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International Price Transmission in CGE Models: How to Reconcile Econometric Evidence and Endogenous Model Response?

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Abstract

The importance of empirically analyzing the transmission to and impacts of international prices on domestic markets is growing, particularly since the 2006 – 2008 food price hike. However, the field is dominated by econometric time-series analysis (PTA) and rather disconnected from analyses based on simulation models such as computable general equilibrium (CGE) models. The missing reconciliation among these tools could be due to: PTA often being concerned with high frequency data and short term adjustment processes, which does not reconcile well with the annual data of CGE analyses; typically little overlap between research teams in econometric time series analysis and those in CGE modeling; and the endogeneity of price transmission in CGE models. Due to this endogeneity, the calibration of CGE models to empirically observed price transmission is not straightforward, as an infinite combination of model parameters and specifications allows for reaching a certain level of price transmission. This paper aims to address the question of how a certain degree of price transmission from the international to the domestic market, which may be determined empirically such as based on a vector error correction model, can be met in a single country CGE model. We examine and validate seven hypothetical determinants including structural characteristics of the model, the parameterization of behavioral functions, and properties of the sectors concerned. The findings of this paper support controlling the pass-through of prices from the international to the domestic market in CGE models.

1 Introduction

The literature on the empirical analysis of the transmission of international prices to domestic markets is dominated by specific analytical methods such as cointegration analysis and the estimation of error correction models. However, connection to the world of Computable General Equilibrium (CGE) modeling, despite their powerfulness in showing the economy-wide implications of price changes, is limited. At most, prior studies have included exogenous assumptions on price transmission which are plugged into CGE models by fixing domestic price levels (see, for example, Mundlak and Larson (1992), Baffes and Gardner (2003), Delgado et al. (2004), and Habermeier et al. (2009)).[1]

Adam (2011) illustrates the real macroeconomic and distributional effects of alternative fiscal and trade policy responses to food price shocks and how these are determined by the structural characteristics of low-income economies. He also investigates impacts of food price shocks on the aggregate price level and the implications of increased food price volatility on the design and conduct of monetary policy in low-income economies. However, despite the consideration of many structural components that might impact the transmission process. For example, the elasticity of substitution between imports and domestic goods and the elasticity of transformation between production for the domestic and the export market are both set to 0.5 without considering the impact of these parameters on price transmission. In doing so, the common approach of selecting elasticity values based on educated guesses and knowledge about particular countries without taking price transmission implications into account is followed.

The missing reconciliation among the research fields of econometric price transmission analysis (PTA) and CGE analysis could be due to several reasons, such as: (1) Empirical PTA being often more concerned with high frequency data and short term adjustment processes, which does not reconcile well with the typical solution period (annual averages) and simulation horizon (medium to long term) of CGE analyses; (2) Different research teams for econometric time series analysis and CGE modeling with typically little overlap; and (3) Price transmission is endogenous to CGE models and is determined by a wide range

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[1] See Adam (2011) for a comprehensive survey and comparisons.

of model parameters and specifications, such as trade shares, share of the sector concerned in the economy, Armington elasticities, elasticities of substitution among value added and intermediate inputs, and elasticities of substitutions within intermediate input categories, factor market closures in general, and their complex interactions. As a consequence, the calibration of CGE models to empirically observed price transmission is not straightforward; an infinite combination of model parameters and specifications allows for reaching a given level of price transmission.

This paper addresses the question of how a certain degree of price transmission from the international to the domestic market, which may be determined empirically (e.g., based on a vector error correction model), can be met in a single country CGE model. To this purpose, we employ as "laboratory" a single country CGE model developed by McDonald (2009) and adjusted to a social accounting matrix for Israel (Siddig et al., 2011). We first formulate a priori assumptions on which model specifications and parameters in a CGE are the main determinants of the resulting degree of price transmission. Subsequently, in a systematic sensitivity analysis we analyze the impact of these determinants and their interaction as well as show how exogenously given degrees of price transmission can be met endogenously in a CGE model based on the calibration of various parameters. As a simple and significant shock, we apply a doubling of international cereal and other crop prices, which is not far from what was observed during the years 2007 and 2008, and investigate how this shock impacts domestic prices in the Israeli economy, which has high import shares of these products.

The paper is organized as follows: in Section 2 we describe the model including its closure rules and the price system; in Section 3 we highlight the database including the SAM and behavioral elasticities and also describe the selected food sectors in Israel; in Section 4 we formulate a priori expectations about the main determinants of price transmission; we present results of a systematic sensitivity analysis in Section 5; and Section 6 contains the conclusion.

2   The Model

2.1 Overview

The single country Computable General Equilibrium (CGE) model STAGE (McDonald, 2009) is used as a basis of our experiments. STAGE is a Social Accounting Matrix (SAM) based model with a mix of non-linear and linear relationships that depict the behavior of the economy's agents. It is a static model with households maximizing their utility according to preferences represented by Stone-Geary utility functions. Households consume commodities available in the domestic market from both domestic production and imports. The substitution between domestic and imported goods is governed by the Constant Elasticity of Substitution (CES) specification (Armington, 1969). Israel is a small country in the world market of wheat, other cereals which comprise of all cereals other than wheat such as rice, corn, barley, rye, and oats, and other crops (the crops which are the focus of this study); hence, world market prices for imports and exports are fixed in the model.

Domestic production is modeled as a two-stage production process with a CES function on top, where intermediate inputs and production factors are combined to generate the output of each activity. At the second stage, intermediate inputs are combined according to Leontief technology, while production factors (land, labor, and capital) are combined according to CES technology, with the optimal ratio of production factors being determined by relative prices. The domestic production of commodities is sold in the domestic or the export market based on a Constant Elasticity of Transformation (CET) specification and dependent on relative prices in these markets. The model is implemented in General Algebraic Modeling System (GAMS) software and adapted to an Israeli SAM (Siddig et al., 2011).

The Israeli 2004 SAM is a detailed SAM that comprises one account for capital, one for land, and 36 for labor. For the purpose of this paper, neither the different labor accounts nor the accounts of taxes on labor are at the focus; hence, they are discussed as one aggregated labor account.

2.2 Price system

Figure (1) shows the interrelationships between the prices for commodities and activities as depicted by the model. The supply prices of the composite commodities (PQS_c) are defined as the weighted averages of the domestically produced commodities that are

consumed domestically (PDD_c) and the domestic prices of imported commodities (PM_c). The domestic prices of imported commodities are defined as the product of the world prices of commodities (PWM_c) multiplied by the exchange rate (ER) plus ad valorem import duties (TM_c). Weights of the domestic and the imported prices in the determination of the average prices are determined by a CES function. The average prices exclude sales taxes, and hence must be uplifted by (ad valorem) sales taxes (TS_c) and excise taxes (TEX_c) to reflect the composite consumer price (PQD_c).

