).

49 Eurostat, Migration and migrant population statistics database.

50 At the global level, inspection of the United Nations Population Division, World Migrant Stock database reveals that, relative to the total population, the young are underrepresented among international migrants, while those of working age and over age 65 are overrepresented.

51 The projections in Table C.2 are based on the 2008 Revision of the United Nations Population Division's World Population Prospects. The figures on dependency ratio should not be compared with the ones in Figure C.4, which are from the 2010 Revision.

52 The overall stability of skilled emigration rates is confirmed if a longer time period is considered. In particular, Defoort (2008) analyses emigration rates to a subset of six OECD destinations (United States, Canada, Australia, Germany, United Kingdom and France) for each five-year period between 1975 and 2000. The author shows that overall emigration rates are stable over the period, but they increased in certain regions (especially in Sub-Saharan Africa and Central America) and decreased in others (mainly in the Caribbean and Northern Africa). Interestingly, inspection of the Docquier et al. (2009) dataset reveals that the emigration rate is higher among high-skilled women than among high-skilled men by 17 per cent on average.

53 Data from the Docquier et al. (2009) dataset. Beine et al. (2007) point out that, without controlling for age of entry, high-skill emigration rates are likely to be overestimated. This is because one could count as high-skill emigrant even individuals who moved already as children and acquired their education at destination. However, their estimates corrected for age of entry are highly correlated with the uncorrected ones.

54 This and the following paragraph draw extensively on the textbook exposition of Feenstra and Taylor (2008).

55 The assumption of constant relative price implies that both the sending and the receiving countries are "small".

56 Notice that constant capital-labour ratios imply constant factor prices. Therefore, in the long run, a shock in factor endowment is fully absorbed by changes in the composition of output that go in opposite directions in the two sectors. This is different from the short run, where changes in the composition of output go in the same direction in the two sectors and there is a fall in the return to the factor whose relative abundance increases (in the case of labour migration, the wage rate falls). The effect of migration on wages is the most researched topic in the migration literature. A review can be found in Hanson (2009).

57 Beverelli and Groppo (2013) analyse the relationship between skilled immigration and the structure of trade in skill-intensive sectors in OECD economies. Preliminary results indicate that – controlling for the relative endowment of skilled natives and capital – countries that are relatively more endowed with skilled immigrants capture a higher share of world trade in skill-intensive sectors.

58 This is because of the assumptions of symmetric demand and technology between countries.

59 Gaston and Nelson (2013) discuss various other cases in which there is complementarity between migration and trade. They suggest that intra-industry trade, trade in the presence of economies of scale and in the presence of international differences in the degree of imperfect competition all give rise to such complementarity.

60 While Wong (1988) estimates an indirect trade utility function, Hijzen and Wright (2010) treat imports and immigrants as intermediate inputs to final output. To find whether immigrants are quantity complements or substitute with trade, they estimate "Rybczynski elasticities", namely the percentage change in the demand for imports due to a percentage change in immigrants.

61 The two channels can also be denoted as "business and social network effect" and the "transplanted home-bias effect" (Bratti et al., 2012).

62 A review can be found in Bratti et al. (2012). The literature evolved from cross-country studies to panel-data ones and to recent contributions trying to establish a causal effect of immigration on trade. Not only permanent, but temporary migration has also been shown to matter (Jansen and Piermartini, 2009).

63 The larger effect of migrant networks on differentiated rather than on homogeneous goods found by Aleksynska and Peri (2012) and several other studies is in line with Rauch's (1999) hypothesis that trade-relevant information conveyed by migrant networks is especially relevant on differentiated goods.

64 Empirical evidence indeed shows that in markets with an increase in less educated immigrants there is a large proportion of sectors with a higher intensity of unskilled workers (Card and Lewis, 2007) and a slower adoption of skill-intensive techniques (Lewis, 2005).

65 Kerr and Lincoln (2010). They also show that in 2000, 47 per cent of the PhD-holders working in science and technology in the United States were foreign-born.