Figure (1): Price Relationships for the STAGE Model
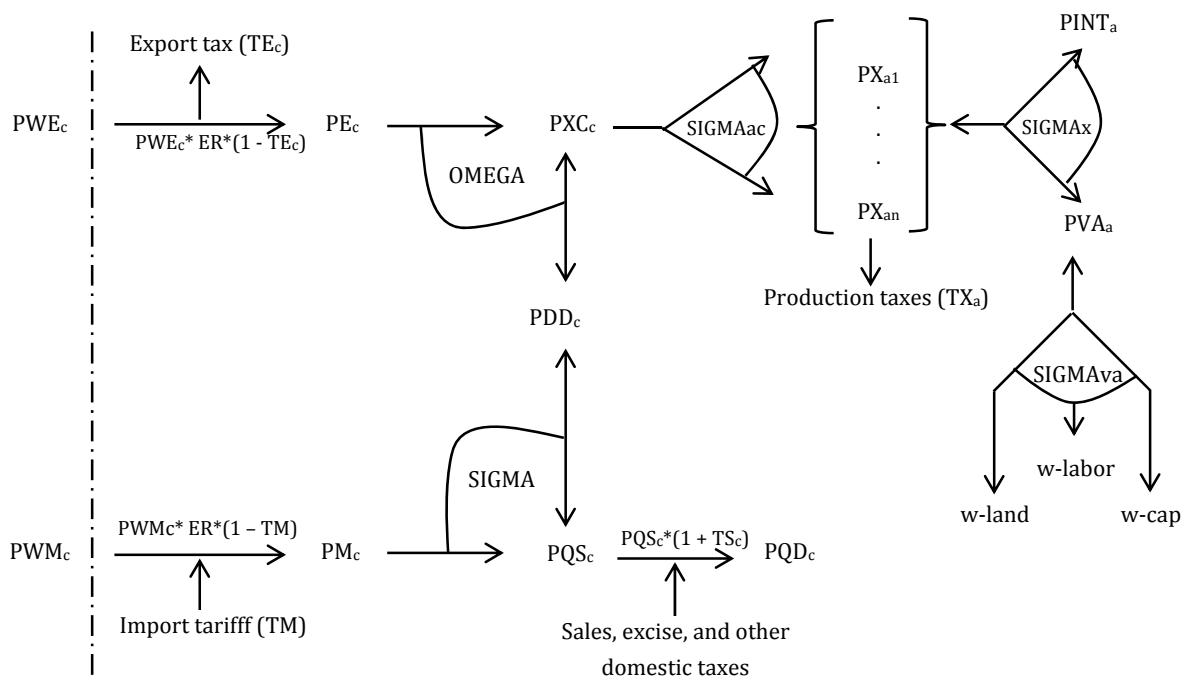
Source: Modified and extended from McDonald (2009).

The producer prices of commodities (PXC_c) are similarly defined as the weighted averages of the prices received for domestically produced commodities sold on domestic (PDD_c) and export (PE_c) markets. Weights adjust endogenously based on a CET function. The prices received on the export market are defined as the product of world price of exports (PWE_c) and the exchange rate (ER) less any export duties due, which are defined by ad valorem export duty rates (TE_c).

This study focusses on a sample of selected prices to investigate the determinants of price transmission from the rest of the world to the domestic market. The selected prices are producer prices of commodities (PXC_c), supply prices of domestically produced commodities on the domestic market (PDD_c), supply prices of composite commodities (PQS_c), value added prices of production activities (PVA_a), and intermediate input prices of production activities ($PINT_a$). Elasticities are also shown in the figure as the trade CES (SIGMA), production CES at the top level (SIGMAx), production CES at the second level (SIGMAva), and trade CET (OMEGA).

2.3 Closure rules

For our analysis we apply the following standard closure: the model is investment driven with the share of investment in domestic final demand being fixed. The government account, all tax rates, government consumption expenditures and transfers are assumed as fixed, while government savings are a free variable. For the factor market, all production factors are assumed fully employed and mobile across sectors in the default closure, which reflects a long term adjustment period. We also employ a modified factor closure which reflects a more medium term adjustment period and considers the amount of capital, skilled labor, and land to be fixed and activity specific, while only unskilled and semi-skilled labor are fully mobile and fully employed. The current account balance is assumed to be fixed, while the exchange rate is the free variable the in default closure. Import and export prices are always fixed.

3   The Database

3.1 Social Accounting Matrix

The Israeli SAM that represents the Israeli economy in the year 2004 is the main database used in this study. It incorporates 43 sectors, 36 labor accounts, 10 household groups, and 18 tax categories other than taxes on production factors (Siddig et al., 2011). The SAM was developed based on data obtained from different official sources in Israel including the Israeli Central Bureau of Statistics (ICBS), the Central Bank of Israel (BOI), and the Israeli Tax Authority (ITA). In addition, non-Israeli sources were used to fill-in gaps in domestic reports such as the World Trade Organization (WTO), the Organization for Economic Co-operation and Development (OECD), and the World Bank.

For this study, details pertaining to production factors, households, or taxes are not relevant; therefore, they will be treated as aggregates throughout the discussion. What matters from the viewpoint and for the objectives of this study is how the selected food sectors are represented in the SAM and what weight they have in the entire Israeli economy.

3.2 Selected food sectors and price trends

Despite their importance in meeting domestic food demand in Israel, wheat, other cereals, and other crops do not represent big shares in aggregated economic variables such as exports, imports, and production. Table (1), shows the percentage share of each in total Israeli imports, exports, production, and factor use. The three commodities together represent only 1.7% of total Israeli imports, 0.8% of exports, and only 0.4% of domestic production; however, their share in the total cultivated land is 33.1% with other crops alone occupying 23.4%. This implies that these three crops will be sensitive to land market closure, while changes in the three crops are expected to have a minor influence on economic variables at the macro-level.

Table 1: Shares of the three commodities in selected variables of the economy (%)

|	Import	Export	Production	Land use	Labour use	Capital use
Wheat	0.37	0.00	0.03	6.97	0.03	0.01
Other cereals	0.59	0.01	0.03	2.87	0.01	0.07
Other crops	0.72	0.75	0.31	23.35	0.25	0.34
Total	1.68	0.76	0.36	33.18	0.29	0.42

Sources: Siddig, et al. (2011), own calculations.

The size of these sectors measured by their contributions to the country's total domestic production shows that other crops have the largest share of the three sectors with a 0.31% contribution, followed by wheat with 0.029%, and other cereals with 0.026%. Similar ranking is also achieved when considering the share of these sectors in their use of total agricultural land and labor. According to their contributions to the country's total exports and imports, the sector other crops has the largest share followed by other cereals and then wheat. There is a similar ranking for the shares of these sectors in total capital use.

If we consider total domestic supply, the wheat and other cereals sectors have a much smaller contribution than the other crops sector. The share of domestic production in the total supply is lowest for other cereals where about 74% is imported, followed by wheat where 71% of its domestic supply is imported (Figure 2). In the other crops sector, which is the largest of the three selected sectors in terms of production, only 30% of its domestic supply is imported (Figure 2). Accordingly, the other crops sector is expected to be less responsive to international market prices from the import side compared to wheat and cereals.

No domestic policy intervention related to taxes, subsidies, or tariffs is considered in this experiment. Moreover, the share of taxes and margins in the supply of the selected commodities is not expected to influence the results significantly.

Figure (2): Components of domestic supply of the three commodities
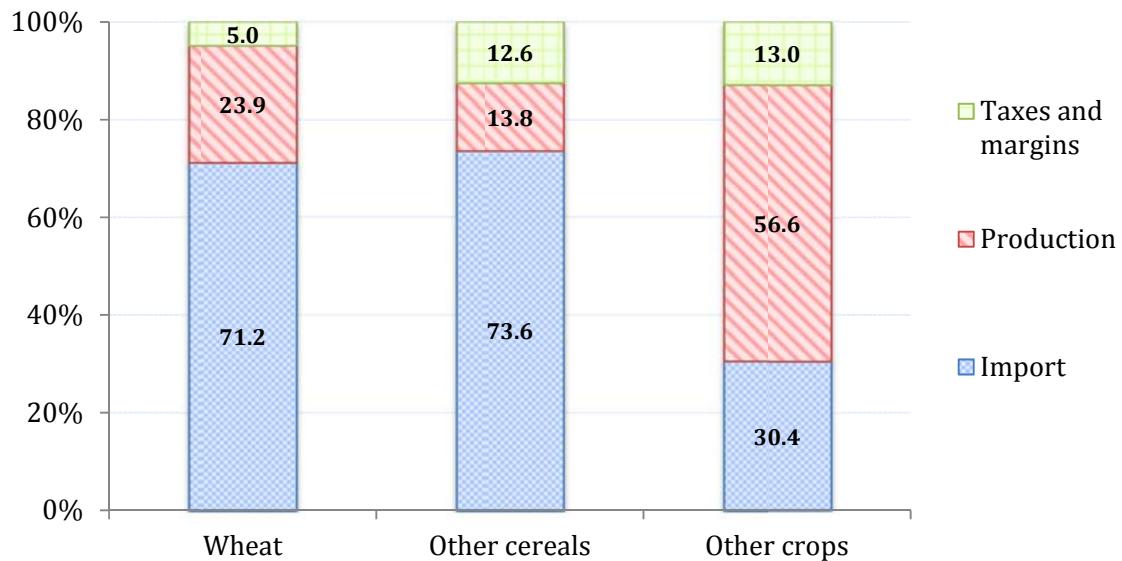
Sources: Siddig, et al. (2011), own calculations.

On the domestic demand side of the three sectors, shown in Figure (3), wheat and other cereals are mostly demanded as intermediates, which account for 99% and 95% of their total demand, respectively. The situation is different for other crops with 44% demanded as intermediate, 32% for exports, 20% by households, and 5% for investment. These different demand structures are also expected to result in different impacts of world prices

changes on domestic markets. For example, the higher export share of other crops should result in domestic prices of this product being more responsive to changes in export prices than those of wheat and other cereals.

Figure (3): Components of domestic demand of the three commodities
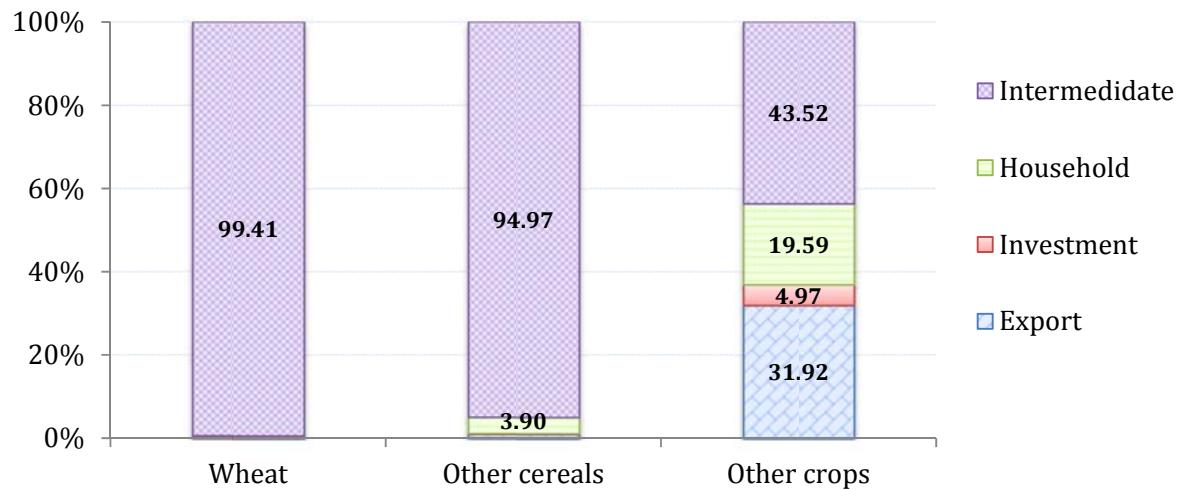
Sources: Siddig, et al. (2011), own calculations.

The cost structure of the three sectors does not differ very much. The share of intermediate demand by wheat, cereals, and other crops in the total cost structure is 62%, 54%, and 56%, while the share of the demand for primary factors is 37%, 43%, and 43%, respectively. The remaining share is devoted to taxes on production and production factors.

Historical and recent information about price trends of the three commodities in both the domestic market and the world market are also relevant to our experiment, as this study is motivated by the importance of the transmission of world market prices in shaping prices trends in Israel.

Figure 4: Trends of domestic and world prices of wheat and other cereals (2001 – 2011)
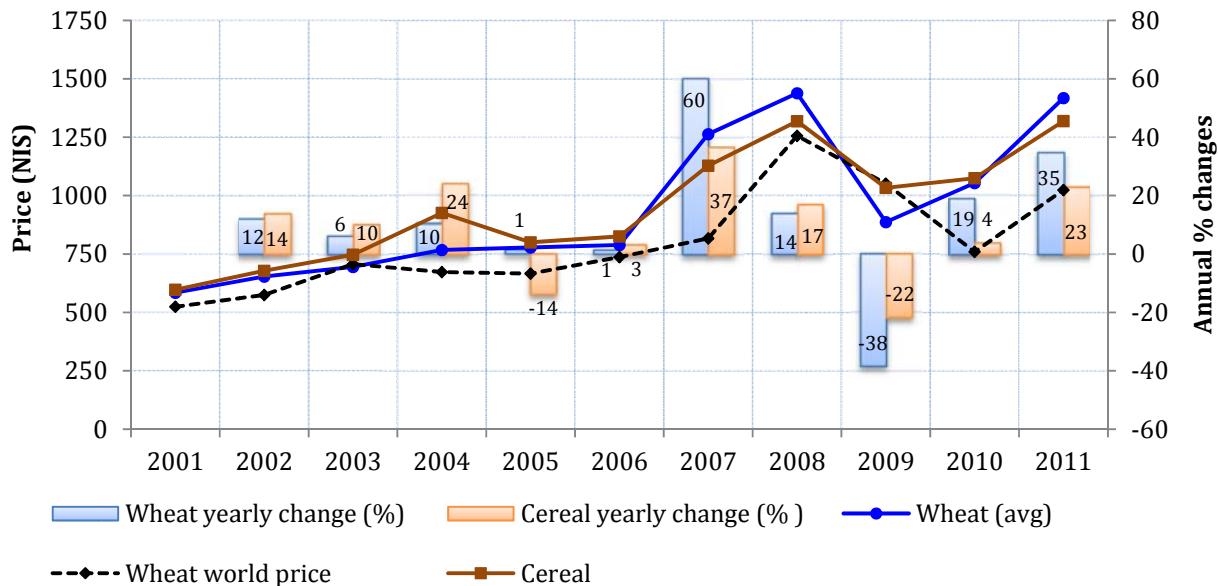
Sources: ICBS (2011), USDA (2011), own calculations.

Figure 4 shows that domestic and international annual prices for cereals show positive percentage changes almost throughout the period. Even without a formal time series analysis, it seems that the domestic price of wheat in Israel is highly influenced by the international price of wheat represented by Kansas[2] wheat in Figure 4 (USDA, 2011). Moreover, other cereal and wheat prices in Israel and Kansas appear to be highly correlated during the last ten years.