66 Chellaraj et al. (2008) find that larger enrollments of international graduate students, as a proportion of total graduate students, result in a significant increase in patents awarded to both university and non-university institutions, as well as in increases in total patent applications. The marginal impact of another foreign graduate student is around 0.88 patent applications and 0.57 patent grants economy-wide. Hunt and Gauthier-Loiselle (2012) find that a one percentage point rise in the share of immigrant college graduates in the population increases patents per capita by 9-18 per cent. Part of this effect reflects the positive spillover effects (crowding in) on native inventors (which may in turn be due to complementarities in innovation). Kerr and Lincoln (2010) find that increases in H-1B admissions substantially increased rates of Indian and Chinese invention in cities that rely more on immigrant scientists. A 10 per cent growth in the H-1B population corresponds to 1-4 per cent higher growth in Indian and Chinese invention for each standard deviation increase in city dependency. They also find some evidence for crowding-in effects. Turning to studies on EU member states, Ozgen et al. (2011) show that the average skill level of immigrants affects patent applications in a sample of 170 EU regions. Moreover, patent applications are positively affected by the diversity of the immigrant community. An increase in the fractionalization index by 0.1 from the regional mean of 0.5 increases patent applications per million inhabitants by about 0.2 per cent. Focusing on France, Germany and the United Kingdom, Venturini et al. (2012) find that highly educated migrants, in general, play a positive role in promoting innovation. In high-technology sectors, in particular, highly skilled foreign workers contribute positively to innovation without crowding out natives.

67 See Hanson (2009) and literature cited therein.

68 Recent contributions along these lines include Di Maria and Stryszowski (2009) and Azarnert (2012).

69 Empirical support for the brain gain hypothesis, at least in some countries including Brazil, China, India and Indonesia (representing more than 80 per cent of the sample population) is found by Beine et al. (2008; 2010).

70 There are other mechanisms through which the migration of educated individuals can have positive effects. First, the remittances sent home by migrants boost the income of those left behind. This can contribute to investment in the sending country (see Section C.2). Remittances may also compensate the amount spent on educating migrants several times over – as shown by Nyarko (2011) in the case of Ghana. Secondly, migrant networks can boost trade in various ways (see Box C.2) and help alleviate capital constraints preventing the development of small enterprises in the source country, as shown by Woodruff and Zenteno (2007) in the case of Mexico.

71 Conversely, Azarnert (2012) argues that, if prospective migrants foresee the possibility of low-skilled guest-worker employment in a higher wage foreign country, the relative attractiveness of skilled employment in the home country might be reduced, with adverse effects on human capital formation and an increase in fertility.

72 The mechanism is as follows. Before the demographic transition, the urban death rate is high due to infectious diseases and urban growth is only sustained by migration. When the demographic transition sets in, the urban death rate falls more rapidly than the rural one. The urban natural increase becomes positive and it drives the growth in urban population. Migration becomes again the main source of urban growth towards the end of the demographic transition, when, due to low fertility, the urban natural growth rate is very low (or negative).

73 Lumpiness is closely related to agglomeration, defined as the spatial concentration of economic activity. There are three main drivers of agglomeration considered in the literature. First, agglomeration has been shown to be driven by firms' objective to share inputs and facilities, and to take advantage of larger markets. Secondly, agglomeration is also guided by the benefits provided by bigger and thicker labour markets, in terms of higher labour supply, better matching between employers and employees and higher worker specialization. Finally, another major driver of agglomeration is firms' and workers' objective to benefit from the higher knowledge flows characterizing big cities.

74 As should be clear from the main text, crucial to the result that lumpiness affects comparative advantage is the violation of factor price equalization. That is, the result is obtained if factor endowments within a country are outside the "cone of diversification" (the factor price equalization set) and one region fully specializes. Factor price equalization within the country can be violated if some factors (like natural resources) are immobile in the presence of differences in the level of amenities between regions (Courant and Deardorff, 1993) and in the presence of agglomeration effects *à la* Krugman (1991) – see Brakman and van Marrewijk (2013) for a detailed explanation. Note that lumpiness can give rise to a direction of trade contrary to the one predicted by the Heckscher-Ohlin theorem.