3.3 Elasticities

Four sets of elasticities are considered crucial in the determination of the level of price transmission from the world to Israel through imports and exports: the constant elasticity of substitution (CES) between imports and domestic goods, the CES between value added and intermediate inputs, the CES for the substitution among the different value added components, and the constant elasticity of transformation (CET) between exports and domestic goods. Section 4 will further add to the assumptions related to the influence of

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[2] Simple average of No. 1 hard red winter ordinary protein and 13% protein, Kansas.

elasticities on the transmission of the world price of imports and exports to domestic markets, while the results section will assess and validate these assumptions based on our empirical findings.

For the default version of our model analysis (pre-sensitivity analysis), the values of the four elasticities are assumed to be 2.0 for the trade elasticities (CES and CET) and 0.8 for production CESs at top and second levels. The selection of these values is based on educated guesses governed by our knowledge about the Israeli economy and guided by the elasticity ranges recommended by Sadoulet & de Janvry (1995).

4   A Priori Assumptions on Drivers of Price Transmission

A priori, we hypothesize the following model components, parameters, and specifications to be crucial in the determination of the degree of price transmission between international and domestic prices:

1. The trade shares (import and export): the higher the trade shares of the sector, the higher the transmission of world market price changes to the domestic market. Imports and exports are imperfect substitutes for domestic products. Therefore, if the initial trade share is very small, it cannot become large (Hanslow, 2001; Kuiper and van Tongeren, 2006).
2. The value share in the domestic economy: the higher the share of the sector in the domestic economy, the higher the impact created by changes in world price on the domestic market price. This is because the domestic price increase is dampened by more production, which happens more easily with smaller sectors. Therefore, if the sector is large, price increases can be dampened by domestic production to a lesser extent only.
3. The share in domestic factor use: sectors could be differentiated according to their use of different factors of production with different implicit price elasticities of factor supply. In case a sector relies heavily on an inelastic factor, price transmission is likely to be higher. This is because with increasing domestic production, the cost of production would increase more than it would if there were a higher factor supply elasticity.
4. The degree of factor mobility among sectors: the higher the factor mobility, the lower the price transmission. This is because increasing domestic supply in case of increasing

international prices dampens the increase in domestic prices; however, the more immobile the factors are, the less this mechanism can work.

5. Armington elasticities and CET elasticities between domestic demand/import demand and domestic supply/export supply: the higher the trade elasticities, the higher the price transmission. This is because higher elasticities allow for higher degrees of substitution, resulting in more demand for the domestically produced product in the case of an increasing world market price.

6. Elasticities of substitution among value added and intermediate inputs: the higher the elasticities, the more options producers have to substitute primary factors by intermediates and vice versa. Therefore, the higher the elasticities, the less of an impact world market price changes will have on domestic prices. In addition, elasticities of substitution within input categories matter because higher elasticities of substitution enable producers to adjust production and thus dampen the price shock domestically.

7. The prevailing exchange rate policy: the domestic currency tends to appreciate if world prices of commodities which are predominantly exported increase, while the domestic currency tends to depreciate if there are rising prices for predominantly imported products.[3] From a price transmission perspective, an increasing world price together with a flexible exchange rate would reduce the pass-through of that increase in case of a currency appreciation and increase the pass-through in case of a currency depreciation.

The following section tries to empirically assess and validate the described hypotheses.

5   Results and Sensitivity Analysis

As a first step, we apply a shock of a 100% increase in world prices for wheat, other cereals, and other crops to the model with standard parameterization and model closures as described in Section 2. This model is found to transmit the 100% increase in the world price to the domestic prices of the three commodities at very different magnitudes (Figure 5). The prices shown in Figure 5 include the domestic price of imports (PM), the supply price of the composite commodity (PQS), the supply price of the domestic commodity in the domestic market (PDD), the composite producer price (PXC), the value added price (PVAa), and the intermediate input price (PINTa).

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[3] The effects of international price shocks on the exchange rate in CGE models depend on the complex interplay of various factors (Devarajan et al., 1993) and are not discussed in this article.

As a first observation, the percentage increase in PM and PE is 96%, rather than the 100% increase in the world market price. The increase is not by the full amount because of an appreciation of the domestic currency against the dollar by about 1.8%. While the change of the prices of imports and exports is equal over all products, the transmission to other domestic prices differs heavily among products. For example, producer prices of wheat, other cereals and other crops increase by 25%, 32%, and 74%, respectively, due to the 100% increase in their world market prices (Figure 5). We make an effort to explain differences among products in Section (5.1) based on sectoral shares in the domestic economy as well as trade shares in total production/use.

Given the high level of observed correlation between the world market price and food prices in Israel (Figure 4), we find that domestic price changes in the standard model specification are too low. Therefore, we carry out a sensitivity analysis in Sections 5.2 to 5.4 to investigate options needed to reach a higher level of price transmission and to assess and validate the hypothetical assumptions made in Section 4.

5.1 Sector shares

The first a priori hypothesis assumes that the higher the trade share, the higher the price transmission. The reaction of the selected sectors to the world price increase measured at the domestic supply price (PQS) ranks the sectors according to their import shares as other cereals, wheat, and other crops have 73%, 69%, and 65% increases in PQS (Figure 5) and import shares are 74%, 71%, and 30% (Figure 2), respectively. For other crops, the 65% increase in PQS seems high if one considers the substantially lower import share for this product group. The impact on PQS for other crops, however, also stems from a strong increase in the export price.

To confirm our interpretation regarding the causes of price changes and particularly those on PQS, we simulated a situation where the shocks are introduced in separate experiments, once from the export side alone and once from the import side alone. In case we only increase import prices, but not export prices, the share increase in PQS for other crops is indeed significantly lower: only 54%. On the other hand, wheat and other cereals are virtually not exported and the effect on PQS stems almost exclusively from the import price shock. If we apply the price shock on the export side only, effects on PQS are clearly ranked

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according to export shares, with other crops ranking first, other cereals second, and wheat third.

Figure (5): Changes in domestic prices following a 100% increase in international prices with default model parameterization and closures (%)
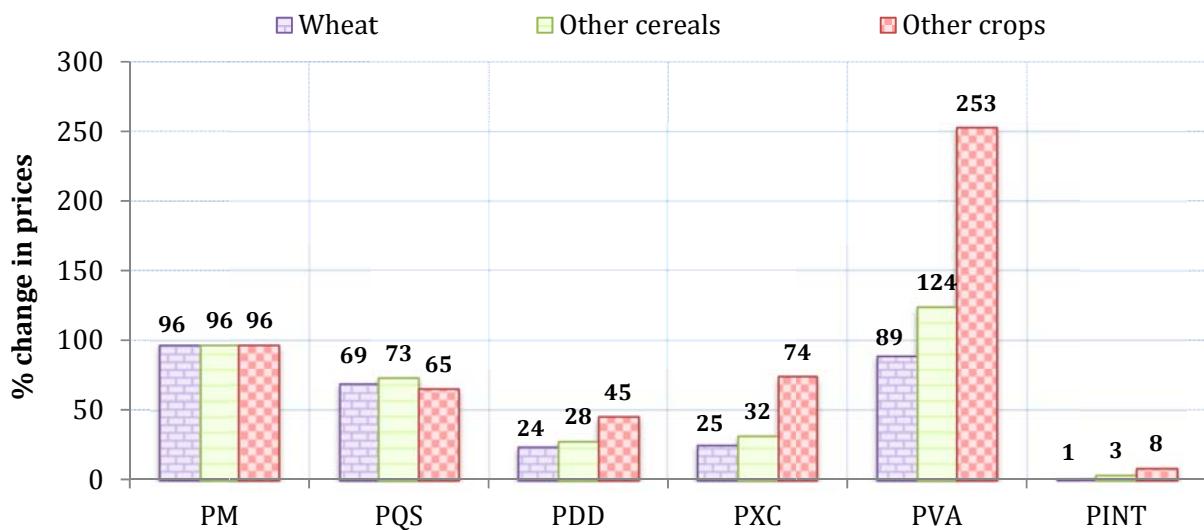