75 In a case study using Spanish data, Requena et al. (2008) also find some evidence of lumpiness.

76 For a comprehensive review of the literature that documents the existence of agglomeration economies, including productivity gains, see Puga (2010). Melo et al. (2009) underline the distinction made in the literature between localization and urbanization economies. The former indicate gains which are mainly related to industrial concentration, while the latter represent gains from city size. Generally, both have an impact on productivity, with urbanization economies being relatively more important for light industries and knowledge-intensive services, such as finance and real estate.

77 For the effect of institutions on demographic change see, for instance, McNicoll (1980) and Bumpass (1990).

78 In the empirical analysis, Do et al. (2012) use instrumental variable techniques (in particular, geography-based instrument for trade patterns) to isolate the causal effect of comparative advantage on fertility.

79 Moreover, variables such as colonial origins and linguistic proximity can both influence trade and immigration. If not properly controlled for, they can confound the relationship between immigrants and trade flows.

80 Briant et al. (2009) use the stocks of immigrants in 1875, 1982 and 1990 as an instrument for the current stock of immigrants. Peri and Requena-Silvente (2010) and Bratti et al. (2012) use an approach *à la* Altonji and Card (1991), whereby the net inflow of immigrants (in the former study) or the stock of immigrants (in the latter study) are imputed based on historical immigration enclaves.

81 See Brülhart (2010) for a survey.

82 In Krugman and Livas Elizondo (1996), trade opening leads to dispersion of economic activity within a country. In the model, there are two agglomeration forces, forward linkages (because of a taste for variety and interregional transport costs, consumers like to locate close to as large a number of producers as possible) and backward linkages (in order to save on transport and fixed set-up costs, monopolistically competitive producers seek to locate their single plant as close to their consumers as possible). The dispersion force is constituted by congestion costs. For low enough trade costs, the congestion force comes to dominate the backward and forward linkages, leading to dispersion of economic activity. The implication they draw is that "the giant Third World metropolis is an unintended by-product of import-substitution policies, and will tend to shrink as developing countries liberalize". However, in a model closer to Krugman (1991), where the intensity of the dispersion force falls with trade opening, Monfort and Nicolini (2000) get the result that the latter induces internal agglomeration.

83 With no change in a country's territory, this implies an increase in road density.

84 http://www.cio.com/article/123230/South_Africa_Outsourcing_Scorecard

85 http://www.icta.mu/mediaoffice/2007/IPLC_en.htm

86 Authors' calculations based on data from the International Monetary Fund.

87 Such as the Heckscher-Ohlin model of trade.

88 At times, they contract with firms in the host country to establish a joint venture (Desai et al., 2004).

89 Analysing industry-level data for 91 countries between 1980 and 1997, Manova (2008a) shows that equity market liberalization boosts exports disproportionately more in sectors that are relatively more dependent on external financing. This is indicative of a direct link between portfolio investment inflows and greater domestic investment in plant, machinery and equipment, which, in turn, increases the supply capacity of firms.

90 Both physical (shares, bonds, property) and human (education and experience).

91 A shortcoming of many of these studies is that they use combined private and public savings data.

92 Authors' calculations based on data from the International Monetary Fund.

93 In this context, a multinational firm will internalize its activities in a foreign country through FDI if the internalization cost is lower than the cost associated with establishing an arm's length contract (Buckley and Casson, 1976).

94 Rapid capital mobility has "levelled the playing field" for international business to some extent. Firms that would like to take advantage of regulatory or trade policies in a foreign country can simply move or sub-contract through a firm located there (Feenstra, 1998).

95 Several factors affect the relationship between R&D expenditure and innovations. Clearly, innovation is partially the result of chance. Therefore, the relationship between R&D and innovation is by nature stochastic. But, in addition, R&D productivity may depend on specific conditions, such as the quality of the education system. For a deeper understanding of the relationship between R&D and innovation, see Chapter 4 of *World Intellectual Property Report* (WIPO, 2011).

96 For guidelines on the collection and use of data on innovation, see *The Oslo Manual* (OECD, 2005).

97 See Khan and Wunsch-Vincent (2011) for a discussion on the different measures of patents available.

98 To address this limitation, Jaffe and Trajtenberg (2002) suggest using the number of patents weighted by their citations.

99 The balance of payments is an important source of information in this respect.

100 Hall (2010) had previously plotted a standard Lorenz curve of business R&D and GDP for 40 economies for two periods, 1999 and 2005. Due to data availability, the 37 countries in our sample include Argentina, Australia, Austria, Belgium, Canada, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom and United States.

101 As discussed in sub-section (a), there are several measures of technological innovation. A simple comparison of the number of patent applications does not capture the value of specific patents. One way the economic literature attempts to address this concern is by counting the number of patent applications in specific filing offices. We also perform the analysis looking at these alternative measures. While the specific ranking of a country may change, the finding that Asian countries have emerged among the major innovating countries is consistent.

102 R&D services cover those services associated with research (e.g. chemistry, biotechnology, medical sciences, applied science and technology which may be related to machinery, electricity, communications, vessels, aircraft, civil engineering, construction, information, etc.) and experimental development of new products and processes.

103 This group was established by UNSD following a request by the UN Statistical Commission to the Inter-agency task force on statistics of international trade in services to develop compilation guidance to accompany the Manual on Statistics of International Trade in Services 2010. The UN expert group includes all participating agencies to the interagency task force as well as national experts in trade in services statistics.

104 See Chapter 1 of *World Intellectual Property Report* (WIPO, 2011).

105 Note that foreign subsidiaries are counted as residents when they provide their local address.

106 Other studies that explore the geographical dimension of international technology include Bottazzi and Peri (2003), Branstetter (2001), Eaton and Kortum (1999), Irwin and Klenow (1994).

107 "Vertically integrated countries" are defined as those country-pairs with a share of trade in intermediate goods above the median.

108 Data are available at http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis.

109 See the article in *The Economist* (12 January 2013) "Innovation pessimism: Has the idea machine broken down?", *The Economist* (2013).

110 In developing countries, the role of government in research is much more pronounced. See WIPO, (2011).

111 New economic geography theory also predicts that as trade costs fall, production initially becomes more concentrated, but then becomes more dispersed. This is because as concentration increases, forces that act against agglomeration become more salient. For example, in order to persuade workers to move into the sectors, firms will have to pay higher wages. This will tend to reduce the incentive for a further expansion of the sector. The level of aggregation at which this turn in the agglomeration pattern will occur will depend on a number of factors. One of these is the technological spillover intensity and the geographical extent of knowledge spillovers. Evidence suggests that the advantage to cluster is particularly important in some knowledge-intensive sectors (Audretsch and Feldman, 1996). This is compatible with the fact that knowledge-intensive sectors have a substantial part of tacit knowledge that is less easily transferable across countries.

112 See Chart 13 in the 2008 *World Trade Report* (WTO, 2008).

113 Laursen and Meliciani (2010) show that ICT affects export market shares also in non-ICT sectors and that small open economies benefit more than other countries from ICT-related foreign knowledge flows.

114 Meliciani (2011).

115 Several factors affect the ability to appropriate returns from innovation. These include lead time, secrecy, complementary assets and patent protection. On the basis of a survey questionnaire administered to 1,478 R&D labs in the US manufacturing sector in 1994, Cohen et al. (2000) find that of these mechanisms patents tend to be the least emphasized by firms.

116 For example, several studies show that countries' growth rates (the ultimate result of innovation) are positively associated with the volumes of trade (Alcalá and Ciccone, 2003; Frankel and Romer, 1999; Sachs and Warner, 1995) and trade opening (Sachs and Warner, 1995; and Sala-i-Martin, 1997).

117 Also see Section B.1.

118 Other studies that point to the same direction include Clerides et al. (1998) and Van Biesebroeck (2005) for African countries, and Hallward-Driemeier et al. (2002) for East Asian countries.