For other prices, the picture is less homogeneous. For both PDD and PXC, the price change is strongest for other crops, which can be explained by the high export share and the direct impact of the export price on PXC (see Figure 1). The strong increase in the producer price for other crops motivates domestic producers to produce more. This dampens the domestic price increase and results in a higher increase in its value added price than for other products. Value added and aggregate intermediate input demand is always driven by increases in production, which translates into higher wages for factors as well as higher prices for intermediates. Therefore, the results for PVA and PINT are not surprising, as they strictly follow their PXC counterparts and rank the three sectors similarly.

In conclusion, we can attribute the size of the domestic price effects to import and export trade shares. Based on this single experiment, we cannot conclude the relevance of the shares of sectors in domestic production, as wheat and other cereals are similar in this respect and the other crops sector differs heavily from the other two sectors not only in terms of its sectoral size, but also in terms of its trade structure, both of which impact on the results.

5.2 Factor mobility

To analyze the relevance of factor mobility for the degree of price transmission, we run the world price shock under the assumption of full factor mobility and compare the results to those obtained in a model closure with full factor immobility. Our expectation is that the level of price transmission is low when there is high factor mobility. This expectation is validated by our results, shown in Figure (6), where the percentage changes in the prices of the three commodities under the assumption of factor mobility and immobility are shown. Other crops and cereals in particular show huge differences in the degree of transmission under the mobility and immobility assumptions. As expected, the highest reactions are at the level of the value added prices, where the percentage changes are 267% and 133% for other crops and cereals under the immobility assumption, respectively, compared to 139% and 67%, respectively under the mobility assumption.

Figure (6): Changes in prices with factor mobility versus immobility assumptions (%)
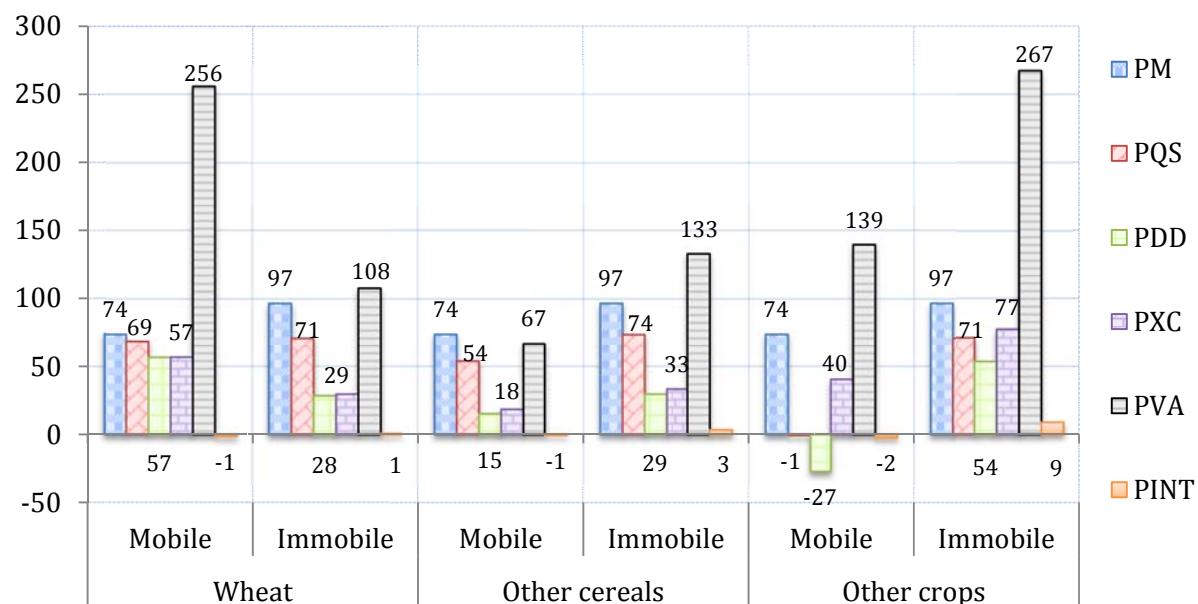
We find that the composite supply price (PQS) and the domestically sold product supply price (PDD)for other crops would even deteriorate in response to a 100% increase in the world market price under the assumption of factor mobility. This is because the increase in the export price for other crops causes a strong increase in the composite producer price, which would be able to attract production factors and increase production fourfold. The strong increase in production and thus supply for the domestic market would result in a

fall of PDD by 27%. PQS would be affected by both this decline in PDD and the increase in PM, with a slightly negative net result of -1%.

Some of the wheat prices behave contrary to expectations; namely for PVA, PXC, and PDD, the pass-through from the international to the domestic market is less under the immobility assumption than it is under the mobility assumption because of cross effects. With mobile factors, the production of other crops increases heavily and replaces land which had previously grown wheat: land use for wheat declines by 81.4%. This results in a scarce domestic supply of wheat and thus higher domestic wheat prices than would occur under the assumption of factor immobility.

5.3 Substitution elasticities

To analyze the impact of the proclaimed determinants (5) and (6), we perform a sensitivity analysis with several values for the following major related elasticities: the trade elasticities (the CES between imports and domestic goods and the CET between exports and domestic goods) and the production CESs (the CES between aggregate primary factors and aggregate intermediate inputs and the CES between the disaggregated primary factors of production).

To enhance the level of price transmission, the default factor market closure is adjusted for this sensitivity analysis. We consider the amount of capital, skilled labor, and land used to be fixed and activity specific, while unskilled and semi-skilled labor are fully mobile and fully employed.

Depending on the sensitivity of the model to the four elasticities and its ability to converge, ten different values are selected for the trade CESs and CETs covering a range between T1 (0.5) and T10 (9.5), while assuming similarity between both of them at each stage. In addition, another ten values are selected for the production CESs assuming similarity between both of them in each stage. The range for the production CESs is between P1 (0.05) and P10 (3.0). The exact values of the trade and production elasticities as well as the default levels used in previous experiments are shown in Table (2).

Table (2): The ranges of elasticity values considered in the sensitivity analysis

Codes	Production CESs	Codes	Trade CES and CET
P1	0.05	T1	0.50
P2	0.38	T2	1.50
P3	0.71	T3	2.50
Default version	0.80		2.00
P4	1.03	T4	3.50
P5	1.36	T5	4.50
P6	1.69	T6	5.50
P7	2.02	T7	6.50
P8	2.35	T8	7.50
P9	2.67	T9	8.50
P10	3.00	T10	9.50

Figure (7) shows the results obtained from the described combination of elasticities. Trade CES and CET are presented at the horizontal axis, while the vertical axis shows the percentage change in prices. Production CESs are identified by different colors.