119 WIPO (2011), Chapter 2 and Maskus (2012) for a review.

120 This is the view, for example, of Javorcik (2004) who finds that weak protection of intellectual property rights deters FDI in technology-intensive sectors that rely heavily on intellectual property rights.

121 See Section C.1 as well as, for example, Agrawal and Oettl (2008), Kerr (2008), Singh (2005).

122 For a review of the existing empirical evidence on FDI and technology spillovers, see Keller (2010). As an example of relevant empirical papers on the issue, see also Blalock and Gertler (2008), Javorcik (2004), Aitken and Harrison (1999), Djankov and Hoekman (2000), Haddad and Harrison (1993) and Konings (2001).

123 See http://www.bbc.co.uk/news/business-20639545 and http://www.dw.de/south-stream-pipeline-construction-begins/a-16435203.

124 There are several measures that can be used to measure volatility. Chen and Hsu (2012) use a moving average of the standard deviation of prices, realized volatility and a GARCH model as measures of energy price volatility. GARCH is the acronym for generalized autoregressive conditional heteroskedasticity and refers to econometric models that allow the variance of a time series to depend on the volatility that was realized in the preceding periods. Therefore, it can capture potential clustering of volatility around specific points in time.

125 Sweeney actually uses the term "depletable" but we treat it as synonymous with exhaustible.

126 See http://www.eia.gov/energy_in_brief/about_shale_gas.cfm.

127 In the case of biofuels for instance, a joint report by the FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, IFPRI, UN HLTF and the WTO (FAO et al., 2011) observes that biofuels now account for a significant share of the global use of several crops – sugar cane, vegetable oil, coarse grains and sugar beet. Beyond, the pitfall posed by industrial policy, the report also notes the environmental and social problems that have arisen from these biofuel subsidies. Growing crops for fuel can potentially emit more greenhouse gases than they save and the subsidies themselves may have played a big role in the increase in commodity prices in 2008, which was particularly harmful to food-importing developing countries (Mitchell, 2008).

128 Part of the reason lies in the difficulty of determining natural resource "abundance" although there may be scope to use environmental accounting methods here as they have been employed to measure natural capital, e.g. forestry, in the valuation of national wealth (Pearce and Atkinson, 1993; Aronsson and Lofgren, 2010).

129 The term "450" comes from the fact that climate researchers assume that the concentration of greenhouse gases in the atmosphere should not exceed 450 parts per million of carbon-dioxide equivalent to be able to have a reasonable chance of reaching the 2°C goal.

130 See the discussion in Milner (1997), Milner et al. (2000) and Milner and Zgovu (2006).

131 This is an example of what is called the "Alchian-Allen effect" or theorem after the two economists, Armen Alchian and William R. Allen, who first analysed the issue. Note that it focuses only on the pure substitution effect and ignores the income effect of the increase in cost, which could run counter to the substitution effect. However, to our knowledge there is no empirical evidence to suggest that the income effect dominates the substitution effect.

132 Strictly speaking, they estimated the dependence of freight charges on price and found an elasticity of about 0.125 to 0.716, with their "preferred" specification being 0.125. Pure iceberg transportation cost will have produced an elasticity of 1 and purely additive transportation cost will have generated an elasticity of zero. The 0.125 estimate is closer to zero.

133 As of the third week of October 2012, a metric ton of iron ore goes for US$ 120, while a troy ounce of gold is worth US$ 1,700. There are 32,151 troy ounces in a metric ton. Compare Table C.17 for average value-to-weight ratios for different product groups and modes of transportation.

134 This is related to what is termed the "O-ring" theory of production (Kremer, 1993). The accident that befell the space shuttle Challenger in 1986 has been attributed to the failure of just one of its many thousands of components – the O-ring – because the very cold weather made it too brittle to withstand the explosive pressure of the Challenger's rockets. When applied to global supply chains and trade in intermediate inputs, the "O-ring" theory says that a delay in the arrival of even one input has a cascading effect on the whole production process, with very costly consequences for the firm.

135 The list of 31 landlocked developing countries can be found at: http://www.un.org/special-rep/ohrlls/lldc/list.htm.

136 C.i.f. refers to the price invoiced by a seller that includes insurance and all other charges up to the named port of destination, while f.o.b. includes all charges up to placing the goods on board a carrier at the port of departure.

137 However, distance is not always immutable. Human action and natural processes can have a dramatic effect on it. For instance, the opening of the Suez and Panama canals dramatically reduced the maritime distance between countries (see the historical discussion in Section B on the effect of these events on trade). Moreover, Arctic warming might open up a polar route that would dramatically shorten the shipping distance between Europe and Asia.

138 A meta-analysis is a statistical analysis of a collection of prior studies, which in this case are estimates of gravity equations. The gravity equation seeks to explain the volume of trade between any pair of countries. Since the GDP of the trade partners and the distance between them are usually included as explanatory variables in the equation, it has been dubbed gravity equation in reference to the analogous role played by mass and distance in the theory of gravity.

139 The source of data on transportation costs is US customs data and its measure of "import charges". US customs defines import charges as "… the aggregate cost of all freight, insurance, and other charges (excluding US import duties) …" These costs reflect transportation between countries and exclude, in almost all cases, inland transportation.

140 Blonigen and Wilson (2008) build upon this method and refine the obtained results by using variation in port efficiency over time. They conclude that the effect of port infrastructure itself is considerably smaller than suggested by Clark et al. (2004), whose estimates are argued to include other country characteristics that are not directly related to port efficiency, such as inland infrastructure or export policies.

141 Several studies confirm that increased competition has also reduced transport prices and increase cargo quantities in air freight. The impact of bilateral open skies agreements on route offerings, air transportation prices and trade volumes are referred to in, among others, Micco and Serebrisky (2006), Zhang et al. (2011) and Cristea and Hummels (2011). Regarding air passenger flows, the study by Piermartini and Ruosova (2013) investigates the impact of air services liberalization using information on 2,300 Air Services Agreements covering 184 countries. They are able to identify provisions in these agreements that are important determinants of the degree of liberalization of the international aviation market. In increasing order of liberalization, these are (i) include multiple designations , (ii) free determination of capacity, (iii) free pricing and community of interest, and (iv) cabotage. They then simulate the effect of each provision being adopted by all country pairs whose current air traffic regulations do not include such a provision. They predict that air passenger traffic would increase by 0.5, 5, 9 and 11 per cent if all existing agreements introduced multiple designation, free determination of capacity, free pricing and community of interest and cabotage, respectively.

142 This is based on Regulation (EC) No 906/2009.

143 http://www.economist.com/node/21527035.

144 The trade facilitation talks were not added to the 2001 Doha Development Agenda before mid-2004.

145 Set out in Annex D of the General Council Decision of 1 August 2004 (WT/L/579).

146 Extending this method to non-OECD countries in the future will give a more complete picture and is likely to show that reductions for other countries are even larger as other studies like OECD (2009) showed.

147 The Aid for Trade initiative was mentioned in the same context as well.

148 Hoekman and Nicita (2010), page 77 ff.

149 Ibid, page 78.

150 See for example Arvis et al. (2007), Otsuki (2011), Wilson et al. (2003) and Wilson et al. (2005).

151 See for example Christ and Ferrantino (2011) and Arvis et al. (2007).

152 For maritime transportation, there are a lot of costs that are independent of fuel. The relative importance of fuel is greater for longer voyages. Furthermore, there is an easy technological fix to adapt to rising fuel prices as ships can slow down and burn less fuel. In the case of planes, they burn a lot of fuel on take-off and landing. For very long flights, planes have to carry more fuel adding to the weight of the plane and reducing its fuel efficiency per cargo carried. The result is a quadratic effect of distance interacting with fuel prices. While planes can slow down and burn less fuel, they have a lot less freedom in this respect than ships. Finally, rising fuel prices induce substitution away from airplanes because fuel prices represent a higher share of operating costs for planes, so the cost elasticity is greater. A switch from planes to ships for the same cargo will sharply lower freight charges, while also incurring greater time costs. This will have a bigger impact on cargoes that are time sensitive.