The results of the sensitivity analysis confirm our fifth assumption with respect to the trade elasticities as shown in Figure (7): all the lines slope up as T values move from T1 to T10. The exceptions are the composite supply prices of wheat and other cereals, where prices increase with increasing trade elasticities only if the production elasticity is unity or less (levels P1 to P4). With higher production elasticities (levels P5 to P10), higher trade elasticities result in less price transmission. This can be explained by considering two different effects with opposite directions caused by higher import CES elasticities in case of increasing import prices:

> Effect 1: A higher elasticity results in more substitution of the domestic commodity for the imported commodity, which raises PDD and thus PQS.
> Effect 2: A higher elasticity results in a higher weight of PDD and a lower weight of PM in the formation of PQS, which depresses PQS.

The lower the production elasticities, the stronger effect 1 (increasing PQS), and the lesser effect 2 (depressing PQS). For wheat and other cereals, effect 1 dominates the total effect on PQS up to a production elasticity of up to unity, whereas effect 2 dominates with production elasticities above unity. In contrast, for other crops the effect of higher trade elasticities on the price transmission from trade prices to PQS is always positive. This

results from the fact that PQS is also impacted by the export price due to a significant export share in this product group.

The sixth a priori assumption – the lower the production elasticities are, the higher the pass-through is – is also validated according to our results. According to Figure (7), the percentage change in the price series increases as production elasticities move toward T1 which has the smallest T value of 0.05. This can be observed from the wide vertical spaces between P values, which become even wider as the elasticity is closer to P1 (see, for instance, PXC for wheat and cereals).

This being said, the strength of pass-through also differs among the different commodities. Figure (7) shows wheat prices reacting stronger to the production elasticities, which is reflected in the wider spaces between the different lines compared to cereals and other crops. On the contrary, other crops show the lowest reaction among the three selected commodities as the lines are closer to one other for all of other crops' price series. This is explained by the size of the other crops' sector, in general, and the amount of resources (VA and intermediates) needed to bring clear increases in its domestic production. The other crops sector is the third biggest agricultural sector in Israel after the fruit and vegetables sector and other the animal farming sector, while the wheat and other cereal sectors are smaller.

Despite the differences among the three commodities in their size, cost structure, demand components, and factor demand, their overall reaction to the elasticity combinations is found to be consistent with the elasticity-related a priori assumptions. The justification for increases in the pass-through as trade elasticities (CES and CET) increase is that domestic producers would realize higher demand for their products due to domestic supply cuts caused by higher world prices as imports decline and exports expand. If domestic goods in this case are not good substitutes for imported ones, the reduction in imports and the increase in exports would hardly happen.

The higher the production CES is, the stronger the reallocation among production factors and intermediates are which allows for a stronger response to higher world prices. Thus, the higher the production CES is, the greater the ability of producers to react and dampen the domestic price increase is by additional supply and vice versa.

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Figure 7: Percentage increase in prices according to elasticity combinations
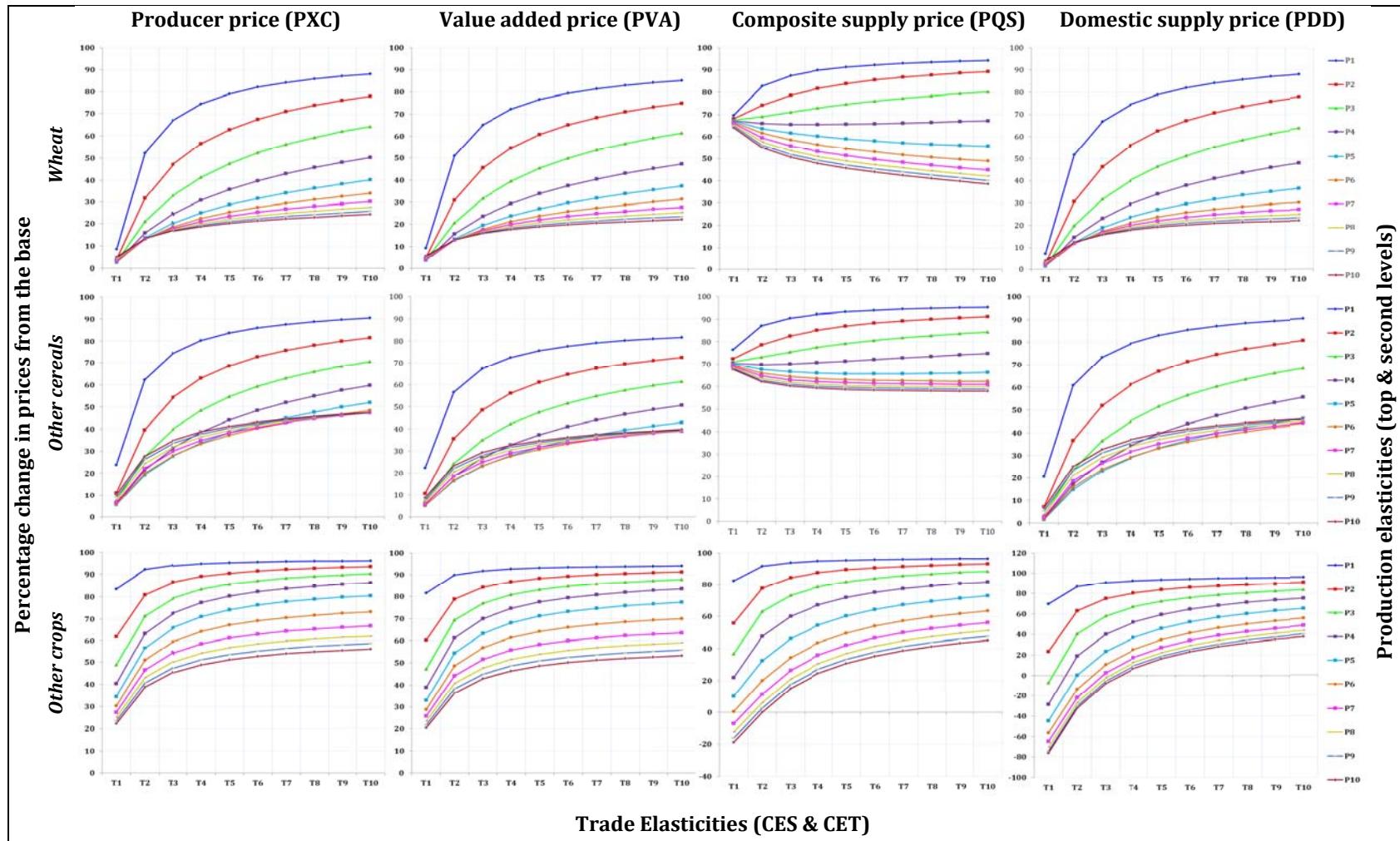
Figure (8) helps determine the obtainable ranges of price transmission using different combinations of trade and production elasticities. For simplicity, only prices of other crops are depicted, where the selection of other crops is related to the size of the sector in the economy: the other crops sector represents the largest food crop sector, with about 70% of its supply produced domestically. Moreover, it could be considered as a typical sector with substantial amounts imported, produced domestically, exported, consumed by households, invested, and used as intermediate inputs. The figure shows the different ranges of prices changes in different colors while combining the different trade and production elasticity values. The highest changes are always shown in red, followed by purple, light green, orange, while the lowest price ranges are always in blue.

Looking at the domestic prices of imports and exports, which represent the bridge between the domestic market and the rest of the world, we find only two possible ranges of changes in prices. The highest obtainable price change for both is 98% by combining P1 and T10, while the lowest obtainable price change is 65% at the combination of P10 and T10. The differences between changes in PWM and PM and changes in PWE and PE are driven by the exchange rate, which appreciates more in these scenarios when trade elasticities are higher. This way of presenting price changes allows for determining various combinations of trade and production elasticities, which result in the desired level of price transmission.

If, for example, the time series analysis confirms that a 100% increase in the world market price of other crops would transmit fully to the producer price, then the CGE model should be able to generate an increase in the producer price close to 100%. The required elasticity levels can be found based on the graph at the top right part of Figure (8), which shows that trade elasticities at T10 and production elasticities at P1 would result in the desired result. However, the selected values of trade elasticities are higher than the recommended range of elasticities that CGE modelers tends to rely upon (Sadoulet and de Janvry, 1995).[4] Thus, these results indicate the importance of considering the specifics of individual countries and commodities in judging plausible

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[4] Experience has shown that the empirical results obtained from simulations with CGEs are quite insensitive to specific values of elasticities, while, instead, they crucially depend upon their order of magnitude. The possible range of substitutability is relatively well represented by four values: 0.3 for very low substitutability, 0.8 for medium-low, 1.2 for medium-high, and 3.0 for very high (Sadoulet and de Janvry, 1995).

elasticity values. Furthermore, calibrating a certain degree of price transmission would typically be only one of many objectives in the parameterization of a CGE.

Figure 8: Price ranges for other crops with different combinations of elasticities
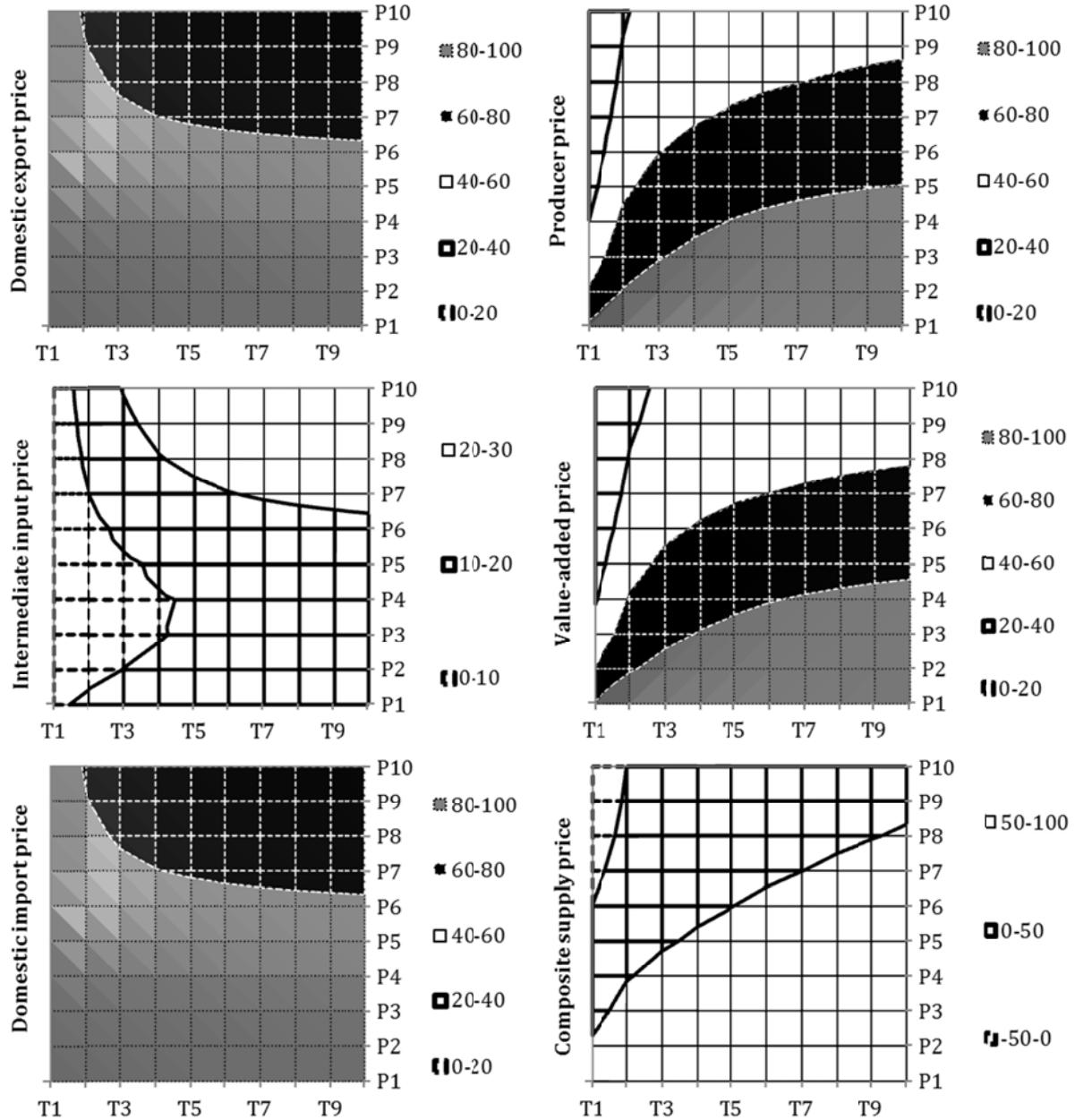
If we consider the producer price of other crops as an example, the highest obtainable range of prices is reflected by the red color and comprises changes between 80% and 100%. The lowest trade elasticity that could be considered here is T1; however, it could be combined with P1 (the lowest production CESs) only to generate a change of 84% in the producer price. On the other hand, the highest production elasticity that could be

considered to obtain changes within the same range is P5, which could be combined with T10 (the highest trade elasticities) only to generate an 80% increase in the producer price of other crops.

The second obtainable range of producer prices (60% to 80%), which is colored in purple, could be achieved by combining the production CESs between P2 and P8 with trade elasticities at different levels. As a general rule, the higher the value of the production CESs, the higher the trade elasticities must be to remain within the same range of price pass through. The lowest obtainable level of pass-through within this range (60.8%) can be achieved by combing P8 and T8, while the highest level of pass-through (79.7%) can be achieved by combing P5 and T9.

A similar approach could be followed to identify different ranges for different prices and commodities in light of the levels of correlations between the world market prices and the domestic prices throughout the price transmission tree shown in Figure (1). For the value added price of Figure (8) (right hand middle panel), for example, there are four possible ranges of price pass-through, there are three for the composite supply price (right hand lower panel)and three for the intermediate input price (left hand middle panel).

These results confirm and validate our fifth and sixth hypotheses, which assume that trade and production elasticities have significant influences on the degree of price transmission from the world to the domestic market within the CGE framework. It is also shown that the transmission is higher if we increase the value of trade elasticities, while it is lower if we increase the value of production elasticities. Therefore, the elasticity combination that allows the CGE model to generate the highest level of pass-through is always the one that considers high trade elasticities together with low production elasticities.

5.4 Exchange rate regime

To examine the influence of the prevailing exchange rate (EXR) regime of the price pass-through, an updated model closure is applied with a fixed EXR. As discussed above, the domestic currency appreciates under our 100% world market price shock. This implies that domestic import and export price changes would be smaller than world market price changes. A fixed exchange rate regime, in contrast, would assure that changes in the domestic prices of imports and exports would remain similar to changes in world prices as the EXR would remain fixed at a value of 1. Figure (9) compares the pass-

through of a 50% increase in world prices of exports and imports for the three selected commodities.