153 Modal shares are calculated by using import values.

154 The former elasticity is 0.088, while the latter is only 0.103.

155 For further details, see http://www.systemicpeace.org/polity/polity4.htm. This section produces a range of simple statistics using trade data and the scores from the Polity IV Project. Nothing in this section implies a judgement on the part of the WTO of any particular form of government.

156 The blue line in Figure C.54 is a simple linear fit of the data. Instead, the red curve represents the best fit of the data that allows for non-linearities.

157 It appears that to date no study has looked in a formal way at the inverted-U relationship between regime transition and trade policy observed in Figure C.54.

158 The construction of the indicator of the depth of trade agreements follows Orefice and Rocha (2011). We consider 100 trade agreements spanning from 1958 to 2011. The depth measure is constructed considering the ten most important provisions in the factor analysis, namely trade-related intellectual property rights (TRIPS), IPR, countervailing measures, movements of capital, public procurement, competition policy, anti-dumping, investment and state aid.

159 Detailed data for "rule of law" and "regulatory quality" for a broad cross-section of countries are only available after 1996 (Kaufmann et al., 2010)

160 A body of economic literature focuses on the causal effects of economic and political reforms (see, among others, Giavazzi and Tabellini (2005) and Giuliano et al. (2012)).

161 The study by Acemoglu et al. (2005) opened the way to a vast literature on the political determinants of the relationship between globalization and economic institutions. Important recent contributions include Dal Bó and Dal Bó (2011), Do and Levchenko (2009), Levchenko (forthcoming), Segura-Cayuela (2006), and Stefanadis (2010).

162 Costinot (2009) offers an alternative framework in which contract enforcement is a crucial determinant of comparative advantage. In this model, better institutions, represented by a higher probability of the enforcement of a contract, allow a country to specialize in the production of more complex goods. These are sectors that require a higher number of tasks (such as research, design, assembly) to produce a unit of the good.

163 The study introduces a measure that quantifies the importance of contract-dependent inputs in the production of final goods. In particular, for each intermediate good it is possible to determine whether it is sold in an organized market or if it is reference-priced in a trade publication or if it is none of these. Goods that are more contract-dependent are those that use a higher fraction of inputs that are not sold in organized markets and do not have a reference price, as those investments are more likely to be relation-specific.

164 For a survey of this literature, see WTO (2011b).

165 See, in particular, Giuliano et al. (2006), Guiso et al. (2009), Spolaore and Wacziarg (2009a; 2009b), Gokmen (2012). This measure is based on the work of Cavalli-Sforza et al. (1996).

166 For a broader discussion of the pro-trade effects of immigration, see Section C.1(c).

167 A related strand of literature analyses the relation between conflicts and trade. In particular, Rohner et al. (2011) provide a theory of trade and conflict where trade hinges on trust and cooperation. They show that policies that foster inter-ethnic trade increase trust between societies and reduce conflicts.

Appendix

Appendix Table C.1: **BERD in the manufacturing sector**
(sum over 18 countries, values in PPP US $ million, 2005 constant prices)

Industry	Value		Share	
	1990-95 average	2005-10 average	1990-95 average	2005-10 average
Fabricated metal products, machinery and equipment, instruments and transport	85,570	139,638	69.1%	72.7%
Coke, petroleum, nuclear fuel, chemicals and products, rubber and plastics	25,914	37,067	20.9%	19.3%
Basic metals	4,240	4,052	3.4%	2.1%
Food, beverages and tobacco	2,594	4,139	2.1%	2.2%
Non-metallic mineral products	2,145	2,142	1.7%	1.1%
Wood, paper, printing, publishing	1,404	1,649	1.1%	0.9%
Textiles, fur and leather	1,070	1,802	0.9%	0.9%
Furniture and other manufacturing	880	1,576	0.7%	0.8%
Manufacturing total (sum over 18 countries)	123,815	192,079		

Source: Authors' computations, based on data from OECD Science, Technology and R&D Database.