Figure 9: The pass-through of a 50% increase in world prices under flexible and fixed exchange rate regimes
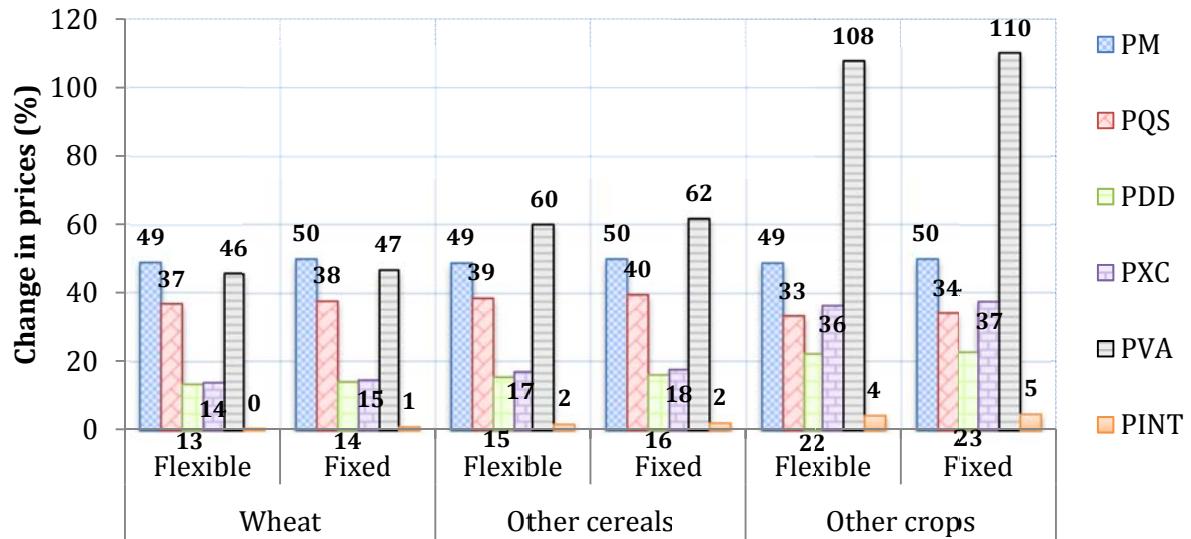

Figure (9) confirms our seventh a priori assumption that a fixed exchange rate results in a higher pass-through of world price increases to domestic markets in case of a currency appreciation and an increase in world market prices. However, if world prices decrease, the pass-through would be higher in the case of a fixed EXR compared to a flexible EXR.

6 Conclusions

Despite the growing number of studies analyzing the pass-through of international prices to domestic markets, particularly after the 2006-2008 food price increase, the empirical methods applied are concentrated on econometric time series analysis such as cointegration analysis and the estimation of vector error correction models. These are powerful methods to describe and forecast price relationships through time, yet compared to economy-wide models such as CGE models, they are less informative regarding implications a certain level of price transmission might have on different actors of the economy.

It therefore seems adequate to use a variety of tools that connects both techniques and harmonizes their linkages in a way that captures and reflects the strength of each. An attractive approach is to calibrate CGE models to meet the level of price pass-through empirically determined by time series analyses, which is our motivation to conduct this

study. We hypothesize seven different determinants, based on general economic sense and trade theory, of the pass-through of international prices to domestic markets. They are grouped in four major categories: (1) structural characteristics, such as the size of the concerned commodity in the domestic economy in terms of supply, demand, production, and trade, as well as its share in the use of domestic factors of production; (2) model closure and basic assumptions related to the mobility of production factors; (3) model parameterization, including assumptions related to the substitution possibilities among domestic and traded goods, as well as producers' options to substitute primary factors by intermediate inputs or to substitute different primary factors for one other; and (4) the prevailing exchange rate regime.

We use a single country CGE model developed by McDonald (2009) together with a detailed Israeli SAM for 2004 (Siddig et al., 2011) as the basis for our experiments. Our findings confirm that the price pass-through from international to the domestic markets in CGEs can be controlled for by configuring its closure rules, production and trade elasticities, factor market closures, and exchange rate regime. General conclusions include the following: (1) higher trade shares of the sector result in greater transmission of the world market price to the domestic market; (2) increasing export prices together with low CET elasticities and high production elasticities may even result in negative effects on domestic consumer prices; (3) greater factor mobility results in lower price transmission; (4) higher trade elasticities result in greater price transmission; (5) higher production elasticities (top and second level) result in more substitution options for producers and less price transmission; and (6) the pass-through of an increasing world price is higher under a fixed exchange rate regime compared to a flexible one if the domestic currency appreciates due to the world market price shock.

The described approach to depict the observed transmission of international commodity prices to domestic markets may be helpful in considering a combination of PTA and CGE modeling. The possibilities of combining the different assumptions of the model structure, elasticities, and closure rules to meet a certain degree of price transmission are manifold. The modeler therefore has considerable freedom to choose a model formulation which targets a certain degree of price transmission. This freedom is helpful, as achieving a certain degree of price transmission will typically be just one target among others, such as capturing the real economy accurately in the choice of factor market closures or basing behavioral parameters on empirical analysis.

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8 **Appendix:** Description of the agricultural sectors of the 2004 SAM

SAM 2004 sectors	Detailed description based on IOT 1995
Cereal : Growing of rice (non-husked), corn, barley, rye, oats, and other cereals	Growing of other cereals and pulses
Growing of wheat	Growing of wheat
Fruit and vegetables including mate and spices, excluding other fruit dried	Growing of citrus Growing of pome fruits Growing of stone fruits Growing of nuts Growing of grapes Growing of bananas Growing of olives Growing of subtropical and other tree crops Growing of vegetables (including melons and pumpkins) Growing of potatoes
Other crops: Growing of rough fodder, cotton, other plant based fibers, oil seeds, soya beans, groundnuts, tobacco. Growing of flowers, seeds, and nursery products. Imports of green coffee, cocoa beans, and bulk tea	Growing of rough fodder Growing of cotton Growing of other field crops (including groundnuts)
Bovine cattle, horses, asses, mules, and hinnies, live, bovine semen, sheep, live goats shorn wool, greasy, and fleece-washed shorn wool	Cattle farming for meat Sheep farming (milk, meat, and wool)
Other animal: Laying hens, poultry farming, and turkey farming. Farming of other animals including fine animal hair, not carded or combed and silk-worm cocoons suitable for reeling	Raising of laying hens Poultry farming for meat Poultry hatcheries Raising of turkeys and other poultry farming Farming of other animals
Meat: Processing of meat and poultry, including CPC Subclass 02962 (pulled wool, greasy, including fleece-washed pulled wool; coarse animal hair) and CPC Subclass 02971 (raw hides and skins of bovine or equine animals, sheep or lambs, goats or kids)	Processing of meat and poultry
Manufacture of edible oils, margarine, and oil products excluding CPC Subclass 21660 (maize (corn) oil and its fractions, not chemically modified)	Manufacture of edible oils, margarine, and oil products

SAM 2004 sectors	Detailed description based on IOT 1995
Milk: Milk of cattle, sheep, and goats	Cattle farming for milk
Forestry, fruit trees (investment to bearing), and imports of natural rubber	Forestry
	Fruit trees (investment to bearing)
	Natural rubber (imports)
Fishing: Pond-culture fisheries. shore and lake fisheries	Pond-culture fisheries
	Shore and lake fisheries