Note: For the purpose of consistency and comparability, aggregation is performed only on countries with BERD data in all industrial breakdowns of the manufacturing sector, for both the period of 1990-95 and 2005-10. As a result, 18 countries in the database satisfy these criteria, and they are: Czech Republic, Denmark, Finland, Germany, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Mexico, Norway, Portugal, Singapore, Slovenia, Spain, Sweden and Turkey.

Appendix Table C.2: **BERD in the services sector**
(Sum over 14 countries; values in PPP US $ million, 2005 constant prices)

Industry	1990-95 average	2005-10 average	Annualized growth
Community, social and personal service activities, etc.	436	728	3.47%
Financial intermediation (includes insurance)	414	1,465	8.79%
Real estate, renting and business activities	3,921	16,088	9.87%
Transport, storage and communications	824	1,761	5.19%
Wholesale, retail trade and motor vehicle repair	603	2,337	9.45%
Total BERD in services sector (sum of 14 countries)	5,710	22,294	9.51%

Source: Authors' computations, based on data from OECD Science, Technology and R&D Database.

Note: For the purpose of consistency and comparability, aggregation is done using only countries with data in all industries under the services sector for the periods of both 1990-95 and 2005-10. As a result, the 14 countries in the sample are Austria, Canada, Czech Republic, Germany, Greece, Hungary, Ireland, Netherlands, Norway, Portugal, Singapore, Slovak Republic, Spain and Turkey; according to the OECD database, the industry break-down of BERD does not add up to the total sectoral BERD.

Appendix Table C.3: **Number of fixed-telephone subscriptions, mobile-cellular telephone subscriptions and internet users per 100 inhabitants, 2011**
(Top 30 economies)

Fixed-telephone		Mobile-cellular telephone		Internet users	
Monaco	96.40	Macao, China	243.50	Iceland	95.02
Chinese Taipei	72.68	Hong Kong, China	209.64	Norway	93.97
Cayman Islands	65.63	Panama	203.88	Netherlands	92.30
Germany	63.05	Saudi Arabia, Kingdom of	191.24	Sweden	91.00
Hong Kong, China	61.06	Antigua and Barbuda	181.64	Luxembourg	90.89
Korea, Republic of	60.90	Russian Federation	179.31	Denmark	90.00
Switzerland	60.82	Suriname	178.88	Finland	89.37
St. Helena	59.65	Oman	168.97	Bermuda	88.34
San Marino	58.88	Cayman Islands	167.67	Qatar	86.20
Iceland	58.43	Anguilla	166.31	New Zealand	86.00
France	55.92	Finland	166.02	Switzerland	85.20
Malta	54.89	Maldives	165.72	Liechtenstein	85.00
Luxembourg	54.10	Dominica	164.02	Korea, Republic of	83.80
Liechtenstein	53.99	Libya	155.70	Guernsey	83.63
United Kingdom	53.24	Austria	154.78	Canada	83.00
Barbados	51.35	Italy	151.84	Germany	83.00
Japan	51.06	Lithuania	151.30	Antigua and Barbuda	82.00
Greece	49.91	Singapore	149.49	United Kingdom	82.00
Sweden	48.72	United Arab Emirates	148.62	Andorra	81.00
United States of America	47.91	Luxembourg	148.27	Faroe Islands	80.73
Canada	47.86	Seychelles	145.71	Austria	79.80
Australia	46.63	Viet Nam	143.39	France	79.58
Israel	46.28	Botswana	142.82	Japan	79.53
Ireland	45.22	Kazakhstan	142.55	Australia	79.00
Denmark	45.13	Uruguay	140.75	Belgium	78.00
Andorra	44.57	Bulgaria	140.68	United States	77.86
Belarus	44.02	Guatemala	140.38	Bahrain, Kingdom of	77.00
Montserrat	43.41	Estonia	138.98	Ireland	76.82
Belgium	43.06	Trinidad and Tobago	135.57	Estonia	76.50
Slovenia	42.89	Argentina	134.92	Singapore	75.00

Source: ITU